INFLUENCE OF PROCESSING ON NUTRITIONAL AND PHYTOCHEMICAL COMPOSITION OF FIG *(FICUS CARICA*) AND KARONDA (*CARISSA SPINARUM)*

Submitted to

LOVELY PROFESSIONAL UNIVERSITY

in partial fulfillment of the requirements for the award of degree of

DOCTOR OF PHILOSOPHY (Ph.D)

IN

NUTRITION AND DIETETICS

by

Ambika Chauhan

Supervised by

Dr. Beenu Tanwar

Assistant Professor

Department of Food Technology & Nutrition
School of Agriculture
Lovely Professional University, Phagwara
Punjab

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ABSTRACT

The present investigation entitled "Influence of processing on nutritional and phytochemical composition of Fig (*Ficus carica*) and Karonda (*Carissa spinarum*)", were carried out in the Department of Food Technology and Nutrition, School of Agriculture, Lovely Professional University, Phagwara, Punjab, during the year 2012-2016. Fruits are known as protective foods. They are rich in antioxidants, vitamins, organic acids, phenolic contents and played important role to improve human health. Various fruits, which are underutilized and poorly addressed by the researcher, needs to be acknowledged, employed and explored today's for future generation. Fruits are perishable in nature, can be preserved for a short time and their availability to the consumers remains seasonal. Therefore, to prolong their shelf life, seasonal fruits must be processed. Thus the present investigation aimed to study the influence of processing (freezing, sun drying and microwave drying) of fig and karonda. Among, all the methods studied, microwave dried method proved effective for nutrient retention. Underutilized fruits are also used as traditional medicine for the treatment of diabetes. So, in this regard, methanolic extract of fig and karonda were proved more effective for the reduction of diabetes in selected group of rats. On the basis of nutritional and sensory evaluation of value added products (bun, muffin, noodles and nuggets) substituted with 15 per cent, 30 per cent and 45 per cent fig and karonda showed better nutritional quality with good acceptability by panel of judges.

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I am greatly thankful to my guide **Dr. Beenu Tanwar** for her continuous source of inspiration, knowledge, motivation and encouragement during the entire period of my research work. Despite her busy schedule, she has been available at every steps with me. I had no knowledge before starting the project. Without her guidance, support and encouragement, i could not have finish my research work.

My sincere thanks also goes to the faculty members, lab technicians and animal house staff members of Lovely Professional University for providing me continuous support throughout my research work. Lastly, I would like to thank my family and friends especially, Devika Chaudhary, Mrs. Shakuntala and Mr. Sunny Chopra for their continuous support, love and never give up spirit.

Finally, I think that this accomplishment would have never been possible without God.

Thanks for giving me opportunity that changed my life!!

Ambika
Dated
12-12-2016

Ambika Chauhan

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CERTIFICATE

I certify that Ambika Chauhan has prepared her thesis titled **" Influence of processing on nutritional and phytochemical composition of Fig (*Ficus carica*) and Karonda (*Carissa spinarum*) "** for the award of Ph.D degree of Lovely Professional University**,** under my guidance and supervision. This present work is mainly the result of her continuous efforts and original investigation under my sincere guidance and supervision.

The research work report is suitable for Ph.D degree award submission in Nutrition and Dietetics.

Beenu

Dr. Beenu Tanwar

Assistant Professor
Department of Dairy Technology
MIDFT, Dudhsagar Dairy
Mehsana, Gujarat

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TABLE OF CONTENTS

TERMINOLOGY

g	=	Gram
µm	=	Microgram
kg	=	Kilogram
°C	=	Degree Celsius
%	=	Percentage
g/ml	=	gram per milliliter
et al	=	And others
i.e.	=	that is
etc.	=	Et cetera
DPPH	=	2,2-Diphenyl-1picrylhydroxyl
Rpm	=	rotation per minute
WF	=	Wheat flour
CS	=	*Carissa spinarum*
FC	=	*Ficus carica*

LIST OF FIGURES

5.20	B1(100% green gram nugget, B2= 15 % Karonda, B3= 30% Karonda, B4= 45 % Karonda)	185

LIST OF TABLES

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The present investigation entitled "Influence of processing on nutritional and phytochemical composition of Fig (*Ficus carica*) and Karonda (*Carissa spinarum*)", were carried out in the Department of Food Technology and Nutrition, School of Agriculture, Lovely Professional University, Phagwara, Punjab, during the year 2012-2016. Fruits are known as protective foods. They are rich in antioxidants, vitamins, organic acids, phenolic contents and played important role to improve human health. Various fruits, which are underutilized and poorly addressed by the researcher, needs to be acknowledged, employed and explored today's for future generation. Fruits are perishable in nature, can be preserved for a short time and their availability to the consumers remains seasonal. Therefore, to prolong their shelf life, seasonal fruits must be processed. Thus the present investigation aimed to study the influence of processing (freezing, sun drying and microwave drying) of fig and karonda. Among, all the methods studied, microwave dried method proved effective for nutrient retention. Underutilized fruits are also used as traditional medicine for the treatment of diabetes. So, in this regard, methanolic extract of fig and karonda were proved more effective for the reduction of diabetes in selected group of rats. On the basis of nutritional and sensory evaluation of value added products (bun, muffin, noodles and nuggets) substituted with 15 per cent, 30 per cent and 45 per cent fig and karonda showed better nutritional quality with good acceptability by panel of judges.

1. INTRODUCTION

World Health Organization (2003) reported that fruits are rich in fiber, antioxidants, organic acids, vitamins, phenolic contents (Salmanian *et al.,* 2014) and considered to be a protective foods (Nicoli *et al.,*1999). They are used as a source of traditional medicine (Jain *et al.,* 2013) to cure many health problems (Mahapatra *et al.,* 2012) and contributes as a main source of livelihood for the poor people (Gajanana *et al.,* 2010).

Underutilized fruits or neglected crops are not cultivated commercially, not grown and rarely found in the market (Agent, 1994). They are nutritionally beneficial for the people and play an important role in human health. These fruit species may be distributed globally, but still find some restriction in their consumption and production system (Williams *et al*., 2002). Several underutilized fruits are unfamiliar, unknown and less eaten. However, underutilized fruits have not yet received much awareness as antioxidant sources compared to commercial fruits. These fruits are neglected due to ignorance factor, lack of information, unavailability, deficient in these fruits promotional campaigns, difficulty in storage and harvesting (Badola and Aitken, 2010). Now, these fruits may be included in the health promotion campaigns (Rukayah, 1992). Different types of underutilized fruits are grown in India like aonla, tamarind, karonda, fig, citron, jackfruit etc. Some fruits, which are still underutilized and proves effective to satisfied nutrition demand. Recent research has been mentioned *Ficus carica* and *Carissa spinarum* are considered for the research purpose due to their higher nutritional value and medicinal uses (Baliga *et al.*, 2011).

Ficus carica is commonly known as "Fig" (Jander and Machado, 2008). *Ficus carica* called fig in English and anjir in Hindi (Wealth of India, 1999). It is riped from late of July to late of September (Anon, 2011). It is a deciduous and cultivated fruit tree from the family Moraceae. It is richest source of mineral elements, calcium and fiber content (Vinson, 1999). Dried fig can be stored for 6-8 months (Venkatartnam, 1988).

Carissa spinarum is an evergreen shrub and fruits got mature in late April. It is cultivated mainly in parts of dry foothills of the Punjab, also in Himalayan tract (India) and also on the coast of the Southern Andaman Islands (Parmar and Kaushal, 1982). Riped fruit has dark black colour. It is mostly cultivated in garden, as hedges for its edible berries (Van der Piji,1972). They

are highly nutritious and good source of protein. So, it is mainly offered for sale at certain places (Parmar and Kaushal, 1982).

Some of the locally available fruits which are very cheap as compared to unseasonable, imported fruits (Grabowski *et al.*,2003). Fruits are highly perishable in nature (Pathak *et al*., 2009), have short life span (7-10 days of post harvest life); (Sozzi *et al.,* 2005) and it affects the storage ability, physiological, nutritional and chemical properties of fruits (Orsat *et al.*,2006).

To minimize the effect of degradation, processing is considered to be a most effective tool. Several processing methods (freezing, sun drying and microwave drying) have been introduced with the aim to increase the shelf life of fruits. Sun drying and microwave drying method are proved to be a most important drying practice for the fruits (Matazu and Haroun, 2004). These methods are mainly used to produce heat to remove moisture content. Moisture content is removed by evaporation with heating process and played very important role to affect the nutrient content of fruits in different ways. It helps to increase or decrease the concentration of some nutrients (Hassan *et al*., 2007).

This study is mainly to carried out to observe the effects of these processing methods on the nutrients of fruits and to determine the most suitable method for nutrient retension rather than to increase their shelf life. So, the aim of this study is to focus on the influence of processing on nutritional and phytochemical composition of underutilized fruits i.e. fig and karonda.

These fruits, mainly in raw form are astringent in taste and accepted less. Nowadays, these fruits are commonly used to prepared value added products, which improves nutritional value and acceptance level of the products (Goyal *et al.*, 2008; Singh *et al*.,2009).

2. REVIEW OF LITERATURE

A review of the literature related to different aspects of the present thesis is presented in this chapter. This includes the importance of underutilized fruits, fig and karonda fruit characteristics (morphological, nutritional and phytochemical), value added products development, experimental designs and influence of processing methods on selected fruits are also discussed.

Importance of fruits

Fruits are known as protective foods (Nicoli *et al.*, 1999). According to the Recommended Dietary Allowances (RDA), the consumption of fruits may increased in our daily diet. World Health Organization (2003) reported that fruits are richest source of dietary fiber, antioxidants and phytochemicals. As underutilized fruits contained folic acid, dietary fiber, proteins, vitamins, carbohydrate, minerals (Nandal and Bhardwaj, 2014) and contributed to control many chronic diseases of ageing (Pandey *et al*., 2014). Its increased fruit consumption has been recommended for the primary prevention of many diseases. Underutilized food crops are lesser known plant species in terms of marketing and research (Thakur, 2014). Underutilized crops are contributed 3.14 per cent of the total geographical area (Rai *et al*., 2005). According to Indian Government Economics statistics the area and production data for the underutilized crops was estimated 25.67 million ha and 43.05 tons in 2013-2014 (Ahmad and Raj, 2012). Today, consumers are becoming more conscious for their health and nutrition. Underutilized fruits are proved beneficial, therapeutically and nutritionally to satisfied consumers demand (Gajana and Godwa, 2010) and played very important role to control many diseases (Gajanana *et al*., 2010). These fruits are contributed great role to supplement human diet also (Vazhacharickal *et al*., 2015). Some fruits, which are at present underutilized and poorly addressed by the researcher (Gajanana *et al*., 2010) and needs to be acknowledged, employed and explored today's for future generation (Padulosi, 2008).

2.2 *FICUS CARICA* (FIG)

Fig characteristics (Morphological, nutritional and phytochemical)

Ficus carica is commonly known as "Fig "(Jander and Machado, 2008). Fruit has different colour (green, brown and purple) and contained numerous seed from 30-1600 per fruit bound with jelly like flesh (Joseph and Raj, 2011). It is a deciduous and cultivated fruit tree which belonging to Moraceae family. It is 50 feet tall and cultivated in Southwest Asia, India commercially only in some centres near Pune (Maharastra) and Anantpur district (South India). Mostly it is grown in Uttar Pradesh, Mysore, Punjab and Himachal Pradesh (The Wealth of India, 2001) ; (Tous and Ferguson,1996). It is richest source of mineral elements, calcium and fiber content (Vinson, 1999). Fig fruits are very nutritious and mainly used to made food products (Guesmi *et al.*,2006). It can be consumed in dried and as well as in preserved forms (Neal, 1965) because of limited intake due to seasonal availability, market accessibility and shelf life (Schmidt *et al.*, 2005). Dried fig could be stored for 6-8 months (Venkatartnam, 1988).

According to United States Department of Agriculture (USDA) dried figs are rich in fiber content and potassium content (Gilani *et al*., 2008) and also contained high quality of calcium (Vinson *et al.,* 2005). It contained total carbohydrate (24.27 mg/100gm), protein content (1.27 mg/100gm), calcium content (44.00 mg/100gm); (Zaenuri *et al.*,2014), iron content (4.09 mg/100gm) and potassium content (194 mg/100gm) in fresh fig fruit, respectively (Morton,1987). Fig fruits are fat as well as sodium free and cholesterol free (Vinson *et al*., 2005; Lianju *et al.*,2003). Dried fig contained higher polyphenol content and it is considered as functional foods (Solomon *et al.,* 2006; Vinson *et al.*,2005). It contained moderately higher content of crude fiber (5.8 %) and more than (28 %) of it is soluble type, which has been supported to control blood sugar (Sadhu,1990). *Ficus carica* have an antioxidant effect, which act as antibacterial, hypoglycemic effect, anti cancerous effect and hypotriglyceridaemic effects etc. (Wang *et al*., 2004). For that reason, it is consumed as fresh, dried and in the preserved form also (Mehraj *et al*., 2013).

In morphological characteristics of fig (*Ficus carica L.)*; Darjazi *et al.* (2011) showed that fresh fig fruit has (8.0 to 43.5 gm/100gm) weight and (21 to 45mm) diameter. Shobaki *et al.*

(2010) reported 82.20 per cent-moisture content, 0.65 per cent-ash content, 12.90 per cent-carbohydrate content, 1.00 per cent - protein content, 1.70 per cent- fat content and 1.55 per cent-fiber content in fig fruit. Similarly Khan *et al*. (2011) mentioned the nutritional composition of local variety of Pakistan fig contained 1.90 g/ 100 gm-ash content, 78.84mg/100gm- calcium content and 5.95 mg/100gm-iron content. Bhogaonkar *et al*. (2014) studied the nutritional potential of fresh *Ficus carica L*. fruits and reported 88.1 gm/100gm- moisture content, 1.3 gm/100gm- protein content, 0.2 gm/100gm-fat content,7.6 gm/100gm- carbohydrate content, 80 mg/100gm- calcium content, 30 mg/100gm- phosphorus content and 1.0 mg/100gm-iron content. Aljane *et al*. (2007) evaluated the atomic absorption analysis of mineral salts in fresh *Ficus carica* (Tunisian cultivars) and mentioned (304.57 mg/100gm) calcium content.

Solomon *et al*. (2006) mentioned that edible portion of fig contained 21.5 mg/100gm-flavonoids content and 11.0 mg/100gm – anthocyanins content. Duenas *et al*. (2008) reported *Ficus carica* fruit skin contained (97 µg/100gm) and pulp (15 µg/100gm) anthocyanin content.

Value added product development

Fruits are perishable in nature (Pathak *et al*., 2009), have short life span (7-10 days of post harvest life); (Sozzi *et al.,* 2005) and it affects the storage ability, physiological, nutritional and chemical properties of fruits (Orsat *et al.,*2006). Some fruits are astringent in taste and accepted less. Nowadays, these fruits are commonly used to prepared value added products, which improves nutritional value and acceptance level of the products (Goyal *et al.,* 2008; Singh *et al*.,2009). However, given studies have shown that the formation of innovative value added product with the incorporation of fruits. Khapre and Satwadhar, (2010) estimated the physico-chemical characteristics of *Ficus carica* fruit cv. DINKAR and its cabinet dried powder. Result showed fig fruit which was dried in a cabinet at temperature 60 °C (20-24 hours) contained 15.41 gm/100gm – fiber content, 22 gm/100gm – potassium and utilized in various value added products viz., icecream, milk shake, burfi and toffee. Chauhan *et al.* (2010) determined the development of food products incorporated with dried fig powder. Five products *viz., Idli, Biryani,* cake, *Gujiya* and *Ladoo* were prepared with the incorporation of *5* per cent, 10 per cent and 15 per cent dried fig powder. Results revealed that in case of sensory attributes, all the products which were incorporated by fig powder were accepted well. Khapre *et al.* (2011)

studied the development of technology for the preparation of *Ficus carica* fruit powder and its utilization in toffee. Fresh sample of Dinkar variety of figs were dried at temperature 60 °C in a cabinet drier for 20–24 hours. The products were prepared by processing of figs *viz.* fig powder and fig toffee. Sakhale *et al.* (2012) evaluated the consistency of fig- mango mixed toffee preparation process. In this study, mango and fig pulp was used in different proportions to prepare mixed toffee. In result, they mentioned that the toffee (80:20) proportions which made with the substitution of fig and mango pulp reported better organoleptic evaluation. Mhalaskar *et al.* (2012) studied the development of technology for fortification of fig (*Ficus carica*) fruit into its value added product- fig toffee. It was prepared with the incorporation of ground fig pulp and other ingredients (liquid glucose, sucrose, edible fat and skim milk powder) were added in suitable amounts. The fig pulp was incorporated with soy protein isolate, ragi powder, papaya pulp and mixture was heated in a cabinet drier for 2 hours at 60 °C temperature. Result showed that the products prepared by the incorporation of figs *viz.*, fig toffees were assessed and found rich in their physico-chemical and sensory parameters. Reddy *et al.* (2014) studied the utilization of an underexploited fruit fig as a preserved product. They studied the process for the preparation of preserved product jam from fig by using pectin source from apple. They found that fig fruit contained calcium, iron, and low fat content and high amount of fiber content. Due to its high nutritional value it was considered to preserve the fruit by preparing jam with many textures, flavors and colours. In this study, fig jam was developed and the quality parameters were assessed. Mule *et al.* (2014) described the preparation, proximate composition and sensory evaluation of buffalo milk shake was incorporated with dried fig fruit with proportion of 5 per cent, 7.5 per cent and 10 per cent. In result, proximate composition of 10 per cent fig contained 4.52 per cent - protein content and 12.78 per cent - sugar content as compared to 5 per cent and 7.5 per cent fig. Result revealed that the overall acceptability score (8.3) was the highest in the sample with 7.5 per cent fig and milk shake prepared from buffalo milk with the incorporation of 5 per cent. *Ficus carica* was more consumer-friendly than buffalo milk shake (control) due to its high nutritive value and better sensory attributes. Tanwar *et al*. (2014) studied the effect of different processing methods on fig product (physicochemical, nutritional and phytochemical composition). They mentioned that processing of fig fruit pulp into jam and nector was resulted to increase the carbohydrates content. Verma and Gupta, (2015) studied the estimation of

phytochemical, nutritional and antioxidant activity of figs (*Ficus religiosa*) and formulated value added product (Hard Candy). Result showed that fig was used for the preparation of hard boiled candies was made with the incorporation of glucose syrup and lemon juice with dried powder of fig incorporated with flavoring and coloring agents. In sensory evaluation, it showed very good acceptability by the panelists. Khapre *et al.* (2015) studies the standardization of *Ficus carica* powder enriched cookies and its composition. In this study fig powder was incorporated in cookies at 0,6,12 and 18 per cent level for nutritional and sensory evaluation. Result showed that cookies were incorporated with 12 per cent fig powder showed that 3.1 per cent- dietary fiber, 6.9 per cent- protein content, 1.1per cent- potassium content and organoleptically accepted well.

Experimental design

Ficus carica have an antioxidant effect, which act as antibacterial, hypoglycemic effect, anti cancerous effect and hypotriglyceridaemic effects etc. (Wang *et al*., 2004). They are used as a source of traditional medicine (Jain *et al.*, 2013) to cure many health problems (Mahapatra *et al.*, 2012). The reports of different studies have shown that therapeutical used of fruits. Perez *et al.* (2000) studied the hypoglycemic effect of fig leaves to control sugar levels in rats and observed for 3 weeks. They selected four groups and each groups contained 13 rats. Result revealed that given aqueous extract was decreased the sugar levels in diabetic rats as compared to other groups. In conclusion, fig leaves proved beneficial for hypoglycemic effect. Shobaki *et al*. (2010) studied the effect of different level of fig leaves on diabetic rats. In this forty eight male rats were divided into two groups. Group first contained (n=6) which was fed on basal diet. Second group (n=46) was injected with 150 mg/kg body weight alloxan to induce hyperglycemia and further divided into seven equal subgroups. One subgroup (n=6) was fed on basal diet and other six subgroups (1-3) were fed on basal diet contained (5%,10%, 20%) levels of *Ficus carica* leaves groups (4-6) were also fed on basal diet contained (4%, 6%, 8%) levels of *Ficus carica* leaves, respectively. Result revealed that Ficus *carica* leaves act as antidiabetic effect. Choudhary *et al*. (2011) studied *Ficus religiosa* Linn effect on diabetes. In this study, the ethanolic extract of fruits was orally given to diabetic and normal rats. They measured of their blood glucose lowering activity. Rats were treated with higher dosages of 250 mg and lower dose of 100 mg according to body weight of rats. Result reported that ethanolic extract of fruits with

higher dose was proved effective for antidiabetic activity as compared to lower dose and showed no effect on the normal rats. Rashidi and Noureddini, (2011) studied the effect fig leaves on sugar levels of diabetic rats. Result showed that diabetic rats that were administered with 0.4 mg/dl of extract proved effective to decrease the blood glucose levels. Statin *et al.* (2012) studied effect of fig extract to control diabetes in diabetic rats. They administered methanolic *Ficus carica* extract dose of 100 mg and dose of 200 mg according to body weight of rats. In result, dose of 200 mg reduced more diabetes as compared to dose of 100 mg. Results indicated that, dose of fig proved to be very effective for antidiabetic activity. Ahmad *et al*. (2013) studied the effect of stem bark of fig to control diabetes. They administered orally prepared extract to diabetic induced rats. Study, concluded that stem bark showed effective results to control diabetes. Kanuur *et al.* (2014) found dried Ficus *carica* fruits were subjected to extraction using (90 %) ethanol and this extract was further evaluated for the adaptogenic activity in rats. In this study, they were analyzed sugar levels. In results, Ficus *carica* extract treated rats were proved effective to reduce sugar levels and act as antidiabetic activity. Ibrahmin *et al*. (2014) determined the effect of fig leaves to control diabetes in rabbits. They selected diabetic rabbits for the study. They have been started to given different selected dosages after seven days of alloxan injection and observed for 6 weeks. They had given 0.3gm fig leaves prepared extract to rats according to their body weight. Study concluded that, *Ficus carica* leaves aqueous extract proved very effective for the reduction of glucose level. It showed better effect by supplementing with insulin to cure diabetes. Jayakumar *et al*. (2014) studied the effect of leaves of *Ficus carica* to control diabetes. In this study, extract was orally given to diabetic rats with selected dosages 200 mg and 400 mg according to body weight of rats. Result mentioned that *Ficus carica* leaves extract proved beneficial to control over polyphagia.

2.3 *CARISSA SPINARUM (*KARONDA)

Karonda characteristics (Morphological, nutritional and phytochemical)

Carissa spinarum is an erect thorny shrub with forked branches (light brown to green colour) usually about 2-3 meter height. Fruits (ovoid berry) are blue in colour, 9 mm in length and 6mm in diameter. Seed has black colour, 5-6 mm in length and 4 mm in diameter (Fatima *et al.*, 2013). Karonda has 1.08 cm-length, 219.6 mg-fresh weight, 2.53 per cent- ash content, 16.0 per cent-

protein content and 16.0 per cent- calcium content (Mishra and Gupta, 2005). *Carissa spinarum* is proved to be an important source of nutrition for the poor people. It contained 73.2 per cent-moisture content, 12.43 per cent-carbohydrate, 3.64 per cent- protein content and 0.72 per cent-phenolic content (Mahapatra *et al.,* 2012). Fresh riped fruit contained (0.73g GAE/100gm) phenolic content, (2118 µM AEAC/g dry wt.) ferric reducing power assay and (1013 mg AEAC/100g dry wt.) DPPH antioxidant activity on dry basis as milligram of ascorbic acid equivalent per 100 grams of sample (Nayak and Basak, 2015).

Value added product development

Value added products played very important role to improve nutritional value and acceptance level of the products (Singh *et al*., 2009). Mentioned studies are explained the formation of many innovative value added products. Hanwate (2005) studied extracted *Carissa caranda* juice at different per cent level of milk along with suitable stabilizer gelatin (0.5%) were added. Result revealed that according to 9 point hedonic scale *Carissa caranda* 10 per cent juice and 7.5 per cent sugar were produced the flavoured milk which was accepted with the highest score of 7.60 amongst the nine different combinations. It was highly accepted in flavoured milk prepared with the use of 10 per cent *Carissa caranda* juice and 7.5 per cent sugar along with 0.5 per cent gelatin on the basis of overall acceptability. Yadav *et al*. (2005) explored the feasibility of the incorporation *Carissa caranda* pulp used as natural flavouring agent in ice-cream. In this study, (0%), (10%), (20%) and (30%) selected fruit pulp was used to prepared for different types of ice-cream. The sample which made with the incorporation of (20%) pulp had contained highest rating (49.15%) and overall acceptability was (7.515) as compared to control and other treatments. Result showed that the incorporation of fruit pulp in ice-cream as natural flavouring agent at 20 per cent was proved to be most desirable and acceptable. Wani *et al.* (2013) studied the shelf life of Karonda jams (*Carissa caranda*) under ambient temperature. The study was based on the variations of sugar and the 5 levels of addition of sugar (850 gm, 950gm, 1050 gm,1150 gm and 1250 gm) were mixed with 1.0 kg of fruit pulp .They were known as 1, 2, 3, 4 and 5 treatment, respectively to obtained data and analyzed it. Result showed that treatment 4 (1150 gm sugar) possessed an ideal value of moisture content, ascorbic acid and overall acceptability. Study concluded that treatment 4th was the best as compared to other treatment in

case of physical, chemical and sensory parameters of jam. Shaheel *et al*. (2015) evaluated the effect of blending of karonda (*Carissa caranda*) juice incorporated with guava, papaya and pineapple juice on its quality and organoleptic evaluation. They evaluated their physico-chemical properties and organoleptic evaluation. They incorporated 25 per cent karonda juice with 75 per cent pineapple juice. Result revealed that it was contained 10.35 per cent- total sugar, 6.96 per cent- reducing sugars and 7.42 - organoleptic score was followed by 50 per cent karonda juice with 50 per cent guava juice of 7.18.

2.3 (e) Experimental designs

Fruits are nutritionally beneficial for the people and play an important role to improve human health (Williams *et al*., 2002). Given studies are well explained, the effects of fruits effects to control diseases. Swami *et al.* (2010) studied *Carissa caranda* effect on diabetic rats. Different dosages (250, 500 and 1000 mg) were selected according to body weight of rats and given orally to rats for the examination of glucose level. The 500 mg and 1000 mg of extract was proved to be very effective to decrease the blood glucose levels after 4 hours, 8 hours and 24 hours in normoglycemic rats as compared to 250 mg/kg extract. In result it revealed that doses of extract proved beneficial to control sugar. Itankar *et al.* (2011) evaluated the unripe *Carissa caranda* fruits effect to control diabetes. They studied the effect of selected fruit effect in alloxan induced diabetic rats. In this study, 400mg according to body weight of rat's drug was orally given to diabetic rats. After that it was observed for 24 hours and decreased the blood glucose levels by 48 per cent and 64.5 per cent. Rahman *et al*. (2011) studied the antihyperglycemic effect of *Carissa caranda L*. leaves in swiss albino mice. Selected extract was administered orally to glucose-loaded mice at dosages 50 mg, 100 mg and 400 mg according to body weight of rats. Result revealed that serum glucose levels were found to be reduced by 15.6 per cent, 17.8 per cent, 20.0 per cent and 47.8 per cent. Present study, concluded that selected methanolic extract was proved very effective to diminished the glucose parameters and act as antidiabetic drug. Fatima *et al.* (2013) examined the effect of *Carissa spinarum* leaves to control sugar levels in alloxan-induced diabetic rats. The extract was given orally at dosages 200,400 and 600 according to body weight of rats. Result revealed that extract at higher dose was proved to be effective than lower dosages.

Influence of processing methods on fruits

Fresh fruits are classified as perishable commodities due to presence of higher moisture content (Orsat *et al.* 2006). Locally available fruits are very cheap, fresh but have short life span. Therefore, processing methods are used to enhance their shelf life. Nowadays, perishable crops are dried in the world (Grabowski *et al.* 2003).

Sun drying

Drying is a technique which is used mainly to dry agricultural products, storage and to extend shelf life. Drying method proved to be one of the oldest method for food preservation (Papu *et al.* 2014). The reports of different studies have shown the influence of drying on nutritional and phytochemical composition of fruits. Farsi *et al.* (2005) studied the comparison of fresh and dried date was grown in Oman for the phenolic content. Selected fruit sample was sun dried at temperature 50°C for 7-10 days. Result showed that after drying process phenolic content was increased and proved that sun dried dates have higher phenolic content as compared to fresh sample. Similar result were reported by Jung *et al*. (2005) for fresh and dried persimmon fruits for their phytochemicals and the antioxidant compounds. Result concluded that dried fruit contained higher amount of bioactive compounds as compared to fresh. Noutchogoue *et al*. (2005) studied the biochemical changes related to hardening phenomenon in Aiele fruit (*Canarium schweinfurthii Eng)*. Sample was collected from West Cameroon and kept for 7 days for the storage, given heat treatment at 45°C temperature for 40 minutes, 70°C for 40 minutes and room temperature at 22°C for a period of 7 days and fourth group was raw fruits. Result revealed that after storage and heating treatment was responsible to increase the lignin content and cellulose content as compared to controlled sample. Xu *et al*. (2007) evaluated the effect of heat treated citrus peel extract for their phenolic compounds and antioxidant capacity. Huyou fresh fruit sample was selected from a farm in China and dried by hot air at temperature 45 °C for 48 hours. After that it was again, oven dried at temperature 120 °C for 60 minutes and 90 minutes. Result revealed that there was found enhancement in antioxidant capacity and phenolic content. Dangcham *et al*. (2008) studied temperature effect on lignin content of mangosteen fruit (red-brown stage) at low storage temperature. Sample was collected from Thailand and stored at temperature 6 °C and 12 °C for 12 days. Result reported that lignin content was increased from

0.57 to 0.725 g/100kg and 0.587 to 0.643 g/100kg at storage temperature 6 °C and 12 °C from 0 to 12 days. Monica *et al*. (2009) evaluated the antioxidant activity of heat treated apricots. Selected sample was air dried at different temperature 55°C and 75°C. In this study they reported higher antioxidant activity at temperature 75°C as compared to 55°C. Wang *et al*. (2009) studied blueberry changes in the phenol and antioxidant capacity by the exposure of ultraviolet light (UV-C). Sample was collected from the orchards in Maryland and illuminated by UV-C device with different UV dosages (6.45 kJ/m^2) at temperature 20°C as compared to control. Result showed that after UV treatment increased phenol from 3.12 to 4.72 mg/100gm and antioxidant capacity from 30.5 to 34.6 µ mol gallic acid equivalent/gm. Patras *et al*. (2010) determined the effect of heat treatment on anthocyanin stability. Thermal processing was responsible for the reduction of anthocyanin pigment and caused major effect on the colour quality due to the presence of some conjugated bond in their structures, which absorbed light at 500 nm , on the basis of red, blue and purple colour in the fruits. In result, study concluded that heating played an important role for the degradation of the anthocyanin pigments. Slatnar *et al.* (2011) studied the impact of fig (*Ficus carica*) drying on the contents of organic acids and phenolic compounds. Selected fruits were processed under sun-drying and oven-drying method. Phenolic compounds of the samples were analyzed three times in a year by using high-performance liquid chromatography. Result mentioned that dried fruits contained higher source of organic acids and phenolic compounds as compared to fresh one. Zivkovic *et al*.(2011) estimated the temperature effect on physical changes in Plum (*Prunus domestica L*.) "Pozegaca variety". In this study selected fruits were dried at temperature 75°C . Result showed that physical characteristics (length and width) was decreased after drying as compared to fresh. Sharifian *et al*.(2012) studied the microwave drying effect on moisture content of fig fruit (*Ficus carica).* In this study weight and temperature of the sample was recorded at regular intervals of 10 seconds to investigate the moisture variation. The result reported that raised the temperature in the microwave proved better removal of the moisture content. Kamiloglu (2012) studied the effect of sun drying on polyphenols and in *vitro* bioavailability of "*Bursa Siyahi"* figs *(Ficus carica L.).* Sample was collected from orchards located in Turkey. Fruits were dried in the sunlight for 8 days at temperature 31°C to 34°C in day time. In this study, they estimated sun drying effect on moisture content, flavonoid content and anthocyanin content. Result revealed

that heating treatment was responsible to reduced the moisture content from 81.4 to 49.7 per cent and also showed reduction in the flavonoid content, anthocyanin content. Mithanka(2012) studied the polyphenol content of *Pseudolachinostylis Maprouneifolia Pax Var* Dikindtii. Fruit sample was selected from a village in Eastern Botswana from a city Gaborone. Fruit sample was sun dried for eight days and used for further analysis. Result showed that phenolic content of sun dried sample was higher (1240.3 mg gallic acid equivalents/l) as compared fresh (838.6 mg gallic acid equivalents/l) and flavonoid content was higher i.e. 159.9 mg quercetin equivalents/l for sun dried sample, 139.1 quercetin equivalents/l for fresh fruit. Amalina *et al*.(2013) evaluated the modification of oil palm mesocarp fiber characteristics using superheated treatment. Sample was collected from Malaysia and dried in the sun light and kept at temperatures 190°C, 210°C and 230°C to analyzed lignin content. Result showed that lignin content of oil palm mesocarp fiber was increased from 28.44 per cent, 45.19 per cent and 49.73 per cent at different temperatures 190°C, 210°C and 230°C. Garcia *et al*. (2013) studied the drying effect on functional properties of (*Ficus carica L.)* var mission. In this study, *Ficus carica* was dried at temperature 45℃ in a thin layer drying equipment for 24 hours. Result revealed that drying process was mainly contributed to increase the phenolic content, antioxidant activity and decreased the anthocyanin content. Moldovan and David, (2014) studied the effect of heat treatment on anthocyanin stability of "Cornelian" cherries. Sample was selected from a local market in Romania and studied its anthocyanin degradation at 2°C temp., 22°C temp. and 75° C temp. Result showed that highest degradation rate of anthocyanin content was at temperature 75°C as compared to 2°C and 22°C. Anantawat (2015) determined the antioxidant activity of gac fruit aril powder by the effect of spray drying condition. Fully riped fruit was used as a sample and dried in a spray dryer at temperature 120°C, 150°C and 170°C. Result revealed that antioxidant activity was increased with increased temperature and ranged from (2758.33, 2797.50 and 2808.33) μg Trolox equivalent/100 gm at temperature 120°C, 150°C and 170°C. Mrabet *et al*.(2015) studied the effect of hydrothermal treatments on date varieties (*Phoenix dactylifera L*.) Garen Gaze. This variety was selected from Southern Tunisia. Dates were treated with direct heating contact at temperature 190°C and analyzed their lignin content and cellulose content. Result showed that increased lignin was 50.38 per cent, 60.80 per cent and cellulose content was 14.36 per cent, 16.34 per cent at temperature 180 °C and 200°C.

Hussain *et al*.(2015) reported the effect of sun drying methods on dates. Sample was selected from Pakistan and dried for 6 to 8 days by direct exposure of sun light during the day time. They analyzed the total phenolic content with their antioxidant activity. Result revealed that, drying process was responsible to increase the total phenolic compounds from 166.80 to 181.50 mg gallic acid equivalent /100 gm and antioxidant activity from 32.35 to 51.31 per cent. Kamiloglu and Capanoglu, (2015) investigated the sun drying effect on anthocyanin content of *Ficus carica.* Samples were collected from Aydin and dried in the sunlight for 8 days at temperature 31 to 34 °C. In result, drying process helped to decrease the anthocyanin content. Sieminska *et al.* (2015) studied the content of phenol and antioxidant activity of wild "Yellow Wonder" strawberry fruits *(Fragaria vesca L.).* Sample was air dried at temperature 40°C till constant weight achieved. They analyzed the content of phenol and antioxidant activity, DPPH (diphenylpicrylhydrazine) in fresh and air died sample. Result revealed that after drying the phenolic content was increased from 1.64 to 4.483 mg/100gm and antioxidant content (DPPH) was also increased from 13.63 to 25.70 per cent.

2.4 (b) Microwave drying

Drying method played very important role for food preservation and to increase the shelf life of the product (Papu *et al.* 2014). Ariffin *et al*. (2000) studied the effect of heat treatment on cellulose content of oil palm empty fruit bunch fiber. Sample was selected from Selangor and dried by using thermal treatment. First sample was dried at temperature 121°C for 15 minutes and another sample was heated at temperature 240°C for 1 hours and 15 minutes. Result reported that heating temperature was responsible to increase the cellulose content. It showed that cellulose content was 51.49 per cent at heating temperature 121°C and increased 54.67 per cent with heating temperature 240°C. Pragati et *al*. (2003) evaluated the heat treatment on nutritional composition of aonla fruit *(Emblica officinalis Garten)* during storage. Fruit samples (riped) were dried by using different methods viz., direct solar and oven drying. Result showed that the level of tannin content was found to be lower in solar drying method (13.60 %) as compared to oven drying method (14.60 %) due to leaching process. Jeong *et al*. (2004) studied the phenolic content and antioxidant activity of citrus peels extract under heat treatment. 5 gm weighed sample was taken in a Pyrex petri dishes and heated at different increased heating temperature in

a pre heated muffle furnace. Result indicated that the antioxidant activities were increased with increased heating temperature. In case of selected sample total phenolic content was also increased from 84.4 to 204.9 mg/100gm and reducing power from 0.27 to 0.96 mg/100gm at temperature 150 °C for 60 min. Study mentioned that heating proved to be a major tool to increase the antioxidant activity. Laleh *et al.* (2006) studied the temperature effect on anthocyanin stability in *Berberis.* Sample was dried in a vacuum evaporator at different heating temperatures. Result reported that anthocyanin content degradation was increased with increased heating temperature. Anthocyanin content loss was observed 41.05 per cent at 5°C temperature, 52.09 per cent at 15°C temperature, 62.33 per cent at 25°C temperature and 89.42 per cent at temperature 35°C. Clary *et al.* (2007) determined the improving grape quality by using microwave vacuum drying. In this study, fresh seedless grapes were dried at temperature 66°C in the microwave. Result showed that microwave dried grapes contained higher nutritional composition. Pacco *et al.* (2007) studied the drying treatment influence on kinetics of 'Gigante de Valinhos' figs. Fig sample was selected from Brazil and dried at temperature 60 °C in an oven for 24 to 48 hours. Result showed that moisture content was decreased from 1.9 to 0.03 per cent with increased temperature and decreased relative humidity. Drying process was caused to increase the apparent density (1.025 to 1.186 gm/ml). Result showed that drying temperature proved effective for the maintance of quality products. Mori *et al*. (2007) studied the loss of anthocyanins in *Vitis vinifera* L. cv. *Cabernet Sauvignon* red- wine grape berries under high temperature. Sample was dried at (15°C, 25°C and 35 °C) temp. in an oven. Result revealed the concentration of anthocyanin (3-glucoside,3-acetylglucoside and3-p-coumaroylglucoside) content was decreased at higher temperature. Anthocyanin content was degraded more at temperature 35 °C as compared to 15°C and 25°C temperature. Data suggested that higher heating temperature was proved effective for the degradation of anthocyanin content due to the inhibition of mRNA transcription of the anthocyanin biosynthetic genes. Elhana (2008) determined microwave drying of apple. In this study, sample was dried in an oven at temperature 100 W and 200W to observe product drying time. Result showed that at 55 per cent of water was removed from the sample at temperature 100W. At 200W, drying constantly increased with the increased microwave output power. Study concluded that 35 per cent drying rate increase with relative increased of density power (W/g). Wojdylo *et al*. (2009) evaluated the influence of

microwaves heat (480 W) on strawberry fruits bioactive compounds. Whole fresh and dried fruits were determined for phenolics (anthocyanins, flavanols and flavonols). Result revealed that heating process affect the ellagic acid, caused degradation of the flavanols and anthocyanins content. Simonyan *et al.* (2009) studied the influence of water content on physical parameters of *Lablab purpureus* (L.) sweet seeds. Sample was oven dried at 130 ^{o}C temperature for 24 hours. They measured the density of the sweet seeds. Result showed that the bulk density was decreased with the improvement of the moisture content. Somsong *et al*. (2010) estimated the influence of preconditioning on dried blueberries. Selected mature fruits were dried at high temperature 70ºC and 90 ºC in a cabinet dryer. Result revealed that the anthocyanin content was decreased by heating process as compared to non heating process i.e. 14.5 mg/100gm-fresh (non heating), 4.9 mg/100gm- dried (at 70ºC) and 6.2 mg/100gm (at 90 ºC) heating temperature. Khanal *et al.* (2010) evaluated the effect of heating on grapes and blueberry pomace fruit anthocyanin content stability. These selected samples were heated in an oven. Result showed reduction in anthocyanin content. In result, total anthocyanin loss was highest at temperature of 105°C, 120°C as compared to temperature 40°C and 60°C. Musto and Satriano, (2010) studied the characteristics of heat- treated strawberry (*Fragaria xananassa*) cv. '*Candonga*' fruits. Selected sample was oven dried at temperature 45°C for 0 hour and 4 hours to analyzed the phenolic content and anthocyanin content. Result revealed that after heat treatment phenolic content was increased from (1.968 to 2.576) mg gallic acid equivalent/100 gm and anthocyanin content was decreased from (0.201 to 0.170) mg of pelargonidin-3-glucoside/ 100gm at temperature 45°C for 0 hour and 4 hours of heating treatment . Akhijahani and Khodaei, (2011) studied some physical properties of strawberry fruit (Kurdistan variety). Sample was selected from a local market in Iran (June, 2010). Fruit sample was oven dried at 75°C temperature for 24 hours. In this study, they determined the physical properties as a function of moisture content. Result revealed that length of the selected fruit was 18.22 mm, 19.54 mm and width was 11.01mm, 13.62 mm at moisture content 24.85 per cent and 66.33 per cent. Study concluded that physical properties (length and width) were improved as the moisture content was increased. Borchani *et al.* (2011) studied the influence of heat treatment on physical and chemical properties of date "Alligh" fiber concentrates. Sample was selected from Tunisia and dried by using sun dried and oven dried method for 48 hours at temperature 40 °C. In this study,

they analyzed the total dietary fiber. Result revealed that drying method contained significantly higher dietary fiber. Cheng (2011) studied the influence of heating treatment on citrus fruit peel phenolic content. They investigated the effects of different drying temperatures in an oven to analyzed the phenolic content and antioxidative activities. Result revealed that at lower temperature (50, 60) °C phenolic content was decreased and at higher temperature (70, 80, 90) °C and 100°C the phenolic content was increased. Jin *et al*. (2011) studied the influence of cultural and temperature on strawberries phenolic compounds and antioxidant activity. In this study, sample was selected from a United States Department of Agriculture (USDA), which was certified organic farm and stored at different temperature in a plastic trays in conventional cultural system. Result revealed that strawberry stored at higher temperature 10°C, had higher antioxidant activity and phenolic content as compared to less storage temperature 0°C and 5°C. Sunmola *et al*. (2011) analyzed the biochemical influence of processing treatment on under-utilized *Carissa papaya* seed. These seeds were dried in oven at temperature 50°C for 48 hours. Result revealed that mature riped fruit seed was contained 1.46 mg/100gm-tannin content and 0.18 mg/100gm- protein content. After processing the tannin content was found to be decreased (1.31 mg/100gm) and protein content was increased (0.41 mg/100gm). Nithiyanantham *et al*. (2012) investigated the differential effects of processing methods on antioxidant activity of species Solanum. Selected samples were dried at temperature 40°C. Result reported that raw fruit was contained 5.3 gm/100gm- tannin content and 7.2 mmol Fe(II) /micromol extract-FRAP (antioxidant activity). After drying tannin content (4.5 gm/100gm) was decreased and antioxidant activity was (28.9 2 mmol Fe (II) /micromol extract, ferric reducing scavenging activity) was increased. Johnson *et al.* (2012) studied the evaluation of anti-nutrient contents of watermelon *Citrullus lanatus.* In this study fresh sample was oven dried at temperature 50°C to measure the phenolic content and flavonoid content. Result revealed that drying process led to increase the phenolic content and decreased the flavonoid content. Sultana *et al*. (2012) analyzed the influence of drying techniques on phenolic content of fruits and their antioxidant activity. Fresh apricot was dried at ambient temperature 30°C for 7 days and oven dried at temperature 80°C for 2 days. Result revealed that after drying the phenolic content and DPPH scavenging capacity was increased from 0.59 to 0.72 gallic acid equivalent gm /100g and 58.7 to 60.8 per cent. Avil *et al*. (2012) studied the effect of different time duration of heat processing on

"Murtanr" berries fruit. Sample was selected from a local market of Poland and lyophilized for 48 hours and dried in an oven at temperature 100°C for different period of time as 10 minutes and 60 minutes. They analyzed the bioactive compounds (flavonoids, tannins and anthocyanins) of berries. Result showed that heat treatment affect the bioactive compounds i.e. flavonoid content was 11.47 mg catechin equivalent/gm and 5.99 47 mg catechin equivalent/gm, tannin content was 8.91 catechin equivalent/gm and 4.94 catechin equivalent/gm, anthocyanin content was 16.7 cyanidin-3-glucoside equivalent/gm and 9.9 cyanidin-3-glucoside equivalent/gm at heating period 10 minutes and 60 minutes. Liu *et al.* (2012) investigated the influence of heating time on citrus fruit (*Citrus sinensis* (L.) by products phenolic content. Sample was selected from Taiwan and orange extract was prepared with heating process. Samples were oven dried at temperature 50 ºC. After 40 hours, the dried by-products were heated again at temperature 100 ºC for (0, 30, 90 and 180) minutes and converted into a fine powder. Phenolic content was (21.65, 24.16, 26.59 and 27.99) mg gallic acid equivalents/100gm at (0, 30, 90 and 180) minutes heating time. Result reported that phenolic content was increased with increased heating temperature. Sharifian *et al.* (2012) reported the effects of microwave heat intensity and pulsing ratio on *Ficus carica* fruit drying process. Weighed sample at regular intervals of ten seconds. Result showed that at pulsing ratio of 1.5 W/g to 4 W/g the drying time of products 200 per cent was increased. And, at pulsing ratio 0.5 W/g to 2.5 W/g the drying time of product 500 per cent was decreased. Study concluded that microwave heat intensity resulted in the raised temperature was responsible for the better removal of moisture content. Wich *et al*. (2012) studied the effect of drying on *Carissa spinarum.* The sample was oven dried at different temperatures in an oven to reach the final moisture content (not more than 5 per cent). Selected fruits were dried at optimum condition, 60°C for 200 minutes. Result revealed that dried *Carissa spinarum* contained highest antioxidant properties and total phenolic content. Lopez *et al.* (2013) estimated the heating effect on phenols and antioxidant activity of goldenberry (*Physalis peruviana* L.). Sample was purchased from Chile and dried at temperature 90 ºC in a convective dryer to analyzed the phenols and antioxidant activity (FRAP). Result showed that heating process increased the phenolic content from 321.05 to 356.68 mg gallic acid/100 gm and antioxidant activity (FRAP) from 99.70 to 109.81 milimoles of Trolox equvivalents/100gm. Irondi *et al*. (2013) evaluated the influence of heat treatment on *Carica papaya* seed

phytochemical composition and antioxidant activities. Fresh sample was collected from Nigeria, June (2012). Sample was dried by two methods. First it was dried for 3 days under direct exposure of sunlight and second was oven dried. Result predicted that oven dried sample led highest phenolic content and antioxidant activity (FRAP) as compared to sun dried sample. Sarkis *et al*. (2013) studied the effects of electric heating on anthocyanin content degradation during the processing of blueberry pulp. Sample was purchased from Italbraz Company (Brazil) and dried by using the selected heating treatment at temperature 60 Hz. The anthocyanin content was studied by using high performance liquid chromatography. Result reported that degradation of anthocyanin content was noticed higher with increased voltage and also showed reduction with decreased voltage. Study, concluded that heating treatment was helped to decrease the anthocyanin content. Kamiloglu *et al.* (2013) estimated the polyphenol composition of black mulberry (*Morus nigra L.).* Sample was selected from a local market in Turkey and converted into fine powder for storage at temperature −80°C. They measured the flavonoid content and anthocyanins content by using Spectrophotometric method. Result showed that after drying flavonoid content and anthocyanin content was decreased from 768.0 to 380 mg catechin equivalent /100gm and 1221.0 to 61.3 mg cyanidin-3-O-glucoside equivalent /100 gm. Candrawinata *et al*. (2014) studied apple pomace fruit for its total phenolic content and antioxidant activity. Apple pomace was selected from a local commercial juice manufacturer (Australia). It was homogenized at temperature (20-90) °C for 5 - 60 minutes. Result revealed that the phenolic content and antioxidant activity was increased with increased heating temperature. Bernard *et al*. (2014) mentioned the influence of heating treatment on phytochemical composition of orange fruit peel. The fruit sample was sun dried at temperature 16.5°C and oven at temperature 50°C. Result reported that orange fruit peel sun dried sample was contained 0.72mg/100gm- tannin content and oven dried sample was contained (0.91 mg/100gm). Alkaloid content of sun dried sample - 0.81 mg/100gm and oven dried sample- 0.99 mg/100gm. Study concluded that tannin and alkaloid content was increased in oven dried sample as compared to sun dried sample. Alfaro *et al*. (2014) evaluated the effects of heating techniques on polyphenol and antioxidant activity of Murtilla (*Ugni molinae* Turcz) fruit. Sample was selected from an Agricultural Research Institute (INIA-Carillanca) and dried by using convective dryer at temperature 65 ºC. Result revealed that after drying the total polyphenolic content and

antioxidant (DPPH) activity was increased from 0.51 to 2.16 mg/100gm and 2111.1 to 3567.41µmol Trolox equivalent /100 g. Anthocyanin content was decreased from 0.106 to 0.012mg cyanidine-3-glucoside equivalent per 100 gram. Ertekin *et al*. (2014) studied the drying of strawberries. Fruit sample was selected from Turkey and oven dried at temperature 60°C, 70°C by infrared radiation (radiator). They evaluated the total phenolic content at different drying temperature. Result revealed that highest amount of total phenolic content of fruit sample were obtained at different drying temperature i.e. 4.44 mg gallic acid equivalent /100 gm – fresh, 11.03mg gallic acid equivalent /100 gm - at 60°C , and 13.96 mg gallic acid equivalent /100 gm - at 70°C temperature. Oancea *et al*. (2014) determined the effect of frozen storage and oven drying on the total anthocyanin content and antioxidant capacity of raspberries. Selected sample was freezed at temperature – 18 °C, oven dried at temperature 60°C. Result revealed that frozen sample was proved to be effective to maintained good anthocyanin content. In case of anthocyanin content, after drying it was decreased as compared to dried. Oven dried sample was also showed better retension of antioxidant activity. Lutz *et al*. (2015) studied the phenolics and antioxidant capacity of fresh and dry blackberry fruits. Fruits were oven dried at temperature 60°C in an oven for 36 hours. Result revealed that moisture content of fresh sample was 841.3 g/100 kg and after dehydration it was decreased 2.1g/100 kg. Drying process was increased the phenol content (22.1mg gallic acid equivalent/100gm –fresh and 126.3 mg gallic acid equivalent/100gm - dried). In case of antioxidant activity (DPPH) was 295.8 µ mol Trolox equivalent/100gm -fresh and after dehydration it was found to be increased by 1203.8 µ mol Trolox equivalent/100gm. In result, dehydrated food proved to be good as functional foods. Adiletta *et al*. (2015) studied the effect of abrasive pretreatment on hot dried goji berry. Fresh fruit sample was selected from Spa farm in Italy and oven dried at temperature 60 °C for 21 hours. In this study, they evaluated the antioxidant DPPH activity. They showed that after drying antioxidant activity was increased. In result, drying method proved to be very effective for the preservation of nutrients. Rabeta and Lin, (2015) studied the influence of different drying techniques on the antioxidant activities of berries fruit. In this study, sample was selected from Malaysia. Sample was oven dried at temperature 30°C for 2 to 3 days. Result revealed that drying method was increased the antioxidant DPPH activity and phenolic content in selected sample i.e. FRAP value 47.1 µmol Fe II/gm- fresh, 537.0 µmol Fe II/gm - dried, DPPH value

42.22 per cent-fresh, 89.64 per cent- dried, phenolic content was 2.9 gallic acid equivalent /100gm-fresh and 24.7 gallic acid equivalent /100gm - dried. Arslan (2015) evaluated the effects of degradation preventive agents on anthocyanins stability in sour cherry fruit. Sample was stored in a room at temperature 24°C (room temperature), oven dried at temperature 45 °C and refrigerated at temperature 4°C. They analyzed the anthocyanin content (cyanidin-3-glucosylrutinoside) in fruits. Result revealed that anthocyanin content was 77.0 mg/l at temperature 24°C, 63.0 mg/l at temperature 45 °C and 80 mg/l at 4°C (refrigerator). Study, concluded that heating process led anthocyanin content degradation. Zaidel *et al*. (2015) studied the anthocyanin stability of red dragon fruit (*Hylocereus polyrhizus*) by using microwave-assisted technique. Sample was dried in a microwave at different temperature 60°C and 80°C with different drying time 2 minutes and 3 minutes. Result showed that higher temperature was proved more effective for the degradation of anthocyanin content as compared to lower temperature. Anantawat (2015) determined the effect of spray drying on antioxidant activity of gac fruit aril powder. Fully riped fruit was dried in a spray dryer at temperature 120°C, 150°C and 170°C. Result revealed that antioxidant activity was increased with increased temperature, that was (2758.33, 2797.50 and 2808.33)µg Trolox equivalent/100 gm at temperature 120°C, 150°C and 170°C . Sharma and Gupta, (2013) determined the antioxidant activity and polyphenols of *Carissa spinarum* (non- edible parts). Sample was dried by microwave at temperature 300 W for 2 minutes. Antioxidant activity was evaluated by using Ferric reducing activity power (FRAP) assays. Results showed that Carissa *spinarum* contained highest antioxidant activity and polyphenols compounds. Nakilcioglu and Hisil, (2013) studied the research on the flavonoid compounds in Sarilop (*Ficus carica L.)* Fig variety. In this study, fruit sample was selected from Turkey, oven dried at temperature 65℃ in an oven till constant weight. Result revealed that fresh sample was contained 82.69 per cent- moisture content and 147.51 mg/ rutin equivalent/100gm – total flavonoid content. After drying these parameters were decreased i.e. 16.73 per cent- moisture content and 52.23 mg/ rutin equivalent /100gm – total flavonoid content. In result, flavonoid content was decreased after drying as compared to fresh. Reyes *et al.* (2013) investigated the inactivation (polyphenol oxidase) in loquat (*Eriobotrya Japonica)* fruit by microwave heat and its phenolic profile. Fresh and dried sample was selected for the study. Result showed that phenolic content was increased after drying as compared to fresh ones. Study

concluded that drying process proved very effective for the enhancement of phenolic content as compared to fresh sample. Garcia *et al.* (2013) studied the effect of heating temperature 45°C and 55°C (in a convective hair dryer) on functional properties figs (*Ficus carica* L., var. Mission). Result showed that after drying the total phenolic content was increased, 2.62 mg/100gm, 3.13 mg/100gm at temperature 45°C, 55°C. In case of anthocyanin content it was decreased, 1.20 mg/100gm and 1.12 mg/100gm at temperature 45°C and 55°C. Safy (2014) studied the density, phenolic content of loquat slices by using dehydration method. Riped fresh loquat (*Eriobotrya japonica*) fruit samples were obtained from local market in Egypt (May, 2012) and oven dried at temperature 80 °C and 90 °C for 50 minutes. Result revealed that density was increased from 0.846 to 0.861 gm/cm^3 and phenolic content was also increased from 312.66 to 320.31 mg/10gm was increased with the rising heating system from 80 to 90 °C. Ayadi *et al.* (2014) analyzed the influence of microwave and solar drying methods on physicochemical properties of kiwifruit. In this study sample was sun dried and microwave dried. They studied the effect of different drying methods on moisture content and total phenolic contents. Result showed that sun dried and microwave dried sample was contained less moisture content and higher phenolic content as compared to fresh. Duan *et al.* (2015) studied the microwave-assisted extraction of anthocyanin content (Cyanidin-3-O-glucose) of Chinese bayberry. Mature fruit sample was collected from China (June, 2013). Sample was heated in a microwave at temperature (800 W). They studied antioxidant activity and anthocyanin content. Result revealed that microwave heat was increased the antioxidant activity from 63.43 to 64.60 per cent at temperature 40°C and 80 °C for 15 minutes. And, anthocyanin content was decreased from 97.00 to 48.00 mg/100gm at temperature 40°C and 80 °C for 15 minutes. Mechlouch *et al.* (2015) evaluated the changes in the physico-chemical properties of palm date of 'Alligh' cultivar at different drying methods. Sample was dried by using different method i.e. sun drying, solar drying and microwave drying at different temperature 90 °C. Result revealed that after drying the polyphenol content was increased, 244.42 mg/100g - open air sun drying, 140.48 mg/100g - direct sun drying, 540.48 mg/100g - microwave drying and 77.37 mg/100g - fresh sample. In result, microwave heating was responsible to increase the antioxidant activity as compared to other methods. Udomkun *et al.* (2015) investigated the drying effect on sorption behavoiur of papayas fruit Sample was selected from Thailand and dried by convective dryer at

temperature 70°C. Result showed that fresh fruit sample was contained 7.74 kg/kg - moisture content, 0.968 gm/cm^3 - apparent density and 1.038 gm/cm^{3-} solid density. Result showed after drying moisture content was decreased 0.15 kg/kg, apparent density and solid density was found to be increased by 1.124 gm/cm^3 and 1.425 gm/$cm^{3.}$

2.4 (c) Freezing

Freezing is a process which help to reduce the temperature of food and help to increase its storage ability. The reports of different studies have shown the influence of freezing on nutritional and phytochemical composition of fruits. Ramaswamy and Tung, (1981) studied the thermophysical properties of apples in relation to freezing. Sample (Golden and Granny Smith apples) were selected for the study and stored at temperature (1-2) °C. In this study, the density was studied under freezing conditions. Result revealed that in unfrozen state, the density of the Golden apple and Granny apple was 8.45 kg/m^3 and 7.88 kg/m^3 but it was decreased, 829 kg/m^3 and 7.86 kg/m^3 respectively after freezing. Ancos *et al.* (2000) estimated the influence of frozen storage temperature on ellagic acid, total phenolic contents and radical scavenging capacity of raspberry fruit. In this study, the four raspberries from different cultivars were selected and quantified by using high performance liquid chromatography. Fresh, frozen and stored fruits were evaluated at temperature -20 °C for the duration of one year. Result showed that the frozen storage process slightly affect the ellagic acid and total phenolic content. Result showed that 12 months frozen sample (ellagic acid) found to be decreased from 14 per cent -21 per cent. Mullen *et al.* (2002) evaluated the effect of frozen storage red raspberries on phenolic, ellagitannins, flavonoids and antioxidant capacity. Result showed it was contained total flavonols content for fresh- 1.0 nmol/g , frozen- 0.8 nmol/g. Total anthocyanin content in fresh sample was 156 cyanidin-3-glucoside equivalents/100gm and 1049 cyanidin-3-glucoside equivalents /100 gm was in frozen sample. In case of fresh sample total phenolic content was 3383 nmole/gallic equivalent and frozen sample was contained 3321 nmole/gallic equivalent. In result, freezing process proved effective to improve the flavonols and anthocyanin content and caused degradation in phenolic content. Zavala *et al.* (2004) studied the influence of storage temperature on anthocyanin content and aroma compounds in strawberry fruit. Fruit sample was selected from Butler,s Orchards (USA) and stored at different temperature in a cold room. Result

revealed that sample which was stored at higher frozen temperature showed higher anthocyanin content as compared lower frozen storage temperature. Lohachoompol *et al*. (2004) estimated drying and freezing effect on anthocyanins and their antioxidant effect of blueberries. Fresh sample was stored for two weeks at temperature 5°C and frozen sample was stored at 0°C for three months and in another treatment fruit was dried in a cabinet dryer. Result revealed that total anthocyanin content was 7.2 mg/100gm- fresh, 5.7 mg/100gm - fresh (2 weeks storage), 4.3 mg/100gm- dried and 7.9 mg/100gm –frozen (1 month storage), 7.9 mg/100gm - frozen (3 months storage). Study, concluded that drying process was helped to decrease and freezing caused improvement in the anthocyanin content. Skupien (2006) studied the chemical composition of fresh and frozen stored blueberry fruit *(Vaccinium corymbosu L.).*In this study samples were stored for 6 months at temperature -25°C. They analyzed the phenolic content. Result revealed that after frozen storage, phenolic content was decreased from 258.8 to 236.4 mg/100gm. Rickman *et al*. (2007) evaluated the phenolic compounds difference in fresh and frozen stored fruits. These samples were stored at temperature -20°C for one year. Result revealed that frozen product lose fewer nutrients. In case of raspberry and blackberries, freezing caused reduction in the phenolic compounds. It contained phenolic compounds was 0.576 gm gallic acid equivalents/kg – fresh and in frozen state it was decreased 0.565 gm gallic acid equivalents/kg. In case of blackberries phenolic content was 9.777 gm gallic acid equivalents/kg (fresh) and 9.036 gm gallic acid equivalents/kg (frozen) sample. The findings indicated that frozen fruits were contained less phenolic content as compared to fresh. Scibisz *et al. (*2007) studied the influence of long-term frozen storage on antioxidant activity of blueberries (*Vaccinium corymbosum L*.). Selected samples were stored for six months at frozen temperature -18°C for the determination of anthocyanin content and phenolic content. Result revealed that sample contained phenolic content was 427.8 mg/100gm- fresh, 427.0 mg/100gm- freezing (at temperature -18°C). Anthocyanin content was 137.6 mg/100gm - fresh, 140.6 mg/100gm - freezing (at -18°C). Study, concluded freezing process caused reduction in the phenolic content and increased the anthocyanin content. Wetwitayaklung et *al*. (2008) studied fresh and preserved fruits of *Ellaeocarpus hygrophilus Kurz*. for their phenolic content and antioxidant activity. Sample was selected from a local market in Nakhon- Pathom province. The fruits were stored at frozen temperature -4°C for 6 months. Result revealed that after freezing the phenolic content

was decreased and antioxidant activity was also low. Poiana *et al*. (2010) examined the effect of freezing method on antioxidant activity of fruits. They selected strawberry as a sample and refrigerated at temperature 5 °C (for 12 hours) and stored for ten months at temperature -18°C. Result revealed that after freezing phenolic content was decreased, 109.212 mg gallic acid equivalent/100gm as compared to fresh 177.43 mg gallic acid equivalent /100gm. Antioxidant activity of fresh sample was 24.37 mM F^{e2}+/kg, after freezing it was decreased (14.22 mM F^{e2}+/kg). Study, concluded that after freezing phenolic content was decreased upto 28 per cent to 47 per cent and caused small losses in the antioxidant activity was recorded. Zheng and Fujan, (2010) studied the fresh *Ficus carica* by treating it with different methods of cold-shock treatment at temperature 0 ℃ for 1.5 hours. Result showed that the effect of the treatment with cold shock at 0 ℃ for 1.5 hours was significantly better to save fruit quality. Study concluded that the fresh keeping effect of cold shock treatment for 1.5 hours was the best, easy and simple way to handle the fruits and not influenced the quality of the *Ficus carica*. Mohammadian *et al*. (2011) determined the bioactive compounds and antioxidant capacities of two citrus cultivars *Citrus sinensis* 'Siavaraz' and *Citrus limon* 'Lisbon'. Fresh sample was collected from Iran and stored at different temperature i.e. (15, 3, 0, -3 and -6) ºC for ten hours to analyze the total flavonoids content and antioxidant capacity. Result reported that freezing temperature was increased the flavonoids content and decreased the antioxidant capacity for both the cultivars. Leong *et al*. (2012) studied the effects of processing on anthocyanins in summer fruits. In this study, they evaluated the effect of freezing at temperature -20°C. Cherries were selected as a sample from Otago region. Result revealed that after processing it was contained anthocyanin content i.e. 207.00 mg/100gm- fresh and 570.08 mg/100gm- freezed. In conclusion, freezing enhanced the release of membrane bound anthocyanins, resulted processing was increased the anthocyanin content as compared to fresh sample. Jan and Rab, (2012) examined the effect of storage period on physical and chemical differences changes in apple fruit. Mature apple was selected as a sample and stored in a cold room for 0, 30, 60, 90, 120 and 150 days. In this study physico-chemical changes were observed in 30 days intervals. Result showed that fruit density was decreased with increased storage period, it was (0.82g/cm^3- at 0 days storage, 0.81 g/cm^3- 30 days storage,0.80 g/cm^3 - 60 days storage, 0.78 g/cm^3 - 90 days storage,0.78 g/cm^3 – 120 days storage, 0.05 g/cm^3 - 150 days storage). Chaparzadesh and Yavari, (2013) evaluated the

antioxidant activity of Golden delicious apple under frozen storage conditions. Sample was selected from orchards in Iran and stored at temperature 1°C for 45 days, 90 days and 135 days in a cold house. Result revealed that during cold storage the content of phenol and antioxidant activity diphenylpicrylhydrazine radical (DPPH) was decreased as storage time increased. Sikora *et al.* (2013) examined chemical composition of fresh and frozen storage blackthorn fruits (*Prunus Spinosa L.).* Fresh sample was collected from a mountain village, in South and frozen at temperature of -18°C. In this study, fresh blackthorn fruit was contained 0.8 gm/100gm- protein content, 0.37 gm/100gm- fat content, 396.19 mg/100gm- anthocyanin content. After freezing it was contained, 0.34 gm/100gm- protein content, 0.33 gm/100gm-fat content, 415.04 mg/100gm-anthocyanin content. In result, due to frozen storage the protein content, fat content was decreased and anthocyanin content was increased.

3. OBJECTIVES OF THE STUDY

1. To evaluate proximate, nutritional, physical and phytochemical composition of fresh fig and Karonda fruits.
2. To assess the influence of processing methods viz. sun drying, microwave drying and freezing on physicochemical, nutritional and phytochemical composition of selected fruits.
3. To evaluate the effect of fruit extract of *Ficus carica* and *Carissa spinarum* on blood glucose level of normoglycemic and diabetic wistar rats
4. To develop various value added products from the selected fruits and analyze their nutritional composition during 6 months of storage.

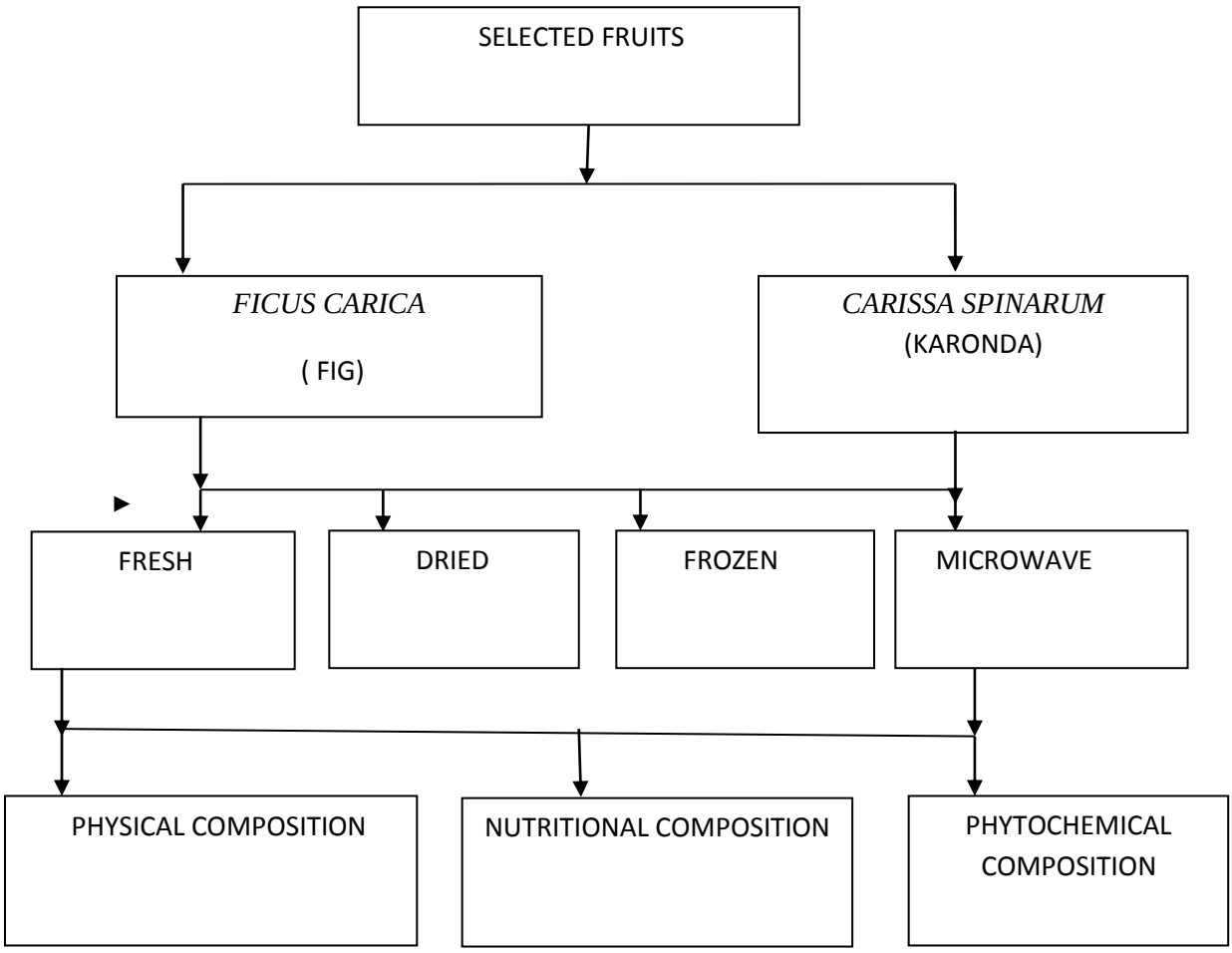

Fig. 4. 1 Flow chart for processing methods

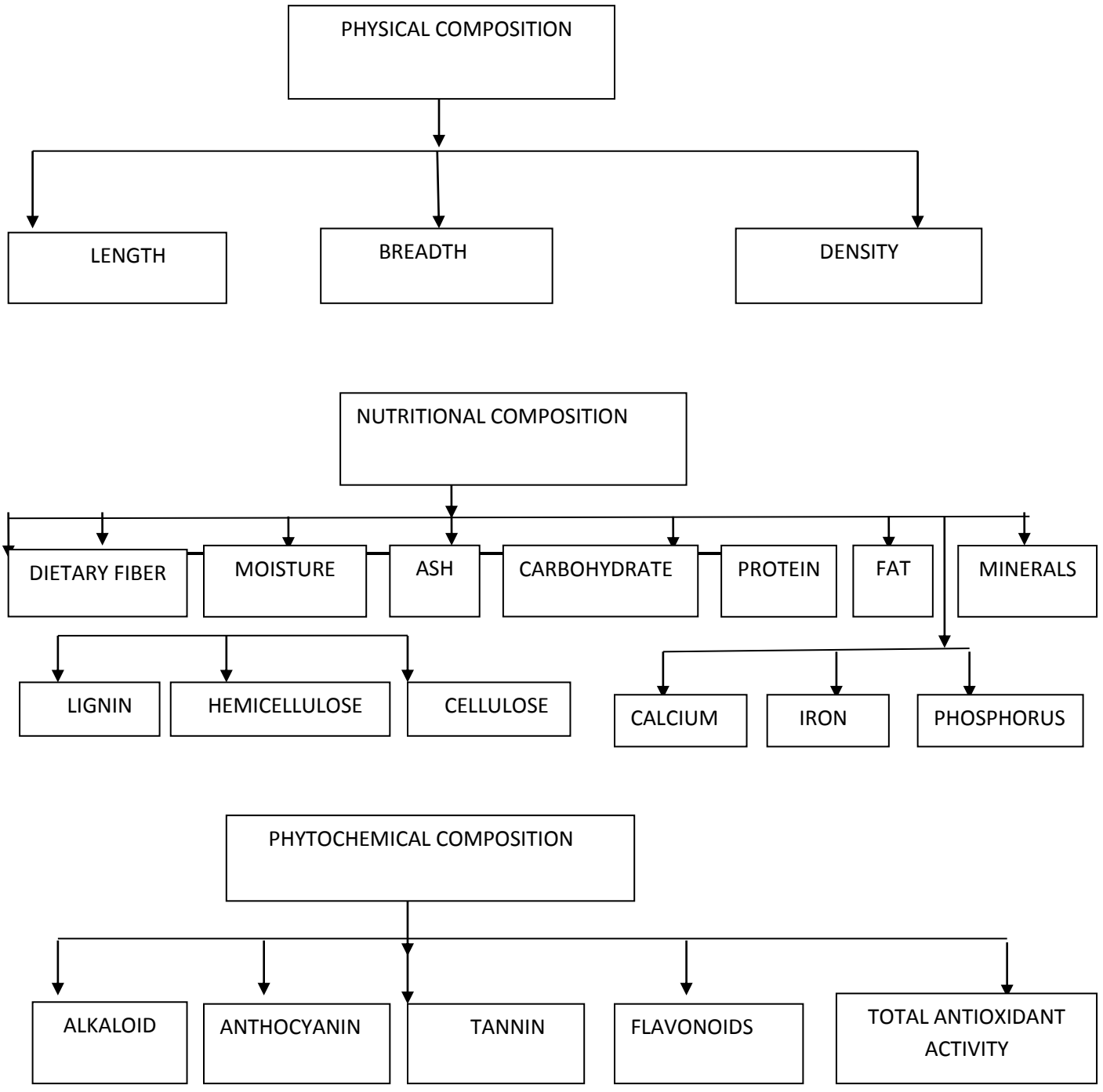

Fig. 4. 1 Flow chart for processing methods

4. RESEARCH METHODOLOGY

The present study was carried out in the Department of Food Technology and Nutrition, School of Agriculture and Food Technology, Lovely Professional University, Phagwara, Punjab. The research methodology and procedures to achieve the set objectives have been described under the following subheads:

4.1 Sample selection

4.2 Sample preparation

4.2 (a) Drying techniques

4.2 (b) Sorting

4.2 (c) Washing

4.2.(d) Sun drying

4.2 (e) Freezing

4.2 (f) Microwave drying

4.3 Physical composition

4.3 (a) Length and width

4.3 (b) Density

4.4 Nutritional composition

4.4 (a) Moisture content

4.4 (b) Ash content

4.4 (c) Carbohydrate content

4.4 (d) Fat content

4.4 (e) Protein content

4.4 (f) Dietary fiber

4.4 (g) Hemicellulose

4.4 (h) Neutral detergent fiber

4.4 (i) Acid detergent fiber

4.4 (j) Cellulose content

4.4 (k) Lignin content

4.5 Extraction preparation

4.5 (a) Total phenolic content

4.5 (b) Total flavonoid content

4.6 Antioxidant activity

4.6 (a) DPPH assay

4.6 (b) FRAP assay

4.7 Tannin content

4.8 Alkaloid content

4.9 Anthocyanin content

4.10 Mineral composition

4.11 Experimental design

4.11 (a) Experimental animals

4.11 (b) Preparation of extracts

4.11 (c) Method for acute toxicity test

4.11 (d) Preparation of interventions

4.11 (e) Animals and induction of diabetes mellitus

4.11 (f) Multiple dose of hypoglycemic study

4.11 (g) Experimental plan

4.12 Value added product development

4.12 (a) Procurement for raw materials

4.12 (b) Fruit powder preparation

4.12 (c) Experimental plan

4.12 (d) Organoleptic evaluation

4.13 Statistical analysis

4.1 Sample selection

Ripened whole fresh *Ficus carica* and *Carissa spinarum* were collected from orchard of a local cultivar from Bilaspur, Himachal Pradesh, (India) during 2014 - 2015.

4.2 Sample Preparation

4.2 (a) Sorting

Fresh, non insected fruits were selected for the study purpose. Discolored fruits were removed before washing.

4.2 (b) Washing

Selected fruits were washed by using distilled water and cleaned properly to remove dust particles. These fruits were dried properly and weighed accurately to and divide into four equal slots. First slot was for fresh (without any treatment), second slot (sun dried), third slot (freezing) and fourth slot was (microwave dried).

4.1 (c) Drying methods

Fruits were exposed to the methods given below:

4.2 (d) Sun drying

Fruits were distributed separately, on the stainless steel trays and dried under direct sunlight for 5 days between 15 July to 20 July, 2015 and stored in cellophane bag for further use.

4.2 (e) Frozen storage

In frozen, the selected whole fresh fruits were packed in polyethylene bags, sealed and safely collected in a freezer at -20°C for 20 days.

4.2 (f) Microwave drying

Selected fresh fruits were placed in a Pyrex petri dish in a single layer and heated for 3 minutes and 15 seconds by using microwave (Sharp R-248e; 800W). Dried fruits were cooled normal temperature. After that again weight was taken to measured the weight loss. After the treatment of different processing methods, selected fruits were used for further analysis.

4.3 Physical composition

4.3 (a) Length and Width

Ten fruits were randomly selected for the measurement of length by using a vernier calliper with 0.01 mm reading accuracy (Mohsenin,1970).

4.3 (b) Density

Randomly ten fruits were selected for mass and measured accurately by using an accurate (0.01) electrical balance (Balasubramanian, 2001). For the measurement of density fruit was weighed and toluene was used to dropped them. The density was calculated by using displacement method. Toluene was used to measure the density of fruits instead of water (Mohsenin, 1986; Gezer *et al.* 2002). Bulk density was calculated with a definite volume beaker. The fruits were poured from 15 cm height into a beaker and excess fruits were discarded. Weighed when it was filled. The bulk density explained as the ratio mass and total volume of the sample (Aydin, 2002).

4.4 Nutritional composition

4.4 (a) Moisture content (AOAC, 2010)

Procedure The moisture content was determined by using oven dried method. 3 gram fruit sample was weighed and taken in a pre heated petri dish. Dried petri dish was kept in oven at temperature 45°C for 3 hrs. It was taken out from pre heated oven then kept in a dessicator for 30 minutes to cool and attained constant weight. Samples were weighed again with petri dish after cooling. Weight loss was represented the moisture content.

Calculation

weight (g) of fruit sample before drying (W1)

weight (g) of fruit sample after drying (W2)

$$\text{Moisture}(\%) = \frac{(W1 - W2)}{W1} X\ 100$$

4.4 (b) Ash content (AOAC, 2010)

Total 3 gm fruit sample was weighed and put in previously pre dried silica crucible. Placed the crucible with lid in the furnance at heating temperature at 550 °C overnight to burn off all

impurities, which were presented on the surface of crucible. After that ashed sample were taken out from the muffle furnance and cooled in a dessicator for 2 hrs. Cooled samples were weighed again and calculated the per cent of ash content given below.

Calculation

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of fruit sample}} X\ 100$$

4.4 (c) Carbohydrate (Hedge and Hofreiter, 1962)

Reagents

5ml of 2 N HCL

Anthrone reagent: Dissolved 200 mg anthrone in 100 ml of ice-cold 95% H_2SO_4.

Standard glucose: Stock- Dissolved 100 mg in 100 ml water.

Working standard: 10 ml of stock diluted to 100 ml with distilled water. Added few drops of toluene and stored in a refrigerator.

Procedure

Take a boiling tube and weighed 100 mg fruit sample in it. Tubes were boiled for three hours in a boiling water bath with 5 ml of 2.5 N HCl. Wait for some time to cooled them at normal temperature. Neutralized it by using sodium carbonate powder until the froth ceases. Made up the volume to 100 ml and centrifuged these tubes. Supernatant was easily collected and taken 0.5, 1 ml aliquots and used it for further analysis. Prepared standards by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of standard solution '0' serves as blank. Made up the volume to 1 ml with distilled water. Anthrone reagent (4 ml) was added and heat them in a boiling water bath for eight minutes. Absorbance was taken at 630 nm. Drawn a standard graph on the X-axis versus absorbance on the Y-axis. From the graph calculated the total carbohydrate present in the sample tube.

Calculation $x = \frac{\text{mg of glucose}}{\text{vol.of fruit sample}}\ X\ 100$

4.4 (d) Fat (AOAC, 2010)

Reagent

Petroleum ether – 250 ml

Procedure

Soxhlet extraction method was used for the fat determination. Bottle was placed with the lid in the incubator at temperature 105 °C overnight. Weighed about 3gm of fruit sample into wraped paper filter. Fruit sample was wrapped in a extraction thimble and transferd into a soxhlet. Filled 250 ml of petroleum ether into the bolltle and fixed it with heating mantle. Connected the soxhlet apparatus and turned on the water to cool them and heated the sample for 14hrs by switched on the heating mantle. Evaporated solvent by using the vacum condenser. Bottle was dried completely at temperature 80°C - 90 °C to evaporate the solvent. Cooled it in a dessicator, after drying. Dried content was weighed with the bottle.

Calculation

$$\text{Fat (\%)} = \frac{\text{Weight of fat}}{\text{weight of fruit sample}} X\ 100$$

4.4 (e) Protein (AOAC, 2010)

Reagents

Kjedahl catalyst- Mixed 1 part of coppersulphate and 9 part of potassium sulphate

Conc.sulphuric acid – 200 ml

NaOH - 40%

HCl - 0.2 N

H_3BO_3 - 4%

Indicator solution- Mixed 200 ml of 0.2 % bromocresol green (in 95% ethanol) in 100 ml of 0.1% methyl red (in 95% ethanol)

Procedure

1gm weight sample was taken in a digestion flask. Then added 200ml of conc. sulphuric acid and 5gm Kjedhal catalyst in it. Prepared a tube which contained heated above mentioned chemical except sample as blank. Inclined position was used for the flask to heat it gently unit frothing ceases. Boiled contineously till solution was cleared. Then, 60 ml of distilled water was added in it and cooled it. Flask was connected immediately to the digestion bulb on condenser

and condenser tip was immersed in the standard acid. Mixed few indicator drops in a receiver. Flask was shaked to mix all contents properly untill, NH_3 was distilled. Removed receiver and washed the tip of condenser. Titratration was done by using the excess standard acid distilled with standard NaOH solution.

Calculation

$$\text{Protein (\%)} = \frac{(\text{A}-\text{B})XNX1.400\ 7X6.25}{\text{W}}$$

Where, A= Vol. (ml) of 0.2 N HCl used sample titration

B = Vol. (ml) of 0.2 N HCl used blank titration

N= Normality of HCl

W= Weight (g) of sample

14.007= Atomic weight of nitrogen

4.4 (f) Dietary fiber content (Van and Robertson, 1977)

4.4 (g) Hemicellulose = NDF-ADF

4.4 (h) Neutral detergent fiber (NDF)

Reagents

Neutral detergent solution
Sodium borate decahydrate -6.81g
Disodium ethylene diamine neutral -18.61 g
Sodium lauryl sulfate neutral – 30g
2- ethoxyethanol – 10 ml
Disodium phosphate anhydrous – 4.5g

Procedure

Dried sample was grinded well to pass through 1 mm screen. Weighed 1 gm of grinded sample in a crucible. Mixed solution of neutral detergent 100 ml into 0.5 gm of sodium sulfite in a crucible at normal temperature. Mixed few drops of n-octanol. After heat treatment refluxed it for 60 minutes from onset of boiling. Filtered properly, boiling water used to wash it three times. After that again wash it with cold acetone. Then, dried for 8 hours at heating

temperature 105 °C. Then kept in a dessicator to cool and weighed. Made ash in a muffle at temperature 550 °C for 2 hours. Cooled it in a dessicator and weighed.

Calculation

$$\text{NDF}\ (\%) = \frac{(\text{weight of crucible} + \text{weight of residue}) - \text{weight of crucible}}{\text{weight of sample}} \text{X}100$$

4.4 (i) Acid detergent fiber (ADF) (AOAC, 1975)

Reagents

Acid detergent solution- 75 ml

Buffer solution (P^H 1.5-2.0): 0.2M HCl -260 ml

0.2 M KCL - 1000ml

Hexadecyltrimethylammonium bromide-20gm dissolved in 1 liter of buffer solution.

Procedure

Dried sample was fine grinded and passed through 1mm screen. Weighed 1 gm of grinded sample. Added 75 ml of acid detergent solution into a Berzelius beaker and heated the sample on a hot plate for 5 minutes. Covered gently with the condenser and refluxed for 1 hour. Beaker was removed for refluxing apparatus and vacuum-filtered hot solution through tared gooch crucible by using 50-60ml hot water with 30 ml acetone. Vacuum has been used to dry fiber by sucking. Then crucible and fibre was dried overnight at temperature 110°C in oven. Percentage of fiber was calculated at dry basis.

Calculations

$$\text{ADF}\ \% = \frac{(\text{weight of crucible} + \text{weight of residue}) - \text{weight of crucible}}{\text{weight of sample}}\ \text{X}100$$

Cellulose= Neutral detergent fiber – Acid detergent fiber

4.4 (j) Cellulose content (Updegroff, 1969)

Reagents

Nitric reagent - Mixed 150 ml (80% acetic acid) and 15 ml (conc. nitric acid)

Anthrone reagent- Dissolved 200 mg anthrone in 100 ml conc. sulphuric acid.

Prepared fresh and chilled for 2 hours before use.

Sulphuric acid- 67%

Procedure

Taken a test tube with 1gm weighed sample. Added 3 ml of nitric acid and mixed in a vortex mixer. After that test tube was heated in a hot water-bath at temperature 100°C for half an hour. Cooled them and centrifuged for 20 minutes and supernatant was removed. Washed residue with distilled water. Mixed 10 ml (67% sulphuric acid) and allowed to stand for 1 hour. After that 1 ml of above solution was taken and diluted it to 100 ml. Then, 1 ml from that dilute solution was also taken and further added 10 ml of anthrone reagent in it. Boiling water bath was used to heat the tubes for ten minutes. Cooled and absorbance was taken at 630 nm. Anthrone reagent and distilled water was used as a blank. Weighed 100 mg cellulose and proceeded was taken in a test tube and all above mentioned steps for standard. Instead of just taken 1 ml of the diluted solution mentioned above taken a series of volumes and colour developed.

Calculation

Drawn the standard graph and cellulose sample was calculated.

4.4 (k) Lignin content (Burke *et al.* 2000)

Reagents

Acid detergent solution-75 ml

Buffer solution (P^H 1.5-2.0): 0.2M HCl -260 ml

0.2 M KCL - 1000ml

Hexadecyltrimethylammonium bromide-20gm dissolved in 1 liter of buffer solution.

Procedure

Dried sample was grinded fine to pass through 1mm screen. Weighed 1 gm of grinded sample . Berzelius beaker was used for the mixing of acid detergent solution and heated the sample on a hot plate for 5 minutes. Beaker was covered with the condenser and refluxed gently for 1 hours. Beaker was removed for refluxing apparatus and through tared gooch crucible was used to vacuum filter with 50-60ml hot water and with 30 ml acetone. Fiber has been sucked dried by using the vacuum. After that crucible and fiber was dried overnight at temperature 110°C in oven. Mixed 1.5 ml of 12 M H_2SO4 to all tubes contained residue fiber and digested at temperature 30°C for 30 minutes. After digestion the acid – insoluble residue was collected by using whatman filter paper with Buckner funnel (45mm) by filteration. Then, washed with water and two times with acetone and sample was dried at temperature 100 °C overnight. Weighed the filter and residue. Made ash at heating temperature 450°C for 6 hours. Weighed again after ashing . Lignin content was determined by the difference in the weight of the residue before and after ashing.

4.5 Extraction preparation

Methanol was used for the extraction of solvent. Taken a conical flask (covered it with aluminum foil) and filled it with 1 gm of weighed sample with 80 per cent methanol. After that agitated it in a orbital shaker at 50°C with 200rpm for two hours (Heidolph Unimax 1010, Schwabach, Germany). Mixture was filtered through a whatman filter paper No.4. Cleared solution was taken for the analysis (Emmy *et al.* 2009).

4.5 (a) Total phenolic content (Thimmaiah, 1999)

Reagents

Fruit powder juice (extract) -0.5 ml

Distilled water- 2.5 ml

Folin- Ciocalteu reagent- 0.5 ml

Sodium carbonate- 2ml

Conc. tannic acid -1000 µg/ml

Procedure

Folin –Ciocalteu (F- C) reagent was used to determine the phenolic content. Mixed 0.5 ml fruit extract in a beaker contained 2.5 ml of distilled water. Added 0.5 ml of Folin -Ciocalteau reagent (1:1) in it and incubated for 3 minutes. After that 2 ml (20% sodium carbonate) was mixed to each tube and kept for 1 minute in a hot boiling water bath. Wait to cool the tubes and taken absorbance at 650 nm. Tannic acid was used as standard. Graph was plotted by using different concentration of standard and absorbance therefore concentration of unknown was intercepted from graph.

4.5 (b) Total flavonoid content (Olajire and Azeez, 2011)

Reagents

Sample extracted - 1ml

Distilled water- 4 ml

Aluminum chloride – 0.3 ml of 10 %

Sodium nitrite- 0.3 ml of 5 %

Sodium hydroxide- 2ml of 1 M

Procedure

Total 1ml of extract solution was mixed in 4 ml (distilled water) and 0.3ml (5% sodium nitrite). Left it for 5 minutes and then mixed with 0.3ml 10% aluminum chloride in all mixture. Added 2ml of 1M NaOH in it after 6 minutes and volume make up to 10 ml with distilled water. After that absorbance was taken at 510 nm. Quercetin was used as a standard and graph was plotted against different concentration of standard and absorbance therefore concentration of unknown was intercepts from graph.

4.6 Antioxidant activity

4.6 (a) DPPH assay (Blois , 1958)

Reagents

DPPH solution- 50 µg/ml

Methanol- 50 µg/ml

Procedure

Antioxidant activity was determined by DPPH radical scavenging method. Extract was taken 50 μg/ml by pipette into DPPH solution conc. 50 μg/ml (1:1) for the initiation of reaction. Incubated it after 30 minutes and taken absorbance at 516 nm. DPPH solution 50 μg/ml was for standard and methanol was used for blank. The experiment was replicated with three independent assay.

Calculation

$$\text{Scavenging activity (\%)} = \frac{(Ac - As)}{Ac} X100$$

Where, Ac = Absorbance of the control

As=Absorbance of the sample

4.6 (b) Antioxidant activity

FRAP assay (Oyaizu,1986)

Reagents

Phosphate buffer- 1 ml

Potassium ferricyanide-1.0 ml

Trichloroacetic acid – 1.0 ml

Ferric chloride- 0.1 ml

Procedure

The antioxidant activity was determined by using (FRAP) ferric reducing assay. In this method 1 ml potassium ferricyanide (1.0 ml, 10 mg/ml) and phosphate buffer (1 ml, 0.2 M, pH 6.6) was mixed together and incubated for 20 minutes at temperature 50 °C. Mixed trichloroacetic acid (1.0 ml,100 mg/ml) with mixture and centrifuged for 5 minutes. Supernatant (1.0 ml) was mixed well by using distilled water (1.0 ml) and ferric chloride (0.1 ml, 1.0 mg/ml). Absorbance was taken at 700 nm.

Calculation

Scavenging activity (%) = $\frac{(A - B)}{A} X100$

4.7 Tannin content (Price *et al*. 1978).

Reagents

Concentrate HCL- 10 ml

Methanol- (1 %)

Vanillin reagent- (0.5% , 5 ml)

Catechin – 1 mg/ml

Procedure

Weighed 200 mg sample was taken in a test tubes. And extraction was done by using 10 ml (1% concentrated HCl) in methanol for 20 minutes. Mixed vanillin reagent (0.5%, 5 ml) to 1 ml extract and left it for 20 minutes at temperature 30°C. Then, taken absorbance at 500nm and result was expressed in catechin equivalents i.e. catechin (mg/100gm) which has been given a colour intensity equivalent to tannins after corrected the blank. Calculation of tannin content was done and results were expressed in mg/ 100 gm.

4.8 Alkaloid content (Herborne, 1973)

Reagents

Acetic acid – 100ml of 10 %

Ethanol – 100 ml

Conc. ammonium hydroxide- drop wise

Procedure

Weighed 5 gm of sample and kept into a 250 ml of beaker. Mixed 100 ml (10% acetic acid and ethanol). Beaker was covered tightly and left it for 4 hours. Filtered it properly and

concentrated it up to one-fourth of its original volume by using a boiling water bath. Concentrated ammonium hydroxide mixed dropwise in this extract till precipitation was completed. After settled down the whole solution, the precipitate was collected. Washed it with diluted ammonium hydroxide. Alkaloid was contained from the left residue after filteration. Dried it properly and weighed.

4.9 Anthocyanin content (Giusti and Wrolstad, 2001)

Reagents

Sample- 1ml

Potassium chloride-5ml

Sodium acetate-5 ml

Procedure

Anthocyanin quantification was done by using P^H- differential method. Taken extract was diluted in a solution of (1.0 M HCL,25 Mm KCL) P^H 1.0 and in a solution (0.4 M CH_3COONa) P^H 4.5. Absorbance was taken against distilled water at 510 nm and 700 nm.

Calculation

Diluted sample absorbance (A) as follows:

$A = (A_{510} – A_{700})$ pH 1.0 – $(A_{510} – A_{700})$ pH 4.5

Monomeric anthocyanin pigment (mg/L) = $x = \frac{(AXMWXDFX1000)}{\varepsilon X1}$

Where,

The molecular weight(MW)

The dilution factor (DF)

The molar absorptivity(ε)

Cyanidin-3-glucoside (pigment content) where MW = 449.2 and ε= 26,900

4.10 Mineral composition (AYUSH, 2008)

Calcium, Iron and Phosphorus

Reagents

Nitric acid- 10 ml

Procedure

Weighed 0.5 gm of coarse fruit sample in a casparian flask and mixed with 10 ml nitric acid. Covered it properly and left for overnight. After that, heated on a electric hot plate till the solution become cleared and transparent . Heat continuously till the solution became light yellow colour and white smoke dispersed. The solution was cooled and then transferred into 50 ml volumetric flask and diluted with the same solvent to the volume and mixed it properly. Prepared reagent blank solution with explained method. The mineral content was carried out from the cleared solution by Inductively coupled plasma- optical emission spectrometry (ICP-OES).

4.11 Experimental Design

4.11 (a) Experimental animals

Healthy male albino rats were 200gm -250gm body weight were mainly used for the study purpose. The rats were acclimatized in the animal house environment for seven days before starting the research work. The study was approved by Animals Ethics Committee in University (Regd. No. 954/PO/AC/06/CPCSEA).

4.11 (b) Preparation of extracts

Microwave dried fruits were selected for the study and converted into fine powder. Petroleum ether was used to remove fat from the powder material. Methanol and water mixture of 1:1 was used for the 72 hours extraction. Filtered extract was concentrated by rotary evaporator and vacuum dessicator was used to keep it. The calculated yield for the extract of *Ficus carica*

extract was 29 per cent and *Carissa spinarum* was 31.6 per cent and with respect to dried powder (Rout *et al.*2013).

4.11 (c) Method for acute toxicity test

Male rats (wistar albino) were fasted overnight and separated into two groups (n=3). Two groups were orally fed with the extract of *Ficus carica* and *Carissa spinarum* separately, in increasing dose of 1000 mg, 2500 mg and 5000 mg according to body weight of rats. And rats were observed continuously for 2 days for change noticed in their behaviour, neurologically, any toxicity sign and mortality. If any, so they were again observed for the next 7 days for any changes in their behavoiur and death. One- tenth and one fifth of the maximum safe dose of the extract were selected for the experiment which was used for acute toxicity (Rout *et al.*2013).

4.11 (d) Preparation of interventions

Selected fruit extract dosage according to body weight of rats i.e. 500 mg. Mixed it with distilled water by using Tween 20 at 25 per cent level. Tween 20 was used as suspending agent. The Metformin dose (50 mg/kg body weight) was also made by same method The sample used for test, solvent and Metformin drug were given orally to rats based on their level of dose according to their body weight (Rout *et al.*2013).

4.11 (e) Animals and induction of diabetes mellitus

Overnight fasted rats were administered (35mg/kg body weight) of single injection of Streptozotocin (STZ) interaperitoneally for the induction of diabetes (Gupta *et al*.2004). STZ solution was prepared by dissolving it into 0.9 per cent of ice cold saline instantly before use. Fasting blood sugar levels were observed (FBG>250 mg/dl)to be diabetic after a week of STZ administration and further used for the experiment (Sachin *et al*.2009).

4.11 (f) Multiple dose hypoglycemic study

Rats were divided into seven groups and each group contained six rats. Every group was either received solvent (2.5 ml), selected fruit extract doses and Metformin 50 mg/kg body weight of everyday 30 minutes before food throughout experimental period. All rats were continuously observed and blood sample was collected on 0,7 14 and 21 days. Blood sample was collected for the measurement of fasting blood sugar level (Ngueguim *et al.* 2007; Kar *et al.* 2006).

4.11 (g) Experimental plan

Seven groups of rats each group contained six rats and conducted a study for 21 days:

Group 1 Rats treated with basal diets (control group)

Group 2- Diabetic control group treated with drug streptozotocin, negative control group (Diabetic+ Streptozotocin)

Group 3- Diabetic rats treated with antidiabetic drugs i.e. metformin and supplemented with basal diet, positive control group (Diabetic + Metformin)

Group 4- Diabetic rats treated with 500 mg extract of *Ficus carica* according to body weight of rats supplemented with basal diet

Group 5- Diabetic rats treated with 500 mg extract of *Carissa spinarum* according to body weight of rats and supplemented with basal diet

Group 6- Normal rats treated with 500 mg extract of *Ficus carica* according to body weight of rats and supplemented with basal diet

Group 7- Normal rats treated with 500 mg extract of *Carissa spinarum* according to body weight of rats and supplemented with basal diet

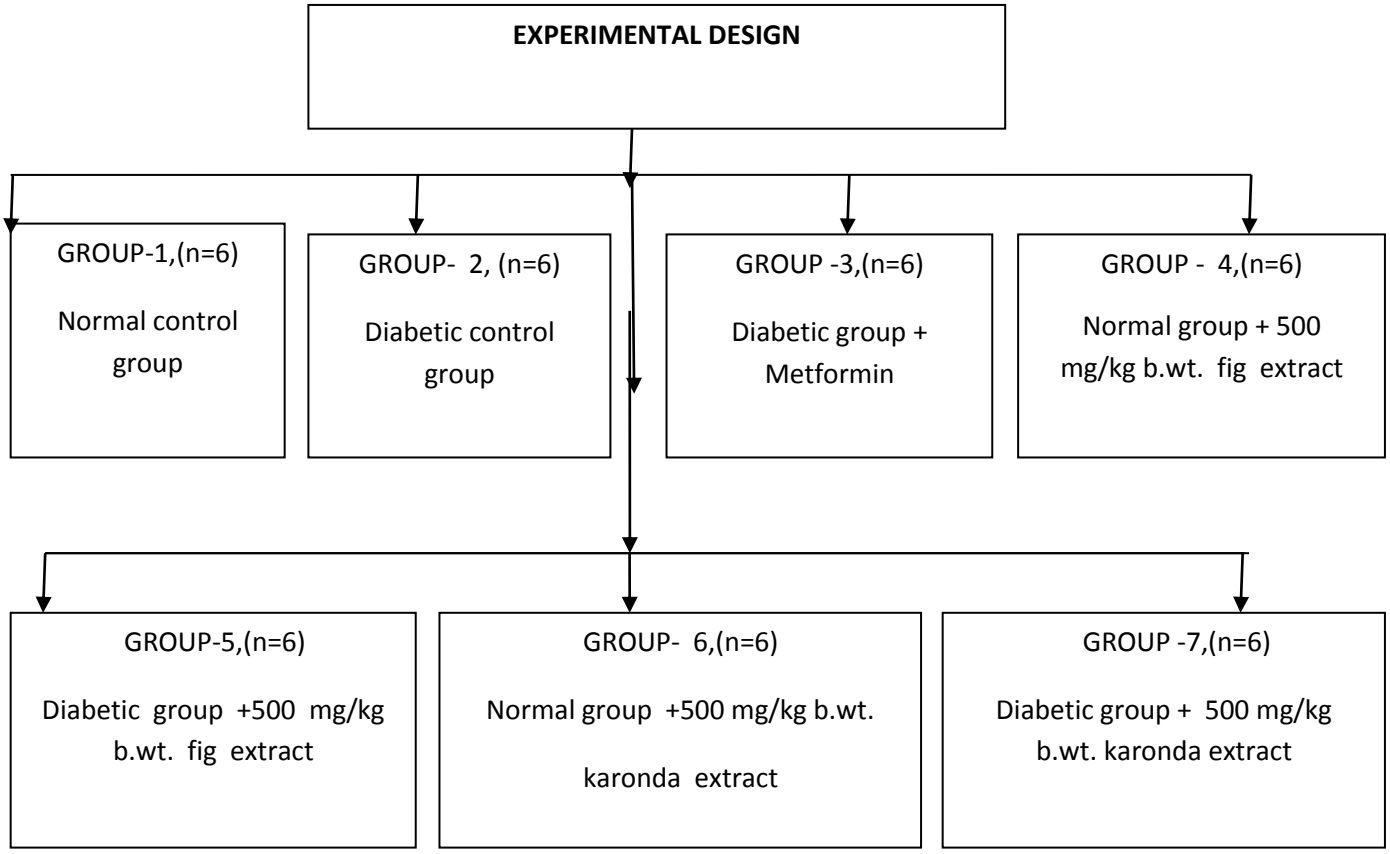

Fig. 4.2 Flow chart for value experimental design

4.12 Value added products development

4.12 (a) Procurement for raw materials

In order to develop (bun ,muffin, noodles and nuggets) value added products, the required materials were purchased from a local market in Jalandhar (wheat flour, R. oil, skimmed milk, honey, baking powder) etc.

4.12 (b) Fruit powder preparation

Fresh fruits were collected and spoiled fruits were removed before washing. Distilled water was used to wash these fruits three times to remove unwanted dirt particles then weighed and divided equally. Selected fruits were dried and distributed separately on the stainless steel trays and microwave dried for 3 minutes and 15 seconds (800W). Dried fruits were grounded fine in a grinding machine and sieved through 1mm sieve. All prepared mixture was stored in airtight container at room temperature and used for further analysis.

4.12 (c) Experiment design

The experimental design for the present research is depicted in **Table 4.1** and **Table 4.1.1** showed the different incorporation of fruits. In **Table 4.1.2** the different ingredients were used in making the buns were given in gm and **Fig 4.1** showed the flowchart for the preparation of buns.

Table 4.1 Experimental plan for bun

S. No.	Parameter	Level	Description
1.	Product	1	Bun
2.	Ingredient	5	Wheat flour, whole fresh fruit, R.oil, yeast powder and salt
3	Samples	8	B1, B2, B3, B4, T1, T2, T3 and T4 (Bun)
4.	Analysis	3	Nutritional analysis, Mineral analysis, sensory analysis

Table 4.2 Treatment description. Different combination of wheat flour, fresh fruit , R.oil, yeast powder and salt were used for the development of bun

Treatment	**Wheat Flour (WF), %**	***Ficus carica* (FC), %**	***Carissa spinarum* (CS), %**
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Where, B1 (Standard) =100% wheat flour bun, B2 = 15% *Carisssa spinarum*, B3= 30% *Carisssa spinarum*, B4= 45% *Carisssa spinarum*), T1= 100 % wheat flour bun , T2 = 15% *Ficus carica*, T3 = 30% *Ficus carica*, T4 = 45% *Ficus carica*

Table 4.3 Ingredients were used in the preparation of bun (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Wheat flour	100	85	70	55	100	85	70	55
2.	Fresh sample	0	15	30	45	0	15	30	45
3.	R.oil	1	1	1	1	1	1	1	1
4.	Yeast powder	2	2	2	2	2	2	2	2
5.	Salt	2	2	2	2	2	2	2	2

Bun Development (Alam *et al.* 2013)

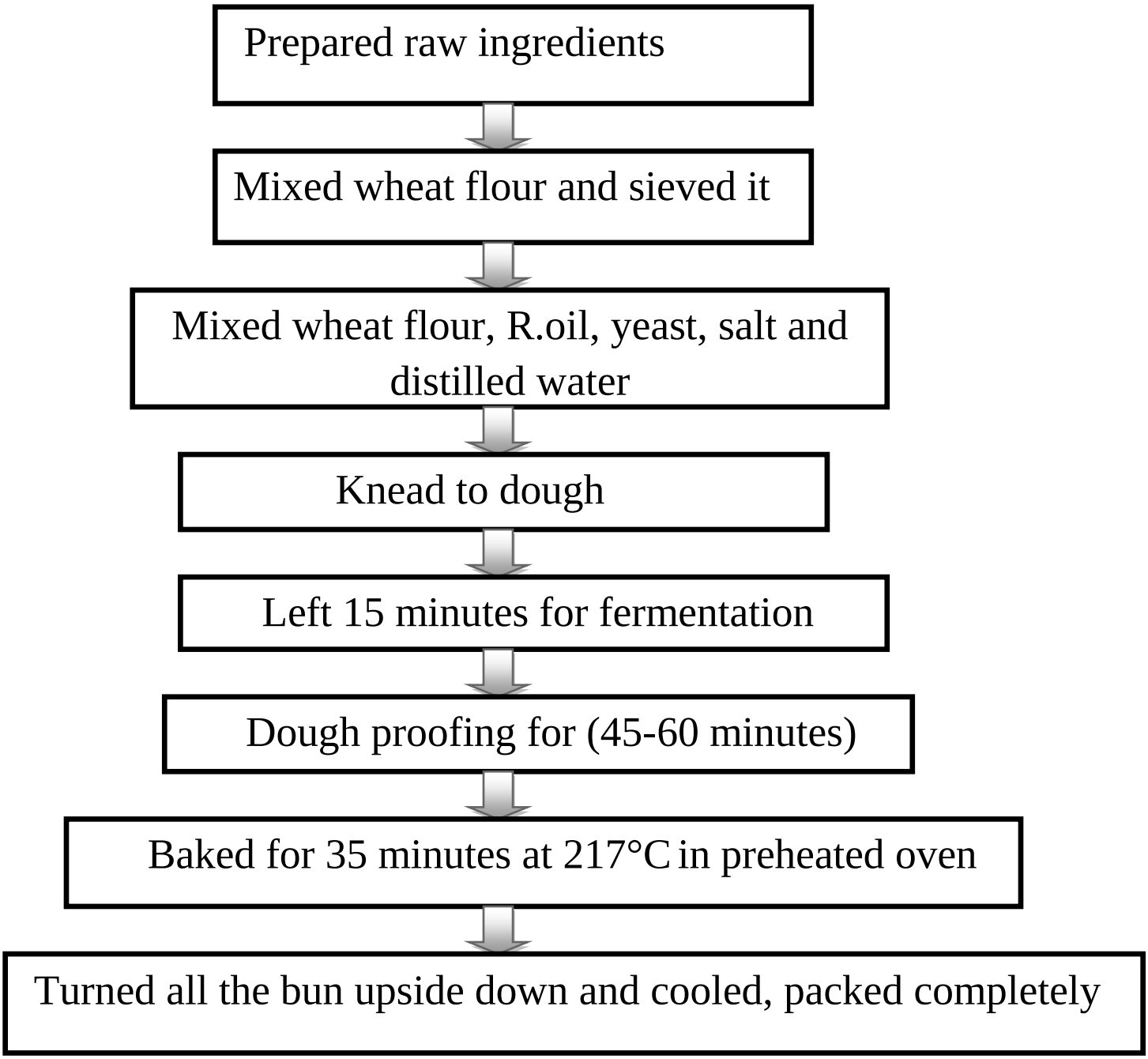

Fig. 4.3 Flow chart for the preparation of bun

Table 4.4 Experimental plan for muffin

S. No.	Parameter	Level	Description
1.	Product	2	Muffin
2.	Ingredient	6	Refined wheat flour, fresh fruit, R.oil, skimmed milk, honey, baking powder
3	Samples	8	B1, B2, B3, B4, T1, T2,T3and T4 (Muffin)
4.	Analysis	3	Nutritional analysis, Mineral analysis, sensory analysis

Table 4.5 Treatment description. Different combination of refined wheat flour, fresh fruit, R.oil, skimmed milk, honey, baking powder were used for the development of muffin

Treatment	**Wheat Flour (WF), %**	***Ficus carica* (FC), %**	***Carissa spinarum*(CS) %**
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Table 4.6 Ingredients were used in the preparation of muffin (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Refined wheat flour	100	85	70	55	100	85	70	55
2.	Sample/fruit powder	0	15	30	45	0	15	30	45
3.	R. oil	15	15	15	15	15	15	15	15
4.	Skimmed milk	25	25	25	25	25	25	25	25
5.	Honey	9	9	9	9	9	9	9	9
6.	Baking powder	1	1	1	1	1	1	1	1

Muffin Development (Uchenna *et al.* 2013)

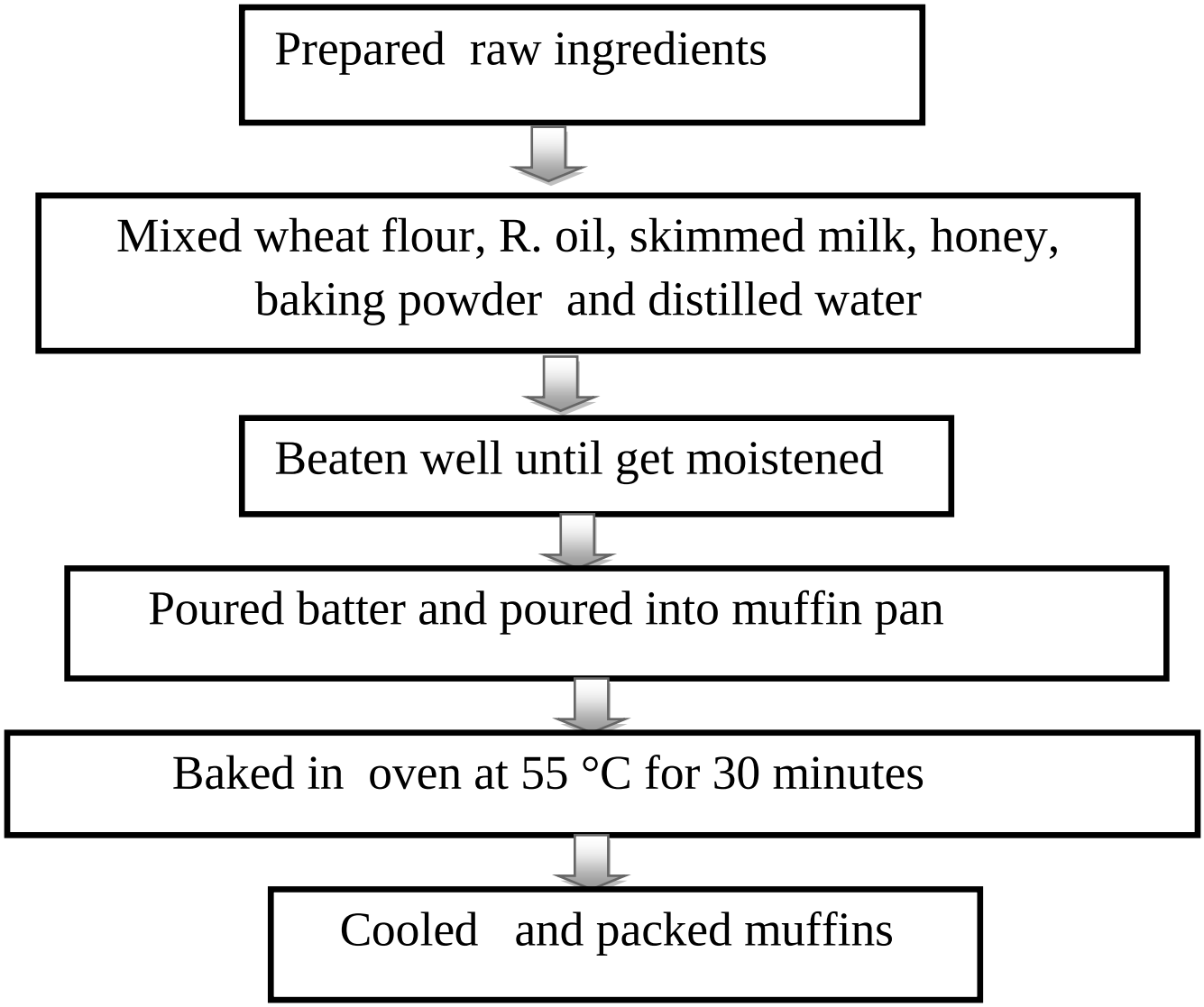

Fig. 4.4 Flow chart for the preparation of muffin

Table 4.7 Experimental plan for noodles

S. No.	Parameter	Level	Description
1.	Product	3	Noodles
2.	Ingredient	2	Wheatflour,fruit powder
3	Samples	8	B1, B2, B3, B4, T1, T2, T3 andT4 (Noodles)
4.	Analysis	2	Nutritional analysis, Mineral analysis

Table 4.8 Treatment description. Different combination of wheat flour, fruit powder was used for the development of noodles

Treatment	Wheat Flour (WF), %	*Ficus carica* (FC), %	*Carissa spinarum* (CS), %
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Table 4.9 Ingredients were used in the preparation of noodles (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Wheat flour	`100	85	70	55	`100	85	70	55
2.	Sample/fruit powder	0	15	30	45	0	15	30	45

Noodles Development (Ibitoye *et al.* 2013)

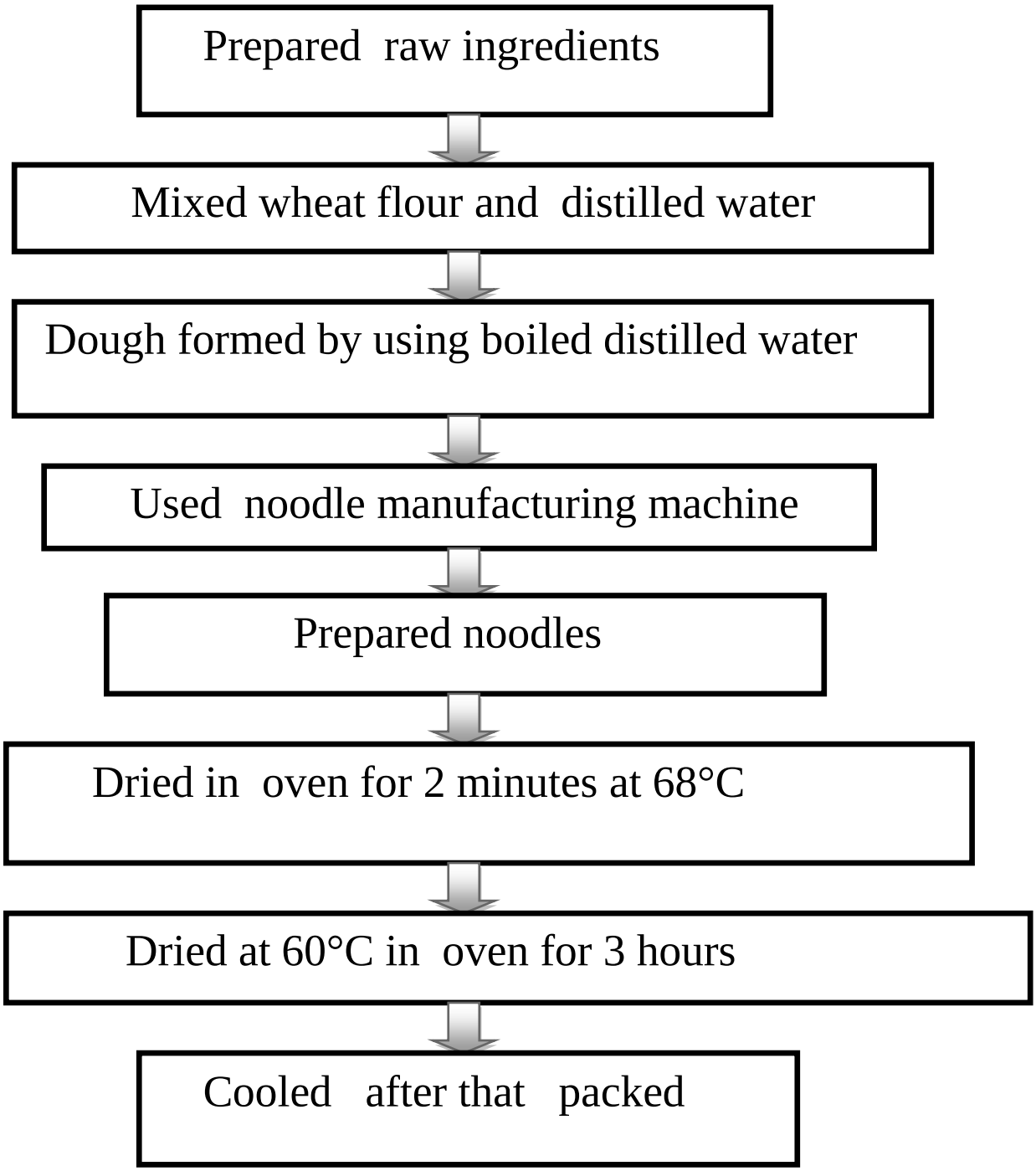

Fig. 4.5 Flow chart for the preparation of noodles

Table 4.10 Experimental plan for nuggets

S. No.	Parameter	Level	Description
1.	Product	4	Nuggets
2.	Ingredient	2	Moong flour, fruit powder
3	Samples	8	B1, B2, B3, B4, T1,T2,T3andT4 (Nuggets)
4.	Analysis	2	Nutritional analysis, Mineral analysis

Table 4.11 Treatment description. Different combination of moong flour, fruit powder was used for development of nuggets

Treatment	**Wheat Flour (WF), %**	***Ficus carica* (FC), %**	***Carissa spinarum* (CS), %**
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Table 4.12 Ingredients used in the preparation of nuggets (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Moong flour	100	85	70	55	100	85	70	55
2.	Sample/fruit powder	0	15	30	45	0	15	30	45

Nugget Development (Pandey *et al.* 2012)

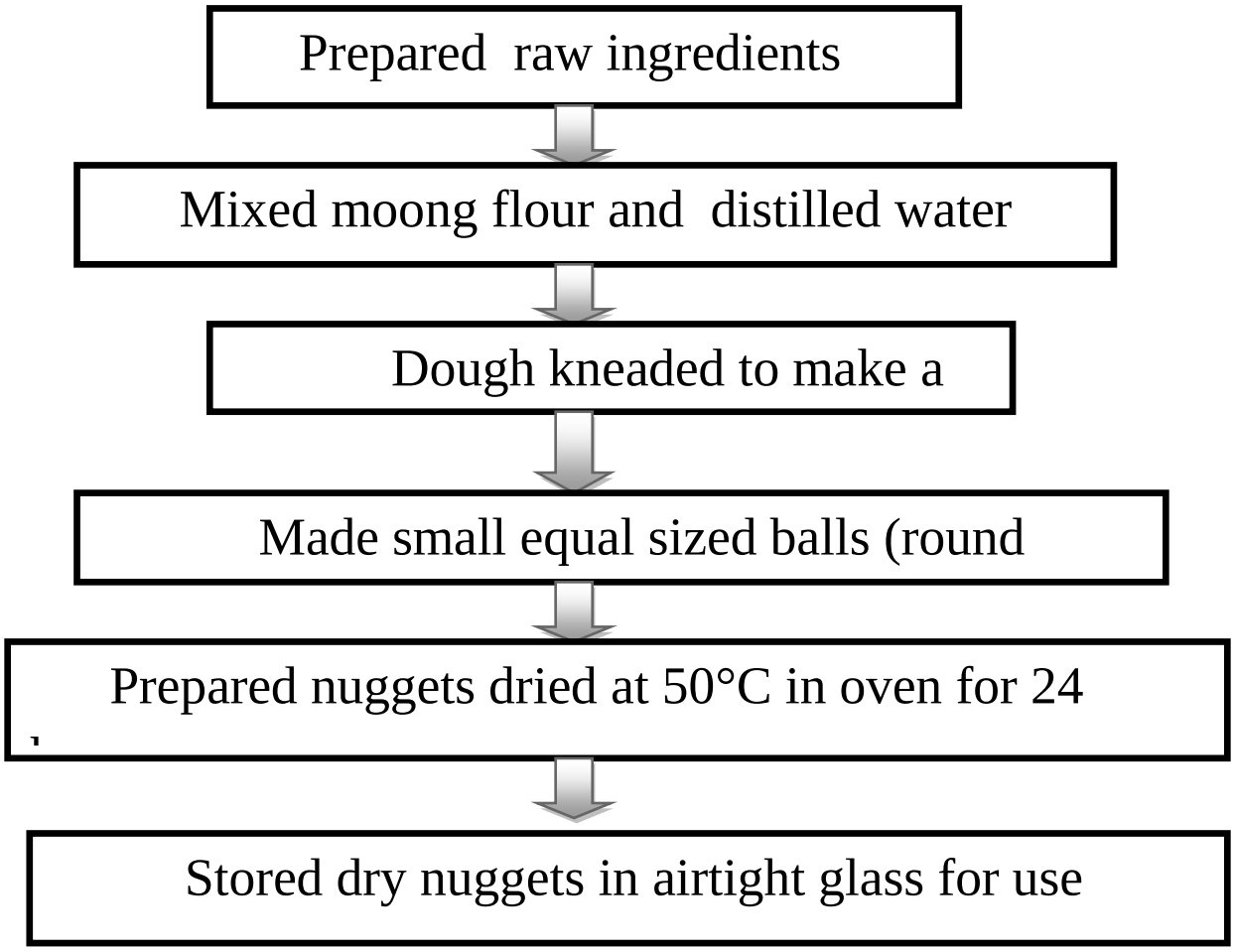

Fig. 4.6 Flow chart for the preparation of nuggets

4.12 (d) Organoleptic evaluation

Bun and muffin samples were evaluated for the appearance, colour, texture, flavor and overall acceptability by using 9 – point hedonic scale (Schutz and Cardello, 2001).

4.13 Statistical analysis

Experiments were performed in triplicates. These results were analyzed by using Graph pad prism 5 software for ANOVA (one-way analysis of variance) with Tukey's test for the determination of significant difference between the mean at 5 per cent level and statistically measured at significant level ($p < 0.05$).

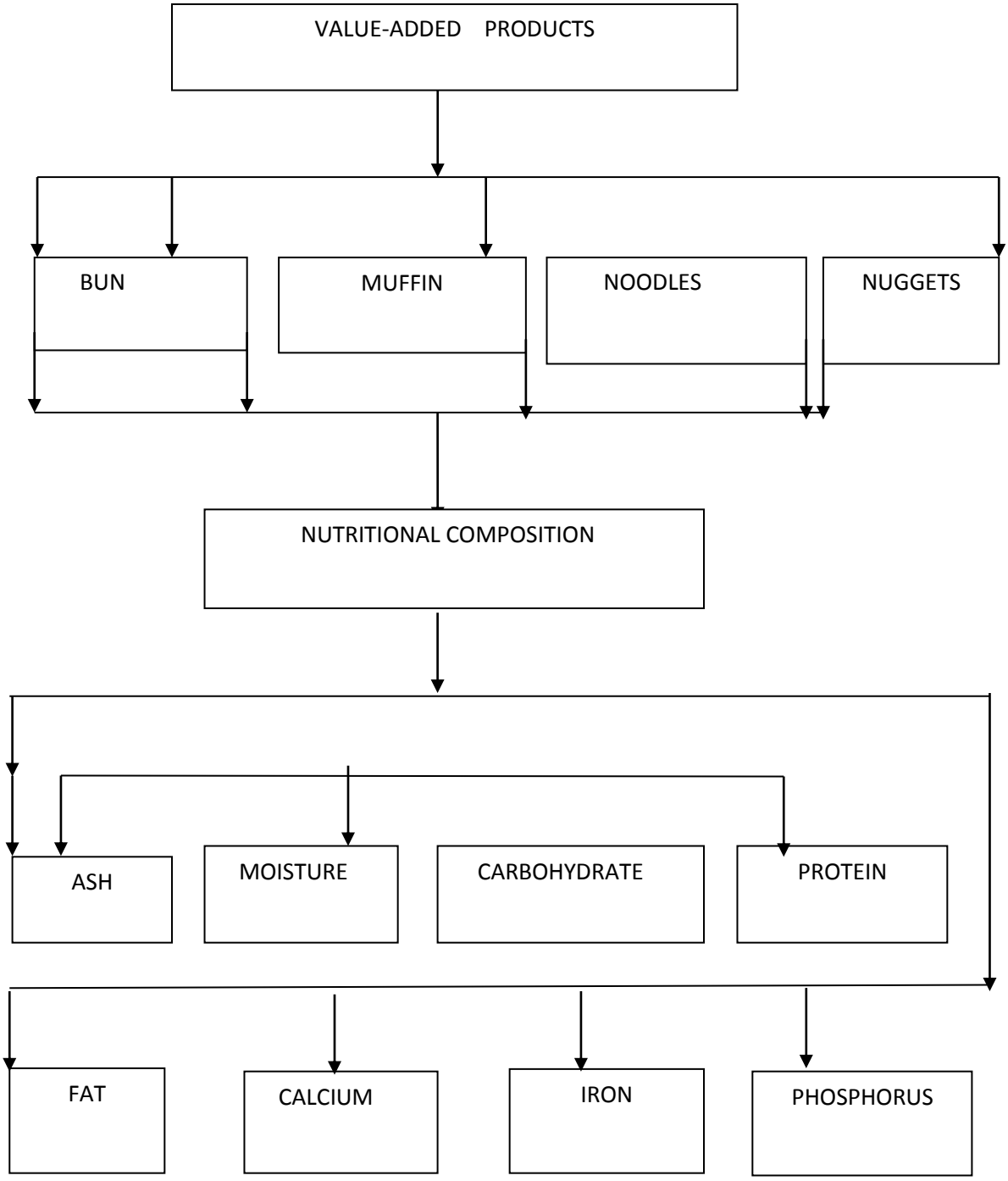

Fig. 4.7 Flow chart for value added products

5. RESULTS AND DISCUSSION

The present study was carried out in the Department of Food Technology and Nutrition, School of Agriculture and Food Technology, Lovely Professional University, Phagwara, Punjab during the year 2012- 2016. The results are discussed in the following subheads:

5.1 Analysis of *Ficus carica* (fig)

5.1 (a) Physical properties of fig

5.1 (b) Nutritional composition of fig

5.1 (c) Dietary composition of fig

5.1 (d) Phytochemical composition of *Ficus carica* (Total phenolic content)

5.1 (e) The total flavonoid content of fig

5.1 (f) Antioxidant activity (DPPH) of fig

5.1 (g) Antioxidant activity (FRAP) of fig

5.1 (h) Anti- nutritional content and anthocyanin content of fig

5.1 (i) Mineral composition of fig

5.2 Analysis of *Carissa spinarum* (Karonda)

5.2 (a) Physical properties of Karonda

5.2 (b) Nutritional composition of Karonda

5.2 (c) Dietary composition of Karonda

5.2 (d) Phytochemical composition of *Carissa spinarum* (Total phenolic content)

5.2 (e) The total flavonoid content of Karonda

5.2 (f) Antioxidant activity (DPPH) of Karonda

5.2 (g) Antioxidant activity (FRAP) of Karonda

5.2 (h) Anti- nutritional content and anthocyanin content of Karonda

5.2 (i) Mineral composition of Karonda

5.3 Experimental design

5.3 (a) Effect of fig (*Ficus carica*) methanolic extract on fasting blood glucose level in diabetic and non diabetic rats

5.3 (b) Effect of fig (*Ficus carica*) methanolic extract on body weight in diabetic and non diabetic rats

5.4 Experimental design

5.4 (a) Effect of Karonda (*Carissa spinarum*) methanolic extract on fasting blood glucose level in diabetic and non diabetic rats

5.4 (b) Effect of Karonda (*Carissa spinarum*) methanolic extract on body weight in diabetic and non diabetic rats

5.5 Formulation of value added product with substitution of fig

5.5 (a) Bun

5.5 (b) Nutritional composition

5.5 (c) Dietary fiber

5.5 (d) Mineral composition

5.5 (e) Organoleptic analysis

5.6 Muffin

5.6 (a) Nutritional composition

5.6 (b) Dietary fiber

5.6 (c) Mineral composition

5.6 (d) Organoleptic analysis

5.7 Noodles

5.7 (a) Nutritional composition

5.7 (b) Dietary fiber

5.7 (c) Mineral composition

5.7 (d) Organoleptic analysis

5.8 Noodles

5.8 (a) Nutritional composition

5.8 (b) Dietary fiber

5.8 (c) Mineral composition

5.8 (d) Organoleptic analysis

5.9 Formulation of value added product with substitution of Karonda

5.9 (a) Bun

5.9 (b) Nutritional composition

5.9 (c) Dietary fiber

5.9 (d) Mineral composition

5.9 (e) Organoleptic analysis

5.10 Muffin

5.10 (a) Nutritional composition

5.10 (b) Dietary fiber

5.10 (c) Mineral composition

5.10 (d) Organoleptic analysis

5.11 Noodles

5.11 (a) Nutritional composition

5.11 (b) Dietary fiber

5.11 (c) Mineral composition

5.11 (d) Organoleptic analysis

5.12 Noodles

5.12 (a) Nutritional composition

5.12 (b) Dietary fiber

5.12 (c) Mineral composition

5.12 (d) Organoleptic analysis

5.1 Analysis of *Ficus carica* (fig)

5.1 (a) Physical properties of fig

The effect of processing methods on the physical properties of fig is depicted in Table 6.1. The length of fresh fig was found to be 15.46 mm. Similar results, i.e. 20 mm to 36 mm were reported by Darjazi *et al*. (2011) in fresh fig fruit. A statistically significant increase ($p< 0.05$) in length was observed in fresh fig sample, the increasing order being MDS<SD <FRS<FS.

Table 5.1 Effect of processing methods on physical properties of fig

Drying methods	FS	SD	FRS	MDS
Length(mm)	15.46 ± 0.05^{a}	14.26 ± 0.05^{b}	14.46 ± 0.05^{c}	14.16 ± 0.05^{bd}
Width(mm)	18.14 ± 0.00^{a}	17.46 ± 0.05^{b}	17.86 ± 0.05^{c}	17.16 ± 0.05^{cd}
Density(gm/cc)	0.95 ± 0.00^{a}	0.93 ± 0.02^{a}	0.94 ± 0.01^{a}	0.91 ± 0.00^{ab}

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample

Length of sun dried fig was found to be 14.26 mm. Length decreased by 7.76 %, in sun dried fig as compared to fresh ones. Length of microwave dried fig was found to be 14.16 mm. Length decreased by 8.40 %, in microwave dried fig as compared to fresh ones. Similar results have been reported by Hazbavi *et al.* (2014), wherein they reported 3.06 % decrease in length in date palm fruit by thermal processing. Similar decrease in length has been reported by Zivcovic *et al*. (2011) in thermal dried plum. This may be attributed to the fact that thermal process leads to decrease in length of fruits as moisture content is reduced (Kashaninejad *et al*.2006) and also due to the shrinkage of fruits (Jha *et al*.2006).

Length of frozen fig was found to be 14.46mm. Length decreased by 6.46 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 4.80 % decrease in length in frozen dates. This decrease in length by frozen storage might be due to the period of cold storage (Al- Yahayai and Al- Kharusi,2012).

The width of fresh fig was found to be 18.14 mm. Similar results, i.e. 21mm to 48 mm was reported by Darjazi *et al*. (2011) in fresh fig fruit. A statistically significant increase ($p<0.05$) in width was observed in fresh fig sample, the increasing order being MDS<SD <FRS<FS.

Width of sun dried fig was found to be 17.46 mm. Width decreased by 3.74 % in sun dried fig as compared to fresh ones. Width of microwave dried fig was found to be 17.16 mm. Width decreased by 5.40 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Hazbavi *et al.*(2014), where they found 1.45 % decrease in width in thermal processed date palm fruit. Similar decrease in width has been reported by Zivcovic *et al*. (2011) in heat treated plum. This decrease in width by thermal process might be due to the reduction of moisture content (Kashaninejad *etal.*2006) and also due to the shrinkage of fruits (Jha *et al.*2006; Hazbavi *et al*, 2014). Width of frozen fig was found to be 17.86 mm. Width decreased by 1.54 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), wherein they reported 7.69 % decrease in width in frozen dates. This decrease in width by frozen storage might be due to the period of cold storage (Al- Yahayai and Al- Kharusi, 2012).

The density of fresh fig was found to be 0.95 gm/cc. Similar results, i.e. 1.46 gm/cc was reported by Razavi *et al*. (2010) in fresh fig fruit. A statistically significant increase ($p<0.05$) in density was observed in fresh sample, the increasing order being MDS<SD <FRS<FS. Density increased in fresh due to higher moisture content that leads to increase volume (Garmakhany *et al.* 2013). Density of sun dried fig was found to be 0.93 gm/cc. Density decreased by 2.10 % in sun dried fig as compared to fresh ones. Density of microwave dried fig was found to be 0.91 gm/cc. Density decreased by 4.21 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Pacco and Menegalli (2004), where they reported decrease in density in thermal dried fig fruit. This is may be attributed to the fact that thermal processing fig becomes more porous.

Density of frozen fig was found to be 0.94 gm/cc. Density decreased by 1.05 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Ramaswamy and Tung (1981), wherein they reported decrease in density by 6.74 % in frozen storage "Golden" apple.

5.1 (b) Nutritional composition of fig

The moisture content of fig fruit is depicted in Table 5.2. Moisture content of fresh fig was found to be 80.2 per cent. Similar results, i.e. 80.61 per cent was reported by Nakilcioglu and Hisil, (2013) in "Sarilop" fresh fig variety. The moisture content increased significantly ($p<0.05$) in frozen fig sample, the increasing order being MDS<SD<FS<FRS.

Table 5.2 Effect of processing methods on nutritional properties of fig

Drying methods	FS	SD	FRS	MDS
Moisture (%)	80.2 ± 0.00^{a}	25.86 ± 2.48^{b}	81.0 ± 1.97^{ac}	25.43 ± 3.23^{bc}
Ash (%)	4.00 ± 0.34^{a}	4.42 ± 0.19^{a}	4.20 ± 0.08^{a}	4.30 ± 0.23^{a}
Carbohydrate (%)	16.3 ± 0.18^{a}	65.15 ± 0.20^{b}	16.0 ± 0.03^{ac}	65.18 ± 0.08^{cd}
Fat (%)	0.53 ± 0.08^{a}	0.56 ± 0.00^{a}	0.51 ± 0.07^{a}	0.59 ± 0.03^{a}
Protein (%)	0.53 ± 0.15^{a}	3.01 ± 0.09^{a}	2.71 ± 0.32^{a}	3.18 ± 0.07^{a}

The moisture content of sun dried fig was found to be 25.85 per cent. Moisture content decreased by 67.75 % in sun dried fig as compared to fresh ones. Similar results have been reported by Siriwattananon and Maneerate (2016), in guava where they found 89.08% decrease in moisture content in sun dried fruit. Moisture content of microwave dried fig was found to be 25.43 per cent. Moisture content decreased by 68.29 % in microwave dried fig as compared to

fresh ones. Similar results have been reported by Nakilcioglu and Hisil (2013), wherein they reported 79.76% decrease in moisture content in fig fruit after thermal process. Similar decrease in moisture content (99.75%) has been reported by Lutz *et al.* (2015) in heat treated blackberry. Kshetrimayum *et al*. (2015), also reported 92.86 % reduction in moisture content in microwave dried guava slices. This reduction in moisture content by thermal process might be due to the rapid water loss (Mechlouch *et al.* 2015), heating temperature (Brooker, 1974) and higher absorption power (Meda *et al.* 2008).

Moisture content of frozen fig was found to be 81.0 per cent. Moisture content increased by 0.99 % in frozen fig as compared to fresh ones. Similar results have been reported by Aleid *et al*. (2014), where they reported 10.51% increase in moisture content in date during frozen storage and Damini *et al*.(2013), wherein they reported 2.45 % increase in the moisture content in frozen marolo pulp. Similar increase in moisture content (1.0 %) has been reported by Boca *et al.* (2014) in frozen strawberry puree. This may be attributed to the fact that frozen storage leads to increase in moisture content of fruits as destruction of cellular structure by syneresis (Sae-Kang and Suphantharika, 2006) that leads to release of intracellular water (Chefteh and Besancon, 1989) which is migrated out of the cell (Damiani *et al*.2013).

The ash content of fig fruit is depicted in Table 5.2. Ash content of fresh fig was found to be 4.00 per cent . Similar results, i.e. 5.74 per cent was reported by Chawla *et al*. (2012) in fresh fig fruit. Ash content increased non significantly ($p>0.05$) in all fig dried samples and the increasing order being FS<FRS<MDS<SD. The ash content of sun dried fig was found to be 4.42 per cent. Ash content increased by 10.5 % in sun dried fig as compared to fresh ones. Ash content of microwave dried fig was found to be 4.30 per cent. Ash content increased by 7.5 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Nordin *et al*. (2013), wherein they reported 12.53 % increase in ash content in palm during thermal process. This increase in ash content by thermal process might be due to the removal of moisture content (Lisa, 1997).

Ash content of frozen fig was found to be 4.20 per cent. Ash content increased by 5.0 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Zolfaghari *et al*. (2010), where they reported 8.3 % increase in ash content in kiwi fruit during frozen storage.

Similar increase in ash content 20 % has been reported by Ogunobanwo *et al*.(2013) in frozen water melon juice. This increase in ash content by frozen storage might be due to the presence of products which has chemical stability (Raji *et al.* 2016).

Fat content of fig fruit is depicted in Table 5.2. Fat content of fresh fig was found to be 0.53 per cent. Similar results, i.e. 0.34 per cent was reported by Mahmoud *et al*. (2013) in fresh fig fruit. A statistically non significant increase ($p<0.05$) in fat content in all dried fig samples and the increasing order being FRS<FS<SD<MDS.

The fat content of sun dried fig was found to be 0.56 per cent. Fat content increased by 5.66 % in sun dried fig as compared to fresh ones. Fat content of microwave dried fig was found to be 0.59 per cent. Fat content increased by 11.32 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Nwaigwe and Adejumo (2015), in African bread fruit where they found 2.10 % increase in fat content during thermal process. This may be attributed to the fact that thermal process leads to increase in fat content of fruits along with removal of moisture content (Morris *et al.* 2004). Fat content of frozen fig was found to be 0.51 per cent. Fat content decreased by 3.77 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 10.81 % decrease in fat content in frozen blackthorn fruit. This decrease in fat content by frozen storage might be due to oxidation (Ryder *et al*.1993) that leads to release oxidative enzymes from various rupture cellular organelles (Boonsumrej *et al.* 2007).

Carbohydrate content of fresh fig was found to be 16.3 per cent. Similar results, i.e. 17.1 per cent was reported by Guvenc *et al*. (2009) in fresh fig fruit. Significant difference ($p<0.05$) increased in carbohydrate content in all fig dried samples and the increasing order being FRS<FS<SD<MDS. The carbohydrate content of sun dried fig was found to be 65.15 per cent. Carbohydrate content increased by 299.69% in sun dried fig as compared to fresh ones. Carbohydrate content of microwave dried fig was found to be 65.18 per cent. Carbohydrate content increased by 299.87% in microwave dried fig as compared to fresh ones. Similar results have been reported by Guvenc *et al*. (2009) in fig fruit where they found 240.39 % increase in carbohydrate content during heat treatment and Clary *et al*. (2007), wherein they reported 265. 27% increase in carbohydrate content in microwave dried grapes. Similar increase in

carbohydrate content (13.15 %) has been reported by Nwaigwe and Adejumo (2015) in thermal treated African bread fruit. This increase in carbohydrate content by thermal process might be due to hydrolytic effect of carbohydrate stored in fruits (Akinhanmi *et al.* 2008).

Carbohydrate content of frozen fig was found to be 65.15 per cent. Carbohydrate content decreased by 1.84 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Galoburda *et al.* (2014), where they reported 55.2% decrease in the carbohydrate content in strawberry puree during frozen storage. Damiani *et al*. (2013), wherein they reported 16.11% decrease in carbohydrate content in frozen marolo pulp. Similar decrease in carbohydrate content (25.78%) has been reported by Zolfaghari *et al*. (2010), in frozen kiwi fruit. This may be attributed to the fact that frozen storage leads to decrease in carbohydrate content of fruits as increase in carbon consumption which is required for fruit respiration (Holland *et al*. 2002) and also due to the breakdown of cell structure during frozen storage (Cheftel and Besancon,1989).

The protein content of fig fruit is depicted in Table 5.2. Protein content of fresh fig was found to be 2.98 per cent. Similar results, i.e.1.30 per cent was reported by Guvenc *et al*. (2009) in fresh fig fruit. Protein content non significantly increased ($p>0.05$) in all fig dried samples and the increasing order being FRS<FS<SD<MDS. The protein content of sun dried fig was found to be 3.01 per cent. Protein content increased by 467.92 % in sun dried fig as compared to fresh ones. Protein content of microwave dried fig was found to be 3.18 per cent. Protein content increased by 500.00 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mahmoud *et al*.(2013) in fig fruit where they found 288.23 % increase in protein content during thermal process and Clary *et al*. (2007), wherein they reported 236.11 % increase in protein content in grapes during heat treatment. Similar increase in protein content (14.28 %) has been reported by Nwaigwe and Adejumo (2015) in African bread fruit during thermal process. This increase in protein content by thermal process might be due to the enhancement in dry matter contents by the concentration of soluble solids (Eze and Akubor, 2012).

Protein content of frozen fig was found to be 2.71 per cent. Protein content decreased by 411.32 % in frozen storage fig as compared to fresh ones. Similar results have been reported by

Sikora *et al.* (2013), where they reported 57.51% decrease in protein content in blackthorn fruit during frozen storage. Similar decrease in protein content (7.79 %) has been reported by Damiani *et al*. (2013) in frozen marolo pulp. This may be attributed to the fact that frozen storage decrease in protein content of fruits as reduction in proteins which are water and salt soluble (Chomnawang *etal.*2007), denaturation of proteins (Ryder *et al.* 1993) and destruction caused by enzymatic activity (Hultman and Rustard, 2004).

5.1 (c) Dietary composition of fig

The neutral detergent fiber (NDF) of fig fruit is depicted in Table 5.3. Neutral detergent fiber of fresh fig was found to be 12.73 per cent. Similar results, i.e. 12.49 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. A statistically significant ($p<0.05$) increase in NDF in all fig dried samples, the increasing order being FRS<FS<SD<MDS

Table 5.3 Effect of processing methods on dietary composition of fig

Drying methods	FS	SD	FRS	MDS
NDF (%)	12.73 ± 0.05^{a}	12.83 ± 0.05^{a}	12.53 ± 0.11^{b}	12.86 ± 0.05^{ac}
ADF (%)	0.40 ± 0.10^{a}	0.56 ± 0.11^{a}	0.38 ± 0.07^{a}	0.60 ± 0.05^{a}
Hemicellulose (%)	12.26 ± 0.05^{a}	12.30 ± 2.17^{a}	12.16 ± 0.05^{a}	12.33 ± 0.11^{a}
Cellulose (%)	15.91 ± 0.05^{a}	16.11 ± 0.07^{a}	15.90 ± 0.40^{a}	16.68 ± 0.05^{b}
Lignin (%)	1.72 ± 0.01^{a}	1.73 ± 0.01^{a}	1.70 ± 0.00^{a}	1.74 ± 0.01^{ab}

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The neutral detergent fiber of sun dried fig was found to be 12.83 per cent. NDF increased by 0.78 % in sun dried fig as compared to fresh ones. NDF in microwave dried fig was found to be 12.86 per cent. NDF increased by 1.02 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Clary *et al*. (2007), where they reported 58 % increase in dietary fiber content in microwave dried grapes. This increase in dietary fiber by thermal process might be due to the formation of Maillard reaction product (Chang and Morris, 1990; Vidal and Frias, 1991) and also due to the reduction in moisture content (Fennema, 1976), by leaching of soluble components to the solution that leads to form the heat resistant complexes between polysaccharides and other mechanism i.e. protein and phenolic content (Caprez *et al.* 1986; Rodriguez *et al.* 2006). Dietary fiber (hemicellulose, cellulose and lignin) also increased (Vasishtha *et al.* 2013) due to releasing of enzymatic fiber components from insoluble cell wall matrix (Hakkinen *et al.*2003).

Neutral detergent fiber of frozen fig was found to be 12.53 per cent. The NDF decreased by 1.57% in frozen storage fig as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 18.13 % decrease in dietary fiber in frozen blackthorn fruit and Salgado *et al.* (1999), wherein they reported reduction in dietary fiber in frozen tropical fruits. This decrease in NDF by frozen storage might be due to the reduction in of cell wall polysaccharides tissues that leads declined dietary fiber (Khan and Vincent, 1996).

Acid detergent fiber (ADF) of fig fruit is depicted in Table 5.3. Acid detergent fiber of fresh fig was found to be 0.40 per cent. Similar results, i.e. 0.74 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. The ADF increased non significantly ($p>0.05$) in dried fig samples, the increasing order being FRS<FS<SD<MDS. The acid detergent fiber of sun dried fig was found to be 0.56 per cent. ADF increased by 40 % in sun dried fig as compared to fresh ones. ADF in microwave dried fig was found to be 0.60 per cent. ADF increased by 50 % in microwave dried fig as compared to fresh ones. Acid detergent fiber in frozen fig was found to be 0.38 per cent. The ADF decreased by 5.0 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Mohajer *et al.* (2016), where they reported 32.66 % decrease in ADF in frozen sainfoin seed.

Hemicellulose content of fresh fig was found to be 12.26 per cent. Similar results, i.e. 12.09 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. A statistically non significant increase ($p>0.05$) in hemicellulose content in fresh fig samples, the increasing order being FRS<FR<SD<MDS. The hemicellulose content of sun dried fig was found to be 12.30 per cent. Hemicellulose content increased by 0.32 % in sun dried fig as compared to fresh ones. Hemicellulose content in microwave dried fig was found to be 12.33 per cent. Hemicellulose content increased by 0.57 % in microwave dried fig. Similar results have been reported by Komolka *et al*. (2012), where they reported 5 % increase in hemicellulose content in common cabbage by thermal processing. Hemicellulose content in frozen fig was found to be 12.16 per cent. The hemicellulose content decreased by 0.06 % in frozen storage fig.

Cellulose content of fig fruit is depicted in Table 5.3. Cellulose content of fresh fig was found to be 15.91 per cent. Similar results, i.e. 22.20 per cent was reported by Nzidda (2010) in " *Ficus polita*" a variety of fig fruit. The cellulose content increased significantly ($p<0.05$) in dried fig samples, the increasing order being FRS<FS<SD<MDS. The cellulose content of sun dried fig was found to be 16.11 per cent. Cellulose content increased by 1.25 % in sun dried fig as compared to fresh ones. Cellulose content in microwave dried fig was found to be 16.68 per cent. Cellulose content increased by 4.83 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015), where they reported 13.7% increase in cellulose content in date fruit during thermal process and Nordin *et al*. (2013), wherein they reported 3.31% increase in oil palm fruit during heat treatment. Cellulose content in frozen fig was found to be 15.90 per cent. The cellulose content decreased by 0.06 % in frozen storage fig as compared to fresh ones.

Lignin content of fresh fig was found to be 1.72 per cent. Similar results, i.e. 2.53 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. The lignin content increased significantly ($p<0.05$) in dried fig samples, the increasing order being FRS<FS<SD<MDS. The lignin content of sun dried fig was found to be 1.73 per cent. Lignin content increased by 0.58 % in sun dried fig as compared to fresh ones. Lignin content in microwave dried fig was found to be 1.74 per cent. Lignin content increased by 1.16 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015) in date fruit where they

found 20.68 % increase in lignin content during thermal process. Similar increase in lignin content (38.79 %) has been reported by Nordin *et al*. (2013) in thermal processed oil palm fruit. This increase in lignin content by thermal process might be due to increase the activity of lignin synthesis enzymes i.e. phenylalanine ammonia lyase (Yun *et al*.2013). Hosseinaei *et al.* (2012) also reported that due to heat, complex structure of lignin is formed which makes it difficult for degradation. Lignin content in frozen fig was found to be 1.70 per cent. The lignin content decreased by 1.16 % in frozen fig as compared to fresh ones. Similar results have been reported by Dangcham *et al*. (2008), where they reported 65.07 % decrease in lignin content in mangosteen fruit at low temperature storage.

5.1 (d) Phytochemical composition of fig (Total Phenolic content)

Processing methods caused remarkable changes in the total phenolic content of fig fruit is depicted in **Figure 5.1**. Total phenolic content (TPC) of fresh fig was found to be 4.58 mg TAE/100gm. Similar results, i.e. 1.15 mg GAE/100gm to 6.98 mg GAE/100gm were reported by Nakilcioglu and Hisil, (2013) in "Sarilop" fresh fig varieties.

A statistically significant increase ($p<0.05$) in TPC was observed in all dried fig samples, the increasing order being FRS<FS <SD<MDS. Total phenolic content of sun dried fig was found to be 4.92 mg TAE/100gm. TPC increased by 7.42 %, in sun dried fig as compared to fresh ones. Al-Farsi *et al.* (2005), reported 22.5 % increase in TPC in dates after sun drying. Total phenolic content of microwave dried fig was found to be 4.94 mg TAE/100gm. TPC increased by 7.86 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Reyes *et al.* (2013) in loquat where they found 10.52 % increase in TPC in microwave dried fruit as compared to fresh ones and Hayat *et al*. (2010), wherein they reported increase from 4.3% to 45.61% in microwave dried pomace. This increase in TPC by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (HMP) by Maillard reaction (Donovan *et al.* 1998) and also due to the breakdown of cellular structure of cells, which makes the phenolic content more extractable (Van *et al.* 2000). Singleton *et al.* (1999) mentioned enhancement in phenolic content may be due to the formation of aglycons by reacting with Folin-Ciocalteau reagent.

Total phenolic content of frozen fig was found to be 4.52 mg TAE/100gm. Frozen stored fig fruits exhibited 1.31 % decrease in total phenolic content as compared to fresh ones. Similar results have been reported by Mullen *et al.* (2002), where they reported 21 to 28 % decrease in the TPC in raspberries during frozen storage as compared to fresh ones. Similar decrease in TPC (0.81%) has been reported by Scibisz and Mitek (2007) in frozen blueberries. This may be attributed to the fact that frozen storage leads to decrease in total phenolic content of fruits as polyphenol oxidase enzymes (PPO) are released by breaking cells and that leads to oxidation of polyphenolics to quinines (De Ancos *et al*. 2000a).

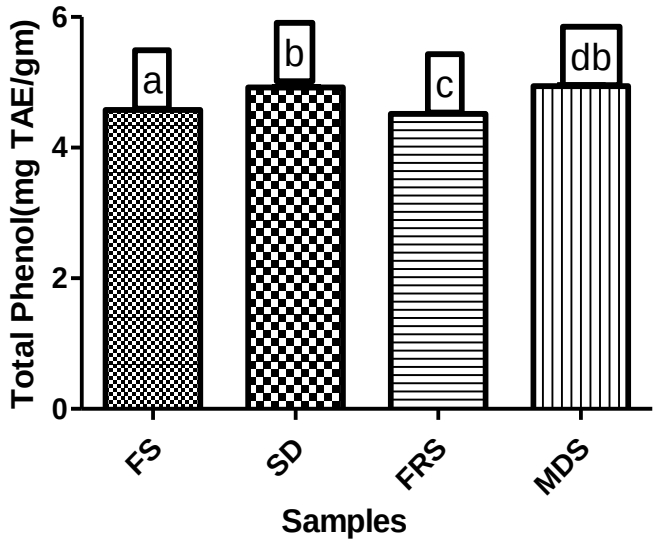

Fig. 5.1 Total Phenolic content of fig

Values are expressed in triplicates (mean ± SD)

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample

5.2 (e) Total Flavonoid content of fig

Flavonoid content of fig fruit is depicted in **Figure 5.2.** Total flavonoid content of fresh fig was found to be 0.21 mg QE/100gm. Similar results, i.e. 1.6 mg catechin equivalent/ 100gm

to 2.3 mg catechin equivalent /100gm were reported by Solomon *et al*. (2006) in "Brunswick " fresh fig varieties.

The total flavonoid content increased significantly ($p<0.05$) in fresh fig sample, the increasing order being SD<MDS<FS<FRS. The flavonoid content of sun dried fig was found to be 0.19 mg QE/100gm. Flavonoid content decreased by 9.52 % in sun dried fig as compared to fresh ones. Similar results have been reported by Wang *et al.* (2016) in jujube fruit where they found 26.75 % decrease in flavonoid content in sun dried fruit. Flavonoid content of microwave dried fig was found to be 0.20 mg QE/100gm. Flavonoid content decreased by 4.76 % in microwave dried fig as compared to fresh ones. Similarly reduction in total flavonoid content (33.3%) has been reported by Salim *et al.* (2014) in microwave dried pepper and Planinic *et al.* (2015), wherein they reported 15.3% reduction in flavonoid content in microwave dried grape fruit. Similar results have been reported by Macias *et al* .(2013), where they reported 23.13 % decrease in flavonoid content in strawberry fruit during thermal process. This decrease in flavonoid content by thermal process (Crozier *et al.* 1995; Price and Rhodes, 1997) might be due to the breakdown of some phytochemicals, which affects cell wall integrity and that leads to migration of some flavonoid components (Davey *et al.* 2000). Ioannou *et al.* (2012) also mentioned that heating process caused degradation might be due to parameters such as pH, oxygen, light, activity of polyphenoleoxidase enzymes and by hydrolysis of C- glycosides bonds, which are presented in flavonoids (Manach *et al.*2004). Flavonoid content of frozen fig was found to be 0.23 mg QE/100gm.

Flavonoid content increased by 9.52 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Mohammadian *et al*.(2011), where they reported 52.11% increase in flavonoid content in "*Citrus limon*" during frozen storage. This may be attributed to the fact that frozen storage leads to increase in flavonoid content of fruits as increase in quercetin derivatives during cold storage (Omer and Canan, 2014) that increases quercetin hydrolysis (Hakkinen *et al*.2000).

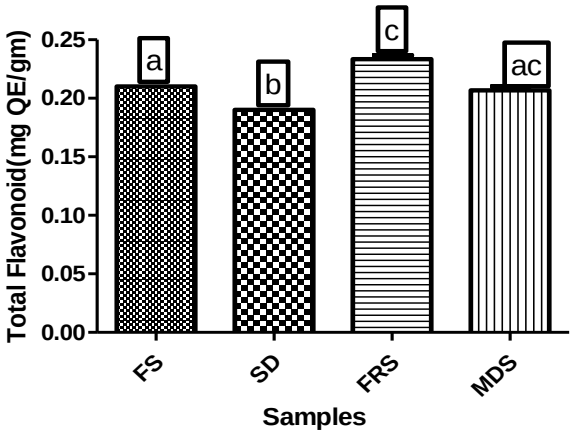

Fig. 5.2 Total Flavonoid content of fig

Values are expressed in triplicates (mean ± SD)

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.1 (f) Antioxidant activity of fig

Processing methods caused remarkable changes in antioxidant activity of fig fruit is depicted in **Figure 5.3.** Antioxidant activity of fresh fig was found to be 73.42 per cent. Similar results, i.e. 75.16 per cent was reported by Wilson *et al*. (2016) in " *Ficus religiosa*" a variety fig fruit.

Antioxidant activity significantly ($p<0.05$) increased in all dried fig sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity of sun dried fig was found to be 75.36 per cent. Antioxidant activity increased by 2.64 % in sun dried fig as compared to fresh ones. Antioxidant activity of microwave dried fig was found to be 75.84 per cent. Antioxidant activity increased by 3.29 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mechlouch *et al.* (2015), where they found 95.32 % increase in antioxidant activity (DPPH) in microwave dried palm date and Juhaimi *et al*.(2015), wherein they reported 280.33 % increase in DPPH antioxidant activity in microwave dried apple. Similar increase in antioxidant activity from 0.27 % to 0.96 % has been reported by Jeong et al.(2004) in heat treated citrus peel extract. This increase in antioxidant activity (DPPH) by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (Raupp *et al*.2011), presence of

naturally occurring compounds such as Maillard reaction products (Yin and Chang,1998; Piga *et al*. 2003;Lee *et al*.2003), released of a free phenolic fraction (Yamaguchi *et al*. 2001), due to oxidative and hydrolytic enzyme (Farsi *et al*.2005), disruption of cell wall that leads to release and enhances antioxidant activity (Chumyan *et al*.2013).

Antioxidant activity of frozen fig was found to be 71.66 per cent. Antioxidant activity (DPPH) decreased by 2.39 % in frozen storage fig as compared to fresh ones. Similar results have been reported by De Ancos *et al.* (2000), where they reported 12 % decrease in antioxidant activity (DPPH) in frozen raspberry fruit and Pimia *et al*.(2003), wherein they reported 20 % decrease in antioxidant activity in frozen peas. Similar decrease in antioxidant activity (1.64 %) has been reported by Mohammadian *et al.*(2011) in frozen "*Citrus limon*. This may be attributed to the fact that frozen storage leads to decrease in antioxidant activity of fruits as disruption of cell structure (Sikora *etal*.2013) and cell wall that leads to release of the oxidative and hydrolytic enzymes that can destroy antioxidant in fruits (Chism,1996).

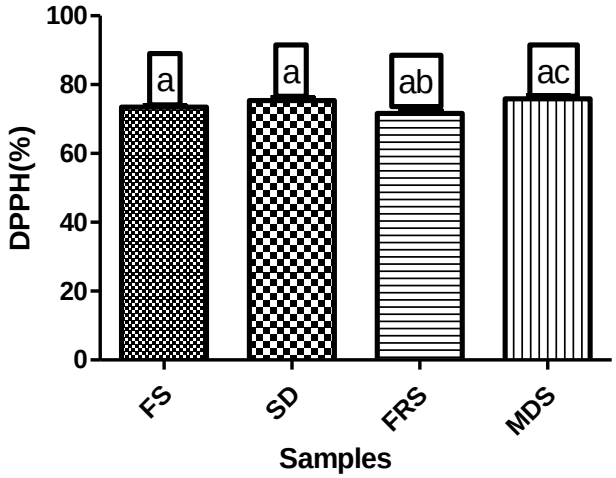

Fig. 5.3 Antioxidant activity (DPPH) of fig

Different superscripts in the same row are significantly different ($p<0.05$).

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.1 (g) Antioxidant activity of fig

Ferric reducing scavenging activity (FRAP) is depicted in **Figure 5.4.** Antioxidant activity of fresh fig was found to be 76.22 per cent. Shivasharanappa and Londonkar, (2014) reported lower antioxidant activity in"*Ficus glomerata*" variety of fig fruit, i.e. 29 per cent to 70 per cent as compared to our results. This difference might be due to many parameters such as fruit colour (Bey and Louaileche, 2015), extraction methods, solvent (Musa *et al.*2011), difference in cultivation (Wand *et al*. 2002; Hakkinen and Torronen, 2000), ripening period (Raffo *et al.* 2012), environmental factor (Wu *etal*.2014). Antioxidant activity non significantly ($p > 0.05$) increased in all dried fig sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity (FRAP) of sun dried fig was found to be 76.55 per cent. Antioxidant activity (FRAP) increased by 0.43 % in sun dried fig as compared to fresh ones. Antioxidant activity of microwave dried fig was found to be 78.54 per cent. Antioxidant activity increased by 3.04 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Piga *et al.* (2003), where they reported increase in antioxidant activity (FRAP) in plum fruit during thermal process. Higher antioxidant activity might be due to relative increase of FRAP value which determined the capacity of plant extract for the donation and acceptance of electrons (Yan *et al.* 2006). This increase in antioxidant activity by thermal process may be due to reduction in moisture content(Abou El-Hana, 2008), inhibition of oxidative enzymes and cell wall destruction which releases antioxidant compounds (Yamaguchi *et al.* 2001).

Antioxidant activity of frozen fig was found to be 75.76 per cent. Antioxidant activity (FRAP) decreased by 0.60 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Poiana *et al*.(2010), where they reported decrease from 6.5% to 12% in frozen strawberry fruit and Nilsson *et al.* (2004), wherein they reported decrease in antioxidant activity (FRAP) in frozen peas.

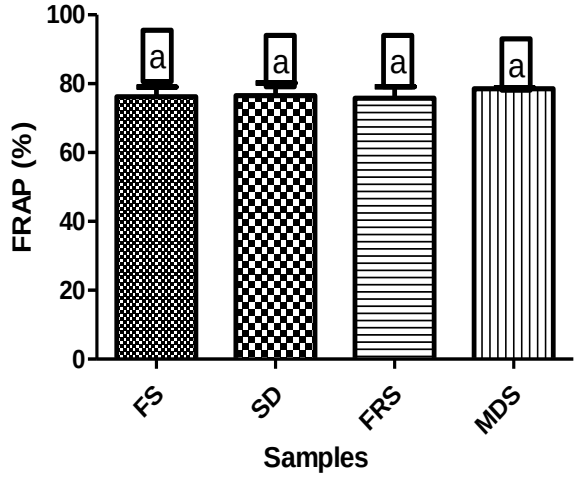

Fig. 5.4 Antioxidant activity (FRAP) of fig

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample

5.1 (h) Anti - nutritional content and anthocyanin content of fig

Tannin content of fresh fig was found to be 0.67 gm/100gm and depicted in Table 5.4. Similar results, i.e. 1.88 gm/100 gm was reported by Noonan and Savage (1999) in "*Ficus Benghalensis* " a variety of fig fruit. Tannin content increased significantly ($p<0.05$) in fresh fig samples, the increasing order being FRS<SD<MDS<FS.

Sun dried fig tannin content was found to be 0.61 gm /100gm. Tannin content decreased by 8.95 % in sun dried fig as compared to fresh ones. Tannin content of microwave dried fig was found to be 0.62 gm /100gm. Tannin content decreased by 7.46 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Pragati *et al.* (2003) in aonla fruit where they found 31.50% decrease in tannin content during thermal process and Nwaigwe and Adejumo (2015), wherein they reported 92.56 % decrease in tannin content in African bread fruit heat treatment. Similar decrease in tannin content (10.58 %) has been reported by Sunmola *et al.* (2011) in *Carica papaya* seed during thermal process. This decrease in tannin content by thermal process might be due to the oxidation of bioactive compounds (Yoshioka *etal.* 1990) and also due to the breakdown of cell structure which migrates the components that

are creating loss by leakage in the presence of oxygen and light (Scheieber *et al*.2001) and also due to various chemical reaction involving enzymes (polyphenoleoxidase) which are responsible to convert tannins into other products (Pragati *et al.* 2003; Mehta,1995).

Table 5.4 Effect of processing methods on anti - nutritional and anthocyanin content of fig

Drying methods	FS	SD	FRS	MDS
Tannin- (gm/100g)	0.67 ± 0.00^{a}	0.61 ± 0.00^{b}	0.60 ± 0.00^{bc}	0.62 ± 0.00^{bd}
Alkaloid- (gm/100g)	7.80 ± 0.04^{a}	7.76 ± 0.02^{a}	7.60 ± 0.1^{b}	7.79 ± 0.04^{ac}
Anthocyanin- (mg/100g)	4.78 ± 0.19^{a}	4.67 ± 0.00^{a}	4.89 ± 0.19^{a}	4.56 ± 0.50^{a}

Tannin content of frozen fig was found to be 0.60 gm /100gm. Tannin content decreased by 10.44 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 33.33 % reduction in tannin content in frozen dates. Similar decrease in tannin content in persimmons fruit has been reported by Nakamura (1961) during frozen storage. This decrease in tannin content by frozen storage might be due to the non-enzymatic activity in fruits (Al-Ogadi and Mutlak, 1986; Abu-Goukh *et al*. 2003), change occurs in chemical properties of tannin (Nakamura ,1961) that leads to coagulate soluble tannin into insoluble (Brackmann *et al.*1997; Matsu and Itoo,1978).

Alkaloid content of fig fruit is depicted in Table 5.4. Total alkaloid content of fresh fig was found to be 7.80 gm /100gm. Similar results, i.e. 9.6 gm/100gm was reported by Soni *et al*. (2014) in fig fruit. A statistically significant increase ($p<0.05$) in alkaloid content was observed in fresh fig samples, the increasing order being FRS<SD<MDS<FS. The alkaloid content of sun dried fig was found to be 7.76 gm /100gm. Alkaloid content decreased by 0.51 % in sun dried fig as compared to fresh ones. Alkaloid content of microwave dried fig was found to be 7.79 gm /100gm. Alkaloid content decreased by 0.12 % in microwave dried fig as compared

to fresh ones. Similar results have been reported by Nwaigwe and Adejumo (2015) in African bread fruit they found 20.75 % decrease in alkaloid content during heat treatment and Irondi *et al*. (2010), wherein they reported decrease in alkaloid content in *Carica papaya* by thermal process. This decrease in alkaloid content by thermal process might be due to the breakdown of cell structure which results migration of components, that leads to loss by various chemical reactions i.e. involving enzymes, light and heat (Atlabachew *et al*. 2013). Alkaloid content of frozen fig was found to be 7.60 gm /100gm. Alkaloid content decreased by 2.56 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Atlabachew *et al*. (2013), where they reported 56 % decrease in alkaloid content (cathinone) in frozen (*Catha Edulis* Forsk) leaves.

The anthocyanin content of fig fruit is depicted in Table 5.4. Total anthocyanin content of fresh fig was found to be 4.78 mg cyanidin-3-glucoside equivalents/100gm. Similar results, i.e. 0.1 mg cynide-3-glucose/100gm to 27.3 mg cynidin-3-glucoside equivalent /100gm were reported by Solomon *et al*. (2006) in "Mission" fresh fig varieties. Anthocyanin content increased non significantly ($p > 0.05$) in frozen fig samples, the increasing order being MDS<SD<FS<FRS.

The anthocyanin content of sun dried fig was found to be 4.67 mg cyanidin-3-glucoside equivalents/100gm. Anthocyanin content decreased by 2.30 % in sun dried fig as compared to fresh ones. Anthocyanin content of microwave dried fig was found to be 4.5 mg /100gm. Anthocyanin content decreased by 2.30 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Wojdylo *et al.* (2009) in strawberry where they found 12.9 % decrease in anthocyanin content in microwave dried fruit. Similar decrease in anthocyanin content (35.69 %) has been reported by Wojdylo *et al*. (2014) in microwave dried sour cherries. This decrease in anthocyanin content by thermal process (Juan *et al*.2013) might be due to different factors i.e. heat, oxygen, metal ion, co-pigmentation and pH (Mishra and Yang, 2008), polyphenol oxidase enzymes activity (Kwok *et al.*2004) and browning reaction (Wrolstad *et al.* 2004).

Total anthocyanin content of frozen fig was found to be 4.89 mg cyanidin-3-glucoside equivalents/100gm. Anthocyanin content increased by 4.60 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Scibisz and Mitek (2007), where they

reported 1.30 % increase in anthocyanin content in frozen blueberries. Similar increase in anthocyanin content (2.16 %) has been reported by Mullen *et al.* (2002) in frozen red raspberries. This increase in anthocyanin content might be due to ice crystal formation that favours to reallocation of water molecules in cell structure, that leads to enhance the release of membrane bound anthocyanin (Szczesniak, 1998; Leong and Oey, 2012) and also due to the cellular disruption in fruits (Skrede, 1996) which contributes to increase the cyanidin -3-galactoside content in fruits (Scibisz and Mitek, 2007).

5.1 (i) Mineral composition of fig

The mineral composition of fig fruit as depicted in Table 5.5. Calcium content of fresh fig was found to be 80.76 mg /100gm. Similar results, i.e.78 mg/100gm was reported by Khan *et al*. (2011) in fresh fig fruit.

Table 5.5 Effect of processing methods on mineral composition of fig

Drying methods	FS	SD	FRS	MDS
Calcium- (mg/100g)	80.6± 0.01 ^{a}	285.23±0.01 ^{b}	80.76± 0.01 ^{c}	302.86± 0.01^{cd}
Iron- (mg/100g)	12.01±0.01^{a}	12.66± 0.01 ^{b}	11.51 ±0.01^{c}	13.20 ±0.01^{dc}
Phosphorus- (mg/100g)	17.66± 0.01^{a}	106.16 ± 0.01^{cd}	17.41± 0.01^{c}	123.13± 0.01 ^{cd}

Calcium content increased significantly ($p<0.05$) in microwave dried fig sample, the increasing order being FS<FRS<SD<MDS. Mineral composition might be increased or decreased by different processing methods (Rickman *et al.* 2007). The calcium content of sun dried fig was found to be 285.23 mg /100gm. Calcium content increased by 253.18% in sun dried fig as compared to fresh ones. Calcium content of microwave dried fig was found to be 302.86 mg /100gm . Calcium content increased by 275.01 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Clary *et al.* (2007) in grapes where they found

157.81 % increase in mineral content in microwave dried fruit and Incedayi *et al.* (2016), wherein they reported 70.93 % increase in calcium content in microwave dried apricot fruit. This increase in calcium content by thermal process might be due to increasing of dry matter content. Ozcan *etal.* (2004) also reported that changes in the concentration of minerals are also depending on the method and the drying temperature used (Ozcan *et al.* 2004).

Calcium content of frozen fig was found to be 80.76 mg /100gm. Calcium content increased by 0.198 % in frozen storage fig as compared to fresh ones. Similar results were reported by Zolfaghari *et al*.(2010), where they reported 13.42 % increase in calcium content in frozen kiwi fruit of "Abbot" cultivar. Similar increase in calcium content (6.25%) has been reported by Bouzari *et al*.(2015) in frozen carrot.

Iron content of fresh fig was found to be 12.01 mg /100gm. Similar results, i.e. 10.09 mg/100gm was reported by Khan *et al*. (2011) in fresh fig. Iron content increased significantly ($p<0.05$)in microwave dried fig sample, the increasing order being FRS<FS<SD<MDS. The iron content of sun dried fig was found to be 12.66 mg /100gm . Iron content increased by 5.41% in sun dried fig as compared to fresh ones. Iron content of microwave dried fig was found to be 13.20 mg /100gm. Iron content increased by 9.90 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Clary *et al*. (2007) in grapes where they found 35.29 % increase in iron content during thermal process. Similar increase in iron content (395.06%) has been reported by Jung *et al*. (2005) in microwave dried persimmon fruit. Iron content of frozen fig was found to be 11.51 mg /100gm. Iron content decreased by 4.16 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Zolfaghari *et al*.(2010) in kiwi fruit where they found 13.80 % decrease in iron content in frozen storage.

Phosphorus content of fresh fig was found to be 17.66 mg /100gm. Guvenc *et al*. (2009) was reported higher phosphorus content in fresh fig fruit i.e. 22 mg/100gm as compared to our results. This differences might be due variation in cultivars, storage period and genetic factor (Zolfaghari *et al.* 2010). Phosphorus content increased significantly ($p<0.05$) in microwave dried fig sample, the increasing order being FRS<FS<SD<MDS. The phosphorus content of sun dried fig was found to be 106.16 mg /100gm. Phosphorus content increased by 501.13 % in sun dried fig as compared to fresh ones. Phosphorus content of microwave dried fig was found

to be 123.13 mg /100gm. Phosphorus content increased by 597.22 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Ozcan and Arslan, (2011) in tomato where they found 250% increase in phosphorus content during heat treatment . Phosphorus content of frozen fig was found to be 17.41 mg /100gm. Phosphorus content decreased by 1.42 % in frozen storage fig as compared to fresh ones. Similar decrease in phosphorus content 14.53 % has been reported by Zolfaghari *et al*.(2010) in frozen kiwi fruit and Ogbadoyi and Musa (2013), wherein they reported reduction in mineral content in frozen storage "*Amaranthus cruentus".* This may be attributed to the fact that frozen storage leads to decrease in iron content of fruits as high moisture content that leads to form ice crystals and causes leakage from the cell membranes (Baker and Gawish, 1997) that leads to reduction in mineral elements (Hui *et al*., 2004; McDonald *et al.,* 2006).

5.2 Analysis of *Carissa spinarum* (Karonda)

5.2 (a) Physical properties of karonda

The length of fresh karonda was found to be 7.46 mm. Similar results, i.e. 6 mm length was reported by Amreen *et al.* (2013) in fresh *Carissa spinarum* fruit. A statistically significant increase ($p<0.05$) in length was observed in fresh karonda sample, the increasing order being MDS<SD <FRS<FS.

Table 5.6 Effect of processing methods on physical properties of karonda

Drying methods	FS	SD	FRS	MDS
Length(mm)	7.46 ± 0.05^{a}	6.06 ± 0.05^{b}	6.36 ± 0.05^{c}	5.96 ± 0.05^{db}
Width(mm)	4.54±0.00a	3.76 ± 0.05^{b}	3.86 ± 0.05^{c}	3.26 ± 0.05^{cd}
Density(gm/cc)	0.64 ± 0.01^{a}	0.61 ± 0.00^{a}	0.62 ± 0.00^{ab}	0.60 ± 0.00^{a}

Where, Fresh- FS, Sun drying-SD, Freezed -FRS, Microwave drying-MDS

Length of sun dried karonda was found to be 6.06 mm. Length was decreased by 20.10 %, in sun dried karonda as compared to fresh ones. Length of microwave dried karonda was found to be 5.96 mm. Length decreased by 20.10 %, in microwave dried karonda as compared to fresh ones. Similar results have been reported by Oztekin *et al.* (2011), wherein they reported 0.70 % decrease in length in berry fruit by thermal processing. Similar decrease in length has been reported by Zivcovic *et al*. (2011) in thermal dried plum.

This may be attributed to the fact that thermal process leads to decrease in length due to the shrinkage of fruits (Hazbavi *etal*. 2014). Length of frozen karonda was found to be 6.36 mm. Length decreased by 14.74 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 4.80 % decrease in length in frozen dates. This decrease in length by frozen storage might be due to the period of cold

storage (Al- Yahayai and Al- Kharusi,2012). The width of fresh karonda was found to be 4.54 mm. Similar results, i.e. 6 mm width was reported by Amreen *et al.(*2013) in fresh *Carissa spinarum* fruit. A statistically significant increase ($p<0.05$) in width was observed in fresh karonda sample, the increasing order being MDS<SD <FRS<FS.

Width of sun dried karonda was found to be 3.76 mm. Width decreased by 17.18 % in sun dried karonda as compared to fresh ones. Width of microwave dried karonda was found to be 3.26 mm. Width decreased by 28.19 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Oztekin *et al.* (2011), wherein they reported 6.79 % decrease in width in berry fruit by thermal processing. Similar decrease in width has been reported by Zivcovic *et al*. (2011) in heat treated plum. This decrease in width by thermal process might be due to the reduction of moisture content (Kashaninejad *et al.*2006) and also due to the shrinkage of fruits (Jha *et al.*2006; Hazbavi *et al*, 2014). Width of frozen karonda was found to be 3.86 mm. Width decreased by 14.97 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), wherein they reported 7.69 % decrease in width in frozen dates. This decrease in width by frozen storage might be due to the period of cold storage (Al- Yahayai and Al- Kharusi, 2012).

The density of fresh karonda was found to be 0.64 gm/cc. Similar results, i.e. 0.82 gm/cc was reported by Din (2008) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically significant increase ($p<0.05$) in density was observed in all dried karonda samples, the increasing order being MDS<SD<FRS<FS. Density increased in fresh fruits due to higher moisture content that leads to increase volume (Garmakhany *et al.* 2013). Density of sun dried karonda was found to be 0.61 gm/cc. Density decreased by 4.68 % in sun dried karonda as compared to fresh ones. Density of microwave dried karonda was found to be 0.60 gm/cc. Density decreased by 6.25 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Pacco and Menegalli (2004), where they reported decreased density in thermal dried fruit. This may be attributed to the fact that fruit becomes more porous due to heating process.

Density of frozen karonda was found to be 0.62 gm/cc. Density decreased by 3.12 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Ramaswamy

and Tung (1981), wherein they reported decrease in density by 6.74 % in frozen storage "Golden" apple.

5.2 (b) Nutritional composition of karonda

The moisture content of karonda fruit is depicted in Table 5.7. Moisture content of fresh karonda was found to be 81.05 per cent. Similar results, i.e. 83.17 per cent was reported by (Morton, 1987) in "*Carissa carandas"* a variety of karonda. The moisture content increased significantly ($p<0.05$) in frozen karonda sample, the increasing order being MDS<SD<FS<FRS.

Table 5.7 Effect of processing methods on nutritional composition of karonda

Drying methods	FS	SD	FRS	MDS
Moisture(%)	81.05 ± 1.97^{a}	16.86 ± 0.75^{b}	82.06 ± 2.19^{ac}	16.83 ± 0.40^{bc}
Ash (%)	2.46 ± 0.06^{a}	2.51 ± 0.05^{a}	2.48 ± 0.07^{a}	2.50 ± 0.06^{a}
Carbohydrate (%)	18.66 ± 0.25^{a}	60.51 ± 0.00^{b}	18.16 ± 0.59^{ac}	61.81 ± 0.01^{cd}
Fat (%)	1.30 ± 0.01^{a}	1.50 ± 0.03^{b}	1.29 ± 0.02^{ac}	1.51 ± 0.01^{bc}
Protein (%)	2.07 ± 0.04^{a}	2.41 ± 0.33^{a}	2.04 ± 0.04^{a}	2.51 ± 0.33^{a}

The moisture content of sun dried karonda was found to be 16.86 per cent. Moisture content decreased by 79.19 % in sun dried karonda as compared to fresh ones. Similar results have been reported by Kamiloglu and Capanoglu (2015), in fig where they found 76% decrease in moisture content in sun dried fruit. Moisture content of microwave dried karonda was found to be 16.83 per cent. Moisture content decreased by 79.23 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015), wherein they reported 88.88% decrease in moisture content in okra after thermal process.

Similar decrease in moisture content (70.32 %) has been reported by Guvenc *et al.* (2009) in heat treated fig. Udomkun *et al*.(2015), also reported 98.06 % reduction in moisture content in thermal dried papaya. This reduction in moisture content by thermal process might be due to the rapid water loss (Mechlouch *et al.* 2015), heating temperature (Brooker, 1974) and higher absorption power (Meda *et al.* 2008).

Moisture content of frozen karonda was found to be 82.06 per cent. Moisture content increased by 1.24 % in frozen karonda as compared to fresh ones. Similar results have been reported by Aleid *et al*. (2014), where they reported 10.51% increase in moisture content in date during frozen storage and Damini *et al*.(2013), wherein they reported 2.45 % increase in the moisture content in frozen marolo pulp. Similar increase in moisture content (1.0 %) has been reported by Boca *et al.* (2014) in frozen strawberry puree. This may be attributed to the fact that frozen storage leads to increase in moisture content of fruits as destruction of cellular structure by syneresis (Sae-Kang and Suphantharika, 2006) that leads to release of intracellular water (Chefteh and Besancon, 1989) which is migrated out of the cell (Damiani *et al*.2013).

The ash content of karonda fruit is depicted in Table 5.7. Ash content of fresh karonda was found to be 2.46 per cent. Similar results, i.e. 2.53 per cent was reported by Mishra and Gupta (2005), in fresh *Carissa spinarum*. The result of ash content non significantly ($p>0.05$) increased in all karonda dried samples and the increasing order being FS<FRS<MDS<SD. The ash content of sun dried karonda was found to be 2.51 per cent. Ash content increased by 2.03 % in sun dried karonda as compared to fresh ones. Ash content of microwave dried karonda was found to be 2.50 per cent. Ash content increased by 1.62 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Guvenc *et al*. (2009), wherein they reported 379.16 % increase in ash content in fig during thermal process. Similar increase 1.48 % ash content in fig fruit during heat treatment has been reported by Mahmoud *et al.* (2013). This increase in ash content by thermal process might be due to the removal of moisture content (Morris *et al.* 2004).

Ash content of frozen karonda was found to be 2.48 per cent. Ash content increased by 0.81 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Zolfaghari *et al*. (2010), where they reported 8.3 % increase in ash content in kiwi fruit during

frozen storage. Similar increase in ash content (20 %) has been reported by Ogunobanwo *et al*.(2013) in frozen water melon juice. This increase in ash content by frozen storage might be due to the presence of products which has chemical stability (Raji *et al.* 2016).

Fat content of karonda fruit is depicted in Table 5.7. Fat content of fresh karonda was found to be 1.30 per cent. Similar results, i.e. 2.57 per cent was reported by Morton (1987) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically significant increase ($p<0.05$) in fat content in all dried karonda samples and the increasing order being FRS<FS<SD<MDS.

The fat content of sun dried karonda was found to be 1.50 per cent. Fat content increased by 15.38 % in sun dried karonda as compared to fresh ones. Fat content of microwave dried karonda was found to be 1.51 per cent. Fat content increased by 16.15% in microwave dried karonda as compared to fresh ones. Similar results have been reported by Mrabet *et al.* (2015), in date where they found 7.64 % increase in fat content during thermal process. This may be attributed to the fact that thermal process leads to increase in fat content of fruits along with removal of moisture content (Morris *et al.* 2004). Fat content of frozen karonda was found to be 1.29 per cent. Fat content decreased by 0.76 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Ogunbanwo *et al.* (2013), where they reported 50 % decrease in fat content in water melon juice and Raji *et al*. (2016) reported decrease 0.95% fat content in *Ewedu* soups during frozen storage. This decrease in fat content by frozen storage might be due to oxidation (Ryder *et al*.1993) that leads to release oxidative enzymes from various rupture cellular organelles (Boonsumrej *et al.* 2007).

Carbohydrate content of fresh karonda was found to be 18.66 per cent. Similar results, i.e. 15.16 per cent was reported by Ara *et al*. (2014) in fresh "*Carissa carandas"* a variety of karonda fruit. The carbohydrate content was significantly ($p<0.05$) increased in all karonda dried samples and the increasing order being FRS<FS<SD<MDS. The carbohydrate content of sun dried karonda was found to be 60.51 per cent. Carbohydrate content increased by 224.27% in sun dried karonda as compared to fresh ones.

Carbohydrate content of microwave dried karonda was found to be 61.81 per cent. Carbohydrate content increased by 231.24 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Guvenc *et al*. (2009) in fig fruit where they

found 240.39 % increase in carbohydrate content during heat treatment and Famurewa and Olumofin,(2015),wherein they reported 141.30 % increase in carbohydrate content in microwave dried okra. Similar increase in carbohydrate content (325.47 %) has been reported by Mahmoud *et al.* (2013) in thermal treated sycamore fruit. This increase in carbohydrate content by thermal process might be due to hydrolytic effect of carbohydrate stored in fruits (Akinhanmi *et al.* 2008).

Carbohydrate content of frozen karonda was found to be 18.16 per cent. Carbohydrate content decreased by 2.67 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Galoburda *et al.* (2014), where they reported 55.2% decrease in the carbohydrate content in strawberry puree during frozen storage. Damiani *et al*. (2013) also reported 16.11 % decrease in carbohydrate content in frozen marolo pulp. Similar decrease in carbohydrate content (25.78%) has been reported by Zolfaghari *et al*.(2010), in frozen kiwi fruit. This may be attributed to the fact that frozen storage leads to decrease in carbohydrate content of fruits due to the breakdown of cell structure during frozen storage (Cheftel and Besancon, 1989).

The protein content of karonda fruit is depicted in Table 5.7. Protein content of fresh karonda was found to be 2.07 per cent. Similar results, i.e. 3.64 per cent was reported by Mahapatra *et al*. (2012) in fresh " *Carissa spinarum"* fruit. The protein content increased non significantly ($p>0.05$) in all karonda dried samples and the increasing order being FRS<FS<SD<MDS. The protein content of sun dried karonda was found to be 2.41 per cent. Protein content increased by 16.42 % in sun dried karonda as compared to fresh ones. Protein content of microwave dried karonda was found to be 2.51 per cent. Protein content increased by 21.25 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Fedha *et al*.(2010) in pumpkin where they found 2.5 % increase in protein content during thermal process and Clary *et al*. (2007), wherein they reported 236.11 % increase in protein content in grapes during heat treatment.

Similar increase in protein content (258.55%) has been reported by Guvenc *et al*. (2009) in fig fruit during thermal process. This increase in protein content by thermal process might be due to

the enhancement in dry matter contents by the concentration of soluble solids (Eze and Akubor, 2012).

Protein content of frozen karonda was found to be 2.04 per cent. Protein content decreased by 1.44% in frozen storage karonda as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 57.51% decrease in protein content in blackthorn fruit during frozen storage. Similar decrease in protein content (4.22 %) has been reported by Ogunbanwo *et al*. (2013) in frozen water melon juice and Raji *et al*. (2016) reported decrease 3.83% protein content in *Ewedu* soups during frozen storage. This may be attributed to the fact that frozen storage decrease in protein content of fruits as reduction in proteins which are water and salt soluble (Chomnawang *et al.*2007), denaturation of proteins (Ryder *et al.* 1993) and destruction caused by enzymatic activity (Hultman and Rustard, 2004).

5.2 (c) Dietary composition of karonda

The neutral detergent fiber (NDF) of karonda fruit is depicted in Table 5.8. Neutral detergent fiber of fresh karonda was found to be 25.43 per cent. Similar results, i.e. 27.27 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit.

NDF was significantly ($p<0.05$) higher in all karonda dried samples, the increasing order being FRS<FS<SD<MDS. The neutral detergent fiber of sun dried karonda was found to be 25.56 per cent. NDF increased by 0.51 % in sun dried karonda as compared to fresh ones. NDF in microwave dried karonda was found to be 26.23 per cent. NDF increased by 3.14 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015), where they reported 6.54 % increase in dietary fiber content in microwave dried okra. Similar increase 102.2 % dietary fiber in *Musa paradisaca* during oven drying has been mentioned by Agoreyo *et al.* (2011) and Mahmoud *et al.* (2013) reported increase 1.48 % ash content in fig fruit during heat treatment. This increase in dietary fiber by thermal process might be due to the formation of Maillard reaction product (Chang and Morris, 1990; Vidal and Frias, 1991) and also due to the reduction in moisture content (Fennema, 1976), by leaching of soluble components to the solution that leads to form the heat resistant complexes between polysaccharides and other mechanism i.e. protein and phenolic content components (Caprez *et al.* 1986; Rodriguez *et al.* 2006). Dietary fiber (hemicellulose,

cellulose and lignin) also increased (Vasishtha *et al.* 2013) due to releasing of enzymatic fiber components from insoluble cell wall matrix (Hakkinen *et al.*2003).

Table 5.8 Effect of processing methods on dietary composition of karonda

Drying methods	FS	SD	FRS	MDS
NDF(%)	25.43± 0.05^{a}	25.56± 0.66^{a}	25.26±0.05^{b}	26.23± 0.05^{ac}
ADF(%)	16.03± 0.11^{a}	16.13± 0.66^{a}	15.96±0.49^{a}	16.50± 0.00^{a}
Hemicellulose (%)	9.40± 0.51^{a}	9.43±0.98^{a}	9.20±0.10^{a}	9.66±0.15^{a}
Cellulose(%)	14.05±0.13^{a}	14.67±0.54^{a}	12.97±0.00^{a}	14.89 ± 0.09^{b}
Lignin (%)	3.10± 0.05^{a}	3.20± 0.05^{a}	3.00± 0.10^{a}	3.33±0.05^{ab}

Neutral detergent fiber of frozen karonda was found to be 25.26 per cent. The NDF decreased by 0.66 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 18.13 % decrease in dietary fiber in frozen blackthorn fruit and Salgado *et al.* (1999), wherein they reported reduction in dietary fiber in frozen tropical fruits and Raji *et al*. (2016) reported decrease 0.92% dietary fiber in *Ewedu* soups during frozen storage. This decrease in NDF by frozen storage might be due to the reduction in of cell wall polysaccharides tissues that leads declined dietary fiber (Khan and Vincent, 1996).

The acid detergent fiber (ADF) of karonda fruit is depicted in Table 5.8. Acid detergent fiber of fresh karonda was found to be 16.03 per cent. Similar results, i.e. 18.03 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. The ADF was non significantly ($p>0.05$) increased in dried karonda samples, the increasing order being

FRS<FS<SD<MDS. The acid detergent fiber of sun dried karonda was found to be 16.13 per cent. ADF increased by 0.62 % in sun dried karonda as compared to fresh ones. ADF in microwave dried karonda was found to be 16.50 per cent. ADF increased by 1.24% in microwave dried karonda as compared to fresh ones. Acid detergent fiber in frozen karonda was found to be 15.96 per cent. The ADF decreased by 4.80 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Mohajer *et al.* (2016), where they reported 32.66 % decrease in ADF in frozen sainfoin seed.

Hemicellulose content of fresh karonda was found to be 9.40 per cent. Similar results, i.e. 9.24 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically non significant increase ($p>0.05$) in hemicellulose content in fresh karonda samples, the increasing order being FRS<FS<SD<MDS. The hemicellulose content of sun dried karonda was found to be 9.43 per cent. Hemicellulose content increased by 0.31 % in sun dried karonda as compared to fresh ones. Hemicellulose content in microwave dried karonda was found to be 9.66 per cent. Hemicellulose content increased by 2.76 % in microwave dried karonda as compared to fresh ones. This increase in hemicellulose content by thermal process. Similar results have been reported by Komolka *et al*. (2012), where they reported 5 % increase in hemicellulose content in common cabbage by thermal processing. Hemicellulose content in frozen karonda was found to be 9.20 per cent. The hemicellulose content decreased by 2.12 % in frozen storage karonda.

Cellulose content of karonda fruit is depicted in Table 5.8. Cellulose content of fresh karonda was found to be 14.05 per cent. Similar results, i.e. 11.64 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. The cellulose content increased significantly ($p<0.05$) in dried karonda samples, the increasing order being FRS<FS<SD<MDS. The cellulose content of sun dried karonda was found to be 14.67 per cent. Cellulose content increased by 4.41% in sun dried karonda as compared to fresh ones. Cellulose content in microwave dried karonda was found to be 14.89 per cent . Cellulose content increased by 5.97 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015), where they reported 13.7% increase in cellulose content in date fruit during thermal process and Nordin *et al*. (2013), wherein they

reported 3.31% increase in oil palm fruit during heat treatment. Cellulose content in frozen karonda was found to be 7.68 per cent. The cellulose content decreased by 7.68 % in frozen storage karonda as compared to fresh ones.

Lignin content of fresh karonda was found to be 3.10 per cent. Similar results i.e. 6.39 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. The lignin content increased significantly($p<0.05$) in dried karonda samples, the increasing order being FRS<FS<SD<MDS. The lignin content of sun dried karonda was found to be 3.20 per cent. Lignin content increased by 3.22 % in sun dried karonda as compared to fresh ones. Lignin content in microwave dried karonda was found to be 3.33 per cent. Lignin content increased by 7.41 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015) in date fruit where they found 20.68 % increase in lignin content during thermal process. Similar increase in lignin content (38.79 %) has been reported by Nordin *et al*. (2013) in thermal processed oil palm fruit. This increase in lignin content by thermal process might be due to increase the activity of lignin synthesis enzymes i.e. phenylalanine ammonia lyase (Yun *et al*. 2013). Hosseinaei *et al.* (2012) also reported that due to heat, complex structure of lignin is formed which makes it difficult for degradation. Lignin content in frozen karonda was found to be 3.00 per cent. The lignin content decreased by 3.23 % in frozen karonda as compared to fresh ones. Similar results have been reported by Dangcham *et al*. (2008), where they reported 65.07 % decrease in lignin content in mangosteen fruit at low temperature storage.

5.2 (d) Phytochemical composition of *Carissa spinarum* (Total phenolic content)

Processing methods caused remarkable changes in the total phenolic content of karonda fruit is depicted in Figure 5.5. Total phenolic content (TPC) of fresh karonda was found to be 5.31 mg TAE/100gm. Similar results i.e. 4.67 mg GAE/100gm was reported by Pewlong *et al.* (2014) in "*Carissa carandas"* a variety of karonda fruit .

A statistically significant increase ($p<0.05$) in TPC was observed in all dried karonda samples, the increasing order being FRS<FS <SD<MDS. Total phenolic content of sun dried karonda was found to be 5.50 mg TAE/100gm. TPC increased by 3.57 %, in sun dried karonda as compared to fresh ones. Sangeeta and Mahanta (2013), reported 30.18 % increase in TPC in tomato after

microwave drying. Total phenolic content of microwave dried karonda was found to be 5.74 mg TAE/100gm. TPC increased by 8.09 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Chumyam *et al.* (2013) in purple skin eggplants where they found 155.42 % increase in TPC in microwave dried fruit as compared to fresh ones and Turkmen *et al.*(2005), wherein they reported 126 % increase TPC in microwave dried pepper. Similar increase 85.12% TPC in pear by thermal treatment has been reported by Oboh *et al.*(2015). This increase in TPC by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (HMP) by Maillard reaction (Donovan *et al.* 1998) and also due to the breakdown of cellular structure of cells, which makes the phenolic content more extractable (Van *et al.* 2000). Singleton *et al.* (1999) mentioned enhancement in phenolic content may be due to the formation of aglycons by reacting with Folin-Ciocalteau reagent.

Phenolic content of frozen karonda was found to be 5.11 mg TAE/100gm. Frozen stored karonda fruits exhibited 3.76 % decrease in total phenolic content as compared to fresh ones. Similar results have been reported by Mullen *et al.* (2002), where they reported 21 to 28 % decrease in the TPC in raspberries during frozen storage as compared to fresh ones. Similar decrease in TPC (0.81%) has been reported by Scibisz and Mitek (2007) in frozen blueberries. This may be attributed to the fact that frozen storage leads to decrease in total phenolic content of fruits as polyphenol oxidase enzymes (PPO) are released by breaking cells and that leads to oxidation of polyphenolics to quinines (De Ancos *et al*. 2000a).

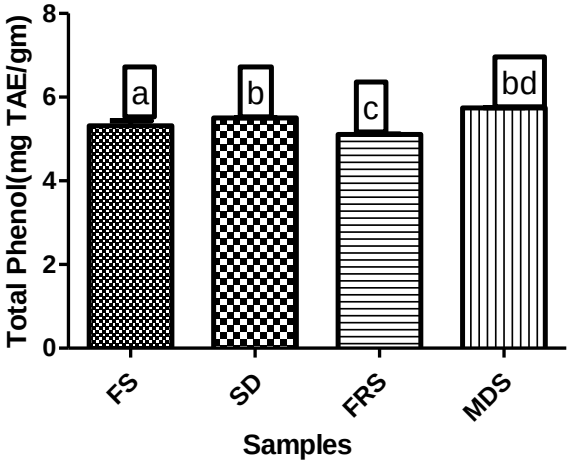

Fig. 5.5 Total Phenolic content of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS= Freezed sample, MDS=Microwave dried sample.

5.2 (e) Total flavonoid content of karonda

Flavonoid content of karonda fruit is depicted in Figure 5.6. Total flavonoid content of fresh karonda was found to be 0.44 mg QE/100gm. Similar results, i.e. 1.53 mg (rutin equivalent /100gm) was reported by Itankar *et al*.(2011) in "*Carissa carandas"* a variety of karonda. The total flavonoid content increased significantly ($p<0.05$) in fresh karonda sample, the increasing order being SD<MDS<FS<FRS. The flavonoid content of sun dried karonda was found to be 0.31 mg QE/100gm. Flavonoid content decreased by 29.54 % in sun dried karonda as compared to fresh ones. Similar results have been reported by Wang *et al.* (2016) in jujube fruit where they found 26.75% decrease in flavonoid content in sun dried fruit. Flavonoid content of microwave dried karonda was found to be 0.32 mg QE/100gm. Flavonoid content decreased by 27.27 % in microwave dried karonda as compared to fresh ones. Similar reduction in total flavonoid content (23.74%) has been reported by Sangeeta and Mahanta (2013) in microwave banana blossom and Planinic *et al.* (2015), wherein they reported 15.3% reduction in flavonoid content in microwave dried grape fruit. Similar results have been reported by Macias *et al* .(2013), where they reported 23.13 % decrease in flavonoid content in strawberry fruit during thermal process. This decrease in flavonoid content by thermal process (Crozier *et al.* 1995;

Price and Rhodes, 1997) might be due to the breakdown of some phytochemicals, which affects cell wall integrity and that leads to migration of some flavonoid components (Davey *et al.* 2000). Ioannou *et al.* (2012) also mentioned that heating process caused degradation might be due to parameters such as pH, oxygen, light, activity of polyphenoleoxidase enzymes and by hydrolysis of C- glycosides bonds, which are presented in flavonoids (Manach *et al.*2004).

Flavonoid content of frozen karonda was found to be 0.52 mg QE/100gm. Flavonoid content increased by 18.18 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Mullen *et al*. (2002), where they reported 21.07 % increase in flavonoid content in red raspberries during frozen storage. This may be attributed to the fact that frozen storage leads to increase in flavonoid content of fruits as increase in quercetin derivatives during cold storage (Omer and Canan, 2014) that increases quercetin hydrolysis (Hakkinen *et al*.2000).

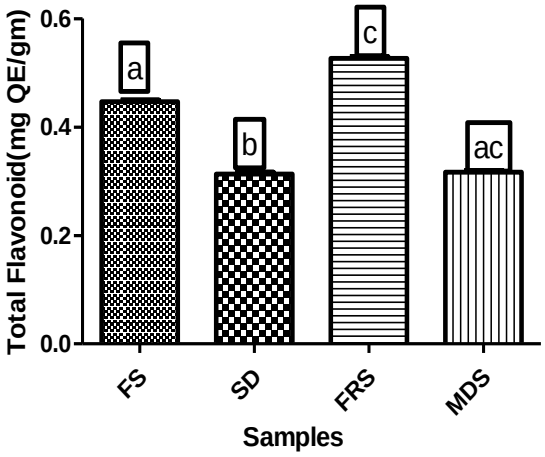

Fig. 5.6 Total Flavonoid content of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.2 (f) Antioxidant activity of karonda

Processing methods caused remarkable changes in antioxidant activity of karonda fruit is depicted in **Figure 5.7.** Antioxidant activity of fresh karonda was found to be 34.45 per cent. Similar results, i.e. 39.1 per cent was reported by Prakash *et al*. (2011) in "*Carissa carandas"* a variety of karonda fruit.

Antioxidant activity significantly ($p<0.05$) increased in all dried karonda sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity of sun dried karonda was found to be 34.47 per cent. Antioxidant activity increased by 0.05 % in sun dried karonda as compared to fresh ones. Antioxidant activity of microwave dried karonda was found to be 34.48 per cent. Antioxidant activity increased by 0.08 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Wojdylo *et al.* (2007), where they found 4.68 % increase in antioxidant activity (DPPH) in thermal dried apple and Chumyan *et al*. (2013), wherein they reported 266.12 % increase in DPPH antioxidant activity in microwave dried eggplants. Similar increase in antioxidant activity 138 % has been reported by Turkmen *et al*. (2005) in microwave heat treated pepper. Similar increase antioxidant activity 112.31% in berries has been reported by Rabeta and Lin (2015) and Sultana *et al.* (2012) also reported increase 3.57 % DPPH antioxidant activity in oven dried apricot. This increase in antioxidant activity (DPPH) by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (Raupp *et al*.2011), presence of naturally occurring compounds such as Maillard reaction products (Yin and Chang,1998; Piga *et al*. 2003; Lee *et al*.2003), released of a free phenolic fraction (Yamaguchi *et al*. 2001), due to oxidative and hydrolytic enzyme (Farsi *et al*.2005), disruption of cell wall that leads to release and enhances antioxidant activity (Chumyan *et al*.2013).

Antioxidant activity of frozen karonda was found to be 30.83 per cent. Antioxidant activity (DPPH) decreased by 10.50 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by De Ancos *et al.* (2000), where they reported 12 % decrease in antioxidant activity (DPPH) in frozen raspberry fruit and Pimia *et al*. (2003), wherein they reported 20 % decrease in antioxidant activity in frozen peas. Similar decrease in antioxidant activity (1.64 %) has been reported by Mohammadian *et al.* (2011) in frozen "*Citrus limon*" .

This may be attributed to the fact that frozen storage leads to decrease in antioxidant activity of fruits as disruption of cell structure (Sikora *etal*.2013).

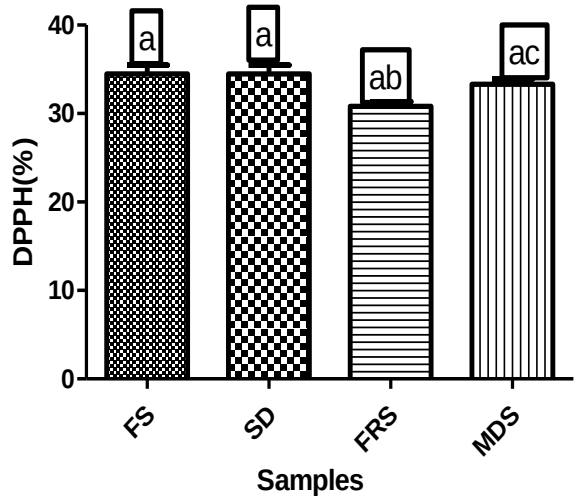

Fig. 5.7 Antioxidant activity (DPPH) of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.2 (g) Antioxidant activity of karonda

Antioxidant activity of karonda fruit is depicted in **Figure 5.8.** Antioxidant activity of fresh karonda was found to be 58.63 per cent. Prakash *et al.* (2011) reported lower antioxidant activity (48.2 %) in "*Carissa carandas*" a variety of karonda fruit as compared to our results. This difference might be due to many parameters such as fruit colour (Bey and Louaileche, 2015), extraction methods, solvent (Musa *et al.* 2011), cultivation location (Wand *et al.* 2002; Hakkinen and Torronen, 2000), ripening stage (Raffo *et al.* 2012), harvested condition and season (Wu *et al* .2014). Antioxidant activity increased non significantly ($p > 0.05$) in all dried karonda sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity (FRAP) of sun dried karonda was found to be 58.68 per cent. Antioxidant activity (FRAP) increased by 0.08 % in sun dried karonda as compared to fresh ones. Antioxidant activity of microwave dried karonda was found to be 58.79 per cent. Antioxidant activity increased by 0.27 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by

Rabeta and Lin (2015), where they reported increase 1040.12% antioxidant activity (FRAP) in berries during thermal process. Higher antioxidant activity might be due to relative increase of FRAP value which determined the capacity of plant extract for the donation and acceptance of electrons (Yan *et al.* 2006). This increase in antioxidant activity by thermal process may be due to reduction in moisture content(Abou El-Hana, 2008), inhibition of oxidative enzymes and cell wall destruction which releases antioxidant compounds (Yamaguchi *et al.* 2001).

Antioxidant activity of frozen karonda was found to be 55.36 per cent. Antioxidant activity (FRAP) decreased by 5.57 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Poiana *et al.*(2010), where they reported decrease from 6.5% to 12% in frozen strawberry fruit and Nilsson *et al.* (2004), wherein they reported decrease in antioxidant activity (FRAP) in frozen peas.

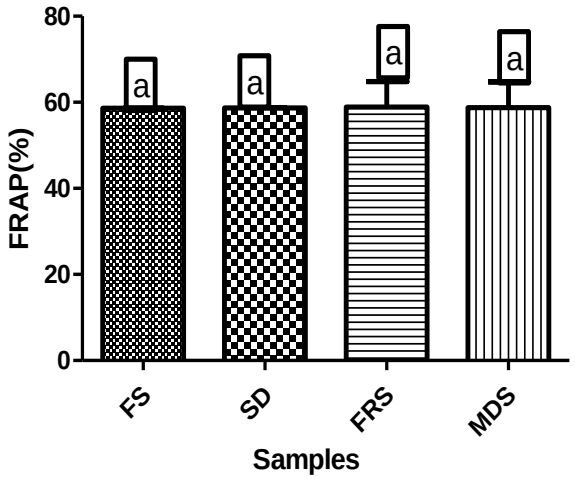

Fig. 5.8 Antioxidant activity (FRAP) of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.2 (h) Anti-nutritional content and anthocyanin content of karonda

Tannin content of fresh karonda was found to be 0.98 gm/100gm. Similar results, i.e. 1.02 gm/100gm was reported by Gupta *et al*. (2014) in "*Carissa carandas"* a variety of karonda fruit. Tannin content increased non significantly ($p>0.05$) increased in fresh karonda samples, the increasing order being FRS<SD<MDS<FS.

Table 5.9 Effect of processing methods on anti-nutritional and anthocyanin content of karonda

Drying methods	FS	SD	FRS	MDS
Tannin- (g/100g)	0.98± 0.01[a]	0.96± 0.01[a]	0.95±0.02 [a]	0.97± 0.00 [a]
Alkaloid- (g/100g)	1.94± 0.00 [a]	1.92±0 .01[a]	1.90±0.00[b]	1.92 ±0 .00[ac]
Anthocyanin- (mg/100g)	54.03± 0.00 [a]	53.43± 0.00[a]	55.20± 2.48 [a]	53.39± 5.02[a]

The tannin content of sun dried karonda was found to be 0.96 gm /100gm. Tannin content decreased by 2.04% in sun dried karonda as compared to fresh ones. Tannin content of microwave dried karonda was found to be 0.97 gm /100gm. Tannin content decreased by 1.02 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Chinyere and Obasi (2013) in leafy vegetable where they found 8.82 % decrease in tannin content during thermal process and Embaby (2011), wherein they reported 15.7 % decrease in tannin content in peanut seed during heat treatment. Similar decrease in tannin content (5.88 %) has been reported by Yusuf and Obiegbuna (2011) in *Vernonia amygdalina* leaf during thermal process. This decrease in tannin content by thermal process might be due to the oxidation of bioactive compounds (Yoshioka *et al.* 1990) and also due to the breakdown of cell structure which migrates the components that are creating loss by leakage in the presence of oxygen and light (Scheieber *et al*. 2001) and also due to various chemical reaction involving

enzymes (polyphenoleoxidase) which are responsible to convert tannins into other products (Pragati *et al.* 2003; Mehta,1995).

Tannin content of frozen karonda was found to be 0.95 gm /100gm. Tannin content decreased by 3.06 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 33.33 % reduction in tannin content in frozen dates. Similar decrease in tannin content in persimmons fruit has been reported by Nakamura (1961) during frozen storage. This decrease in tannin content by frozen storage might be due to the non-enzymatic activity in fruits (Al-Ogadi and Mutlak, 1986; Abu-Goukh *et al*. 2003), change occurs in chemical properties of tannin (Nakamura ,1961) that leads to coagulate soluble tannin into insoluble (Brackmann *et al.*1997; Matsu and Itoo,1978).

Alkaloid content of karonda fruit is depicted in Table 5.9. Total alkaloid content of fresh karonda was found to be 1.94 gm /100gm. Similar results, i.e. 1.96 gm/100gm was reported by Gupta *et al*. (2014) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically significant increase ($p<0.05$) in alkaloid content was observed in fresh karonda samples, the increasing order being FRS<SD<MDS<FS. The alkaloid content of sun dried karonda was found to be 1.92 gm /100gm. Alkaloid content decreased by 1.03 % in sun dried karonda as compared to fresh ones. Alkaloid content of microwave dried karonda was found to be 1.92 gm /100gm. Alkaloid content decreased by 1.03 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Chinyere and Obasi (2013) in leafy vegetable they found 22.83 % decrease in alkaloid content during heat treatment and Yusuf and Obiegbuna (2011), wherein they reported decrease 68.12% alkaloid content in *Vernonia amygdalina* by thermal process. This decrease in alkaloid content by thermal process might be due to the breakdown of cell structure which results migration of components that leads to loss by various chemical reactions i.e. involving enzymes, light and heat (Atlabachew *et al*. 2013). Alkaloid content of frozen karonda was found to be 1.90 gm /100gm. Alkaloid content decreased by 2.06 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Atlabachew *et al*. (2007), where they reported 56 % decrease in alkaloid content (cathinone) in frozen (*Catha Edulis* Forsk) leaves.

The anthocyanin content of karonda fruit is depicted in Table 5.9. Total anthocyanin content of fresh karonda was found to be 54.03 mg cyanidin-3-glucoside equivalents/100gm. Similar results, i.e. 54 mg/100gm was reported by Pewlong *et al*. (2014) in "*Carissa carandas"* a variety of karonda fruit.

Anthocyanin content increased non significantly ($p>0.05$) in frozen karonda samples, the increasing order being MDS<SD<FS<FRS. The anthocyanin content of sun dried karonda was found to be 53.43 mg /100gm. Anthocyanin content decreased by 1.11 % in sun dried karonda as compared to fresh ones. Anthocyanin content of microwave dried karonda was found to be 53.39 mg /100gm. Anthocyanin content decreased by 1.18 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Wojdylo *et al.* (2009) in strawberry where they found 12.9 % decrease in anthocyanin content in microwave dried fruit. Similar decrease in anthocyanin content (35.69 %) has been reported by Wojdylo *et al*. (2014) in microwave dried sour cherries. This decrease in anthocyanin content by thermal process (Juan *et al*.2013) might be due to different factors i.e. heat, oxygen, metal ion, co-pigmentation and pH (Mishra and Yang, 2008), polyphenol oxidase enzymes activity (Kwok *et al*.2004) and browning reaction (Wrolstad *et al.* 2004).

Anthocyanin content of frozen karonda was found to be 55.20 mg /100gm. Anthocyanin content increased by 2.16 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Scibisz and Mitek (2007), where they reported 1.30 % increase in anthocyanin content in frozen blueberries. Similar increase in anthocyanin content (2.16%) has been reported by Mullen *et al.* (2002) in frozen red raspberries. This increase in anthocyanin content might be due to ice crystal formation that favours to reallocation of water molecules in cell structure, that leads to enhance the release of membrane bound anthocyanin (Szczesniak, 1998; Leong and Oey, 2012) and also due to the cellular disruption in fruits (Skrede, 1996) which contributes to increase the cyanidin -3-galactoside content in fruits (Scibisz and Mitek, 2007).

5.2 (i) Mineral composition of karonda

The mineral composition of karonda fruit is depicted in Table 5.10. Calcium content of fresh karonda was found to be 29.00 mg /100gm. Similar results, i.e. 28.89 mg/100gm was reported

by Ara *et al*. (2014) in "*Carissa carandas"* a variety of karonda fruit. Calcium content increased significantly ($p<0.05$) in microwave dried karonda sample, the increasing order being FRS<FS<SD<MDS.

Table 5.10 Effect of processing methods on mineral composition of karonda

Drying methods	FS	SD	FRS	MDS
Calcium- (mg/100g)	29.00 ± 0.57^{a}	275.67 ± 0.00^{b}	28.9 ± 0.05^{c}	286.35 ± 0.00^{cd}
Iron- (mg/100g)	3.45 ± 0.00^{a}	12.43 ± 0.00^{b}	3.40 ± 0.05^{c}	12.82 ± 0.00^{cd}
Phosphorus- (mg/100g)	32.10 ± 0.05^{a}	106.20 ± 0.00^{b}	31.90 ± 0.05^{c}	$108.50\pm .00^{cd}$

Mineral composition might be increased or decreased by different processing methods (Rickman *et al.* 2007). The calcium content of sun dried karonda was found to be 275.67 mg /100gm. Calcium content increased by 850.6 % in sun dried karonda as compared to fresh ones. Calcium content of microwave dried karonda was found to be 286.35 mg /100gm. Calcium content increased by 887.44 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015), where they found 1028.09 % increase calcium content in microwave dried okra and Incedayi *et al.* (2016), wherein they reported 70.93 % increase in calcium content in microwave dried apricot fruit. This increase in calcium content by thermal process might be due to increasing of dry matter content. Ozcan *et al.* (2004) also reported that changes in the concentration of minerals are also depending on the method and the drying temperature used (Ozcan *et al.* 2004).

Calcium content of frozen karonda was found to be 28.9 mg /100gm. Calcium content decreased by 0.34 % in frozen storage karonda as compared to fresh ones. Similar results were reported by Zolfaghari *et al*. (2010), where they reported 1.53 % decrease in calcium content

in frozen kiwi fruit of "Monty" cultivar. Similar decrease in calcium content (5.23%) has been reported by Bouzari *et al*.(2014) in frozen strawberries.

Iron content of fresh karonda was found to be 3.45 mg /100gm. Similar results, i.e. 6.24 mg/100gm was reported by Dalal *et al*. (2010) in fresh "*Carissa carandas"* a variety of karonda fruit. Iron content increased significantly ($p<0.05$) in microwave dried karonda sample, the increasing order being FRS<FS<SD<MDS. The iron content of sun dried karonda was found to be 12.43 mg /100gm. Iron content increased by 260.28 % in sun dried karonda as compared to fresh ones. Iron content of microwave dried karonda was found to be 12.82 mg /100gm. Iron content increased by 271.59 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015) in okra where they found 963.75 % increase in iron content during thermal process. Similar increase in iron content (395.06%) has been reported by Jung *et al*. (2005) in microwave dried persimmon fruit. Iron content of frozen karonda was found to be 3.40 mg /100gm. Iron content decreased by 1.44 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Musa (2013) in *Amaranthus cruentus* leaf where they found 33.19 % decrease in iron content in frozen storage.

Phosphorus content of fresh karonda was found to be 32.10 mg /100gm. Similar results, i.e. 38 mg/100gm was reported by "CSIR NEW DELHI" (1950) in "*Carissa carandas"* a variety of karonda fruit. Phosphorus content increased significantly ($p<0.05$) in microwave dried karonda sample, the increasing order being FRS<FS<MDS<SD. The phosphorus content of sun dried karonda was found to be 106.20 mg /100gm. Phosphorus content increased by 230.85 % in sun dried karonda as compared to fresh ones. Phosphorus content of microwave dried karonda was found to be 108.50 mg/100gm. Phosphorus content increased by 238.01 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015) in okra where they found 811.45 % increase in phosphorus content during microwave heat treatment. Phosphorus content of frozen karonda was found to be 31.90 mg /100gm. Phosphorus content decreased by 1.42 % in frozen storage karonda as compared to fresh ones. Similar decrease in phosphorus content (0.62 %) has been reported by Zolfaghari *et al*.(2010) in frozen kiwi fruit and Ogbadoyi and Musa (2013), wherein they reported reduction in mineral content in frozen storage "*Amaranthus cruentus".* This may be attributed to the fact

that frozen storage leads to decrease in iron content of fruits as high moisture content that leads to form ice crystals and causes leakage from the cell membranes (Baker and Gawish, 1997) that leads reduction in mineral elements (Hui *et al*. 2004; McDonald *et al.* 2006).

5.3 Experimental Design

5.3 (a) Effect of fig (*Ficus carica)* methanolic extract on fasting blood glucose (FBG) level on diabetic and normoglycemic rats

The aim of the present study is to explored the scientific basis of the utility of fig (*Ficus carica*) fruit methanolic extract to improve FBG level in selected group of rats. The calculated percentage yield of methanolic extract of fig fruit was 31.6 per cent. Acute toxicity test revealed non toxic nature of fig fruit methanolic extract on rats. There was no lethality and toxic reactions at any dose.

The effect of fig methanolic fruit extract on fasting blood glucose level in rats is depicted in **Table 5.11**. FBG level was found highest on 21th day (277.45 mg/dl) and lowest on 0 day (259.35 mg/dl). FBG level in normal control group ranged from 95.61 to 97.27 mg/dl. The FBG level were increased in diabetic rats whose having streptozotocin intraperitoneal injection, ranged from 259.35 to 277.45 mg/dl. FBG level significantly ($p<0.05$) increased (171.25%) on starting 0 day in diabetic control group as compared to normal group. And, on 7th day (1.98 %), 14th day (5.20 %) and 21th day (6.97%), FBG level increased after 3 days of streptozotocin intraperitoneal injection to rats as compared to 0 day. FBG level was highest on 21 th day (277.45 mg/dl) and lowest on 0 day before the start of treatment (259.35 mg/dl). The increase in fasting blood glucose level might be due to streptozotocin injection which causes death of β-cells that leads insufficient production of insulin and elevates blood glucose level (Shen *et al.* 2010).

Metformin treated diabetic rats fasting glucose level ranged from 266.27 to 90.34 mg/dl. FBG level significantly ($p<0.05$) reduced on 7 th day (59.06 %), 14th day (63.62 %) and 21th day (66.07 %) with repeated oral dose administration of metformin (50 mg/kg b.wt.) as compared to 0 day. This decrease in fasting blood glucose level might be due to metformin suppress hepatic glucose production (Stumvoll *et al.*1995) and improved the insulin sensitivity that leads enhancement in binding of insulin to its receptors in several cell (Yanardag *et al.* 2005).

Table 5.11 : Effect of fig (*Ficus carica)* methanolic extract on FBG level in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14Day	21 Day
	Diabetic					
I	Control	35mg/kg	259.35±6.11^{a} (↑171.25%)*	264.50±5.08^{b} (↑ 173.10%)*	272.86±3.79^{bc} (↑181.79%)*	277.45±4.05^{bc} (↑ 185.23%)*
II	Metformin	50 mg/kg	266.27±6.61^{a}	109.0± 5.81^{b} (↓58.79 %)$^{\#}$	96.85±1.61^{bc} (↓64.50 %)$^{\#}$	90.34±3.36^{bc} (↓ 67.43 %)$^{\#}$
III	Fig extract	500 mg/kg	255.33± 1.90^{a}	197.0± 2.25^{b} (↓ 25.51%)$^{\#}$	187.13±2.38^{bc} (↓31.41 %)$^{\#}$	169.64±4.56^{bc} (↓38.85%)$^{\#}$
	Normoglycemic					
IV	Control group	_	95.61±1.78^{a}	96.85±1.61^{a}	96.83±1.84^{a}	97.27±1.59^{b}
V	Fig extract	500 mg/kg	96.87± 1.34^{a}	96.86±1.43^{a} (↓ 0.01%)*	94.42±4.45^{a} (↓2.48%)*	91.30±5.23^{ab} (↓ 6.13%)*

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

Administration of repeated dose of fig methanolic extract (500 mg/kg) body weight of rats had significantly ($p<0.05$) reduced the FBG level in diabetic rats after seven days. The FBG level significantly ($p<0.05$) reduced on7th day (22.84 %), 14 th day (26.71%) and 21 th day (33.56%) as compared to 0 day. This reduction in FBG level might be due to methanolic fruit extract creates anti- hyperglycemic effect by increasing pancreatic secreation of insulin from β cells (Stanley *et al.* 2004).

Administration of repeated oral dose of fig methanolic extract significantly ($p<0.05$) proved effective for the reduction of FBG level in normal group of rats after seven days. The FBG level reduced on 7 th day (0.01 %), 14th day (2.52 %) and 21th day (5.74 %) as compared to 0 day. As per standard protocol, we used to perform activity for 21 days (Girija *et al*. 2011; Kumar *et al*.2012). Drug treatment for diabetes, if normalizes the effect within 21 days only and significant improvement in all parameters of diabetes were improving so that study was conducted these many days only.

5.3 (b) Effect of fig (*Ficus carica)* methanolic extract on body weight in diabetic and normoglycemic rats

The effect of selected fruit methanolic extract on the body weight in diabetic and normoglycemic rats are depicted in **Table 5.12.** Normal group of rats body weight was significantly ($p<0.05$) increased on 7th day (1.37 %), 14 th day (2.32 %) and 21th day (3.02 %) as compared to 0 day.

The body weight was significantly ($p<0.05$) reduced (4.13 %) on starting 0 day in diabetic control group as compared to normal control group and on 7th day (1.59 %), 14 th day (2.23 %) and 21 thday (3.85 %) as compared to 0 day. The reduction in body weight might be due to muscle wasting (Islam, 2011). Repeated administration of metformin dose was significantly reduced the body weight in diabetic rats on 7th day (0.58 %), 14 th day (1.04 %) but showed improvement on 21 th day (1.24 %) as compared to 0 day. The reduction in body weight in diabetic rats might be due to breakdown of tissue protein (Andulla and Varadacharyulu, 2003).

Table 5.12 : Effect of fig (*Ficus carica)* methanolic extract on body weight in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14 Day	21 Day
	Diabetic					
I	Control	35mg/kg	241.0±4.08[a] (↓4.13 %)[*]	238.40±3.41[a] (↓ 6.37 %)[*]	235.61±4.31[ab] (↓ 8.40 %)[*]	231.72±4.10[b] (↓ 10.53%)[*]
II	Metformin	50 mg/kg	240.10±1.07[a]	238.70±1.78[a] (↑ 0.64 %)	237.60± 2.31[ab] (↑0.84 %)	237.11±3.36[ab] (↑ 2.32 %)[#]
III	Fig extract	500 mg/kg	244.76±1.87[a]	246.13±2.20[a] (↑ 3.24 %)[#]	249.43±2.60[b] (↑ 5.86 %) [#]	252.44±2.09[bc] (↑ 8.94%)[#]
	Normoglycemic					
IV	Control group	-	251.40±1.35[a]	254.85±2.17[b]	257.24 ±1.89[bc]	259.0±1.69[bc]
V	Fig extract	500 mg/kg	252.56±1.35[a]	256.46±1.95[b] (↑ 0.63 %)	258.23±1.43[bc] (↑ 0.38 %)	260.17± 1.01[bc] (↑ 0.45 %)

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

The effect of repeated fig methanolic extract (500 mg/kg b.wt) had significantly ($p<0.05$) improved diabetic rats body weight on 7th day (0.56 %), 14 th day (1.90 %) and 21 th day (3.13 %) as compared to 0 day. This increase in body weight might be due to improved metabolic disturbance by given fruit extract that leads reduction in polyphagia, polyuria and polydipsia. It also helps to control muscle wasting (Whitton and Hems, 1975). Repeated oral dose of fig methanolic extract (500 mg/kg) according to body weight of rats proved very effective to increase the body weight in normal rats on7th day (1.54 %), 14 th day (2.24 %) and 21 th day (3.01%) as compared to 0 day.

5.4 Experimental Design

5.4 (a) Effect of karonda (*Carissa spinarum)* methanolic extract on fasting blood glucose level in diabetic and normoglycemic rats

The aim of the present study is to explored the scientific basis of the utility of karonda (*Carissa spinarum*), fruit methanolic extract to improve FBG level in selected group of rats. The calculated percentage yield of methanolic extract of karonda fruit was 29 per cent. Acute toxicity test revealed non toxic nature of karonda fruit methanolic extract on rats. There was no lethality and toxic reactions at any dose.

The effect of karonda methanolic fruit extract on fasting blood glucose level in rats is depicted in **Table 5. 13**. FBG level was found highest on 21th day (277.45 mg/dl) and lowest on 0 day (259.35 mg/dl). FBG level in normal control group ranged from 95.61 to 97.27 mg/dl. The FBG level were increased in diabetic rats whose having streptozotocin intraperitoneal injection, ranged from 259.35 to 277.45 mg/dl. FBG level significantly ($p<0.05$) increased (171.25%) on starting 0 day in diabetic control group as compared to normal group. And, on 7th day (1.98 %), 14th day (5.20 %) and 21th day (6.97%), FBG level increased after 3 days of streptozotocin intraperitoneal injection to rats as compared to 0 day. The increase in fasting blood glucose level might be due to streptozotocin injection which causes death of β-cells that leads insufficient production of insulin and elevated blood glucose level (Rossetti *et al.* 1990).

Metformin treated diabetic rats fasting blood glucose level ranged from 266.27 to 90.34 mg/dl. FBG level significantly ($p<0.05$) reduced on 7 th day (59.06 %), 14th day (63.62 %) and 21th day (66.07 %) with repeated oral dose administration of metformin (50 mg/kg b.wt.) as compared to 0 day. This decrease in fasting blood glucose level might be due to metformin suppress hepatic glucose production (Stumvoll *et al*.1995) and improved the insulin sensitivity that leads enhancement in binding of insulin to its receptors in several cell (Yanardag *et al.* 2005).

Table 5.13 : Effect of karonda (*Carissa spinarum)* methanolic extract on fasting blood glucose level in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14Day	21 Day
	Diabetic					
I	Control	35mg/kg	259.35±6.11[a] (↑171.25%)[*]	264.50±5.08[b] (↑ 173.10%)[*]	272.86±3.79[bc] (↑181.79%)[*]	277.45±4.05[bc] (↑ 185.23%)[*]
II	Metformin	50 mg/kg	266.27±6.61[a]	109.0± 5.81[b] (↓58.79 %)[#]	96.85±1.61[bc] (↓64.50 %)[#]	90.34±3.36[bc] (↓ 67.43 %)[#]
III	karonda extract	500 mg/kg	264.90±5.50[a]	192.73±6.12[b] (↓ 27.10 %)[#]	178.88±5.39[bc] (↓ 34.44%)[#]	168.22±5.23[bc] (↓39.36%)[#]
	Normoglycemic					
IV	Control group	_	95.61±1.78[a]	96.85±1.61[a]	96.83±1.84[a]	97.27±1.59[b]
V	Karonda extract	500 mg/kg	95.70±1.63[a]	90.10±5.38[b] (↓ 6.96 %)	85.63±2.39[bc] (↓11.56%)	81.72±3.52[bc] (↓ 15.98%)[*]

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

Administration of repeated dose of karonda methanolic extract (500 mg/kg) body weight of rats had significantly ($p< 0.05$) reduced the FBG level in diabetic rats after seven days. The FBG level significantly ($p< 0.05$) reduced on 7 th day (27.24 %), 14th day (32.47 %) and 21th day (36.49%) as compared to 0 day. Administration of repeated oral dose of karonda methanolic extract significantly ($p<0.05$) proved effective for the reduction of FBG level in normal group of rats after seven days. The FBG level reduced on 7 th day (5.85 %), 14th day (10.52%) and 21th day (14.60%) as compared to 0 day. This reduction in FBG level might be due to methanolic fruit extract creates anti- hyperglycemic effect by increasing pancreatic secreation of insulin from β cells (Stanley *et al.* 2004) and due to the presence of flavonoid content and tannin content in methanolic extract of selected fruits (Sanwal and Chaudhory, 2011).

5.4 (b) Effect of karonda (*Carissa spinarum)* methanolic extract on body weight in diabetic and normoglycemic rats

The effect of selected fruit methanolic extract on the body weight in diabetic and normoglycemic rats are depicted in **Table 5.14.**

Table 5.14 : Effect of karonda (*Carissa spinarum)* methanolic extract on body weight in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14Day	21 Day
	Diabetic					
I	Control	35mg/kg	241.0±4.08^{a} (↓4.13 %)*	238.40±3.41^{a} (↓ 6.37 %)*	235.61±4.31^{ab} (↓ 8.40 %)*	231.72±4.10^{b} (↓ 10.53%)*
II	Metformin	50 mg/kg	240.10±1.07^{a}	238.70±1.78^{a} (↑ 0.64 %)	237.60± 0.31^{ab} (↑0.84 %)	237.11±3.36^{ab} (↑ 2.32 %)$^{\#}$
III	karonda extract	500 mg/kg	240.22±7.62^{a}	246.27±2.21^{ab} (↑ 3.30 %) $^{\#}$	248.67±2.71^{bc} (↑ 5.54 %) $^{\#}$	252.27±2.68^{b} (↑ 8.86 %)$^{\#}$
	Normoglycemic					
IV	Control group	-	251.40±1.35^{a}	254.85±2.17^{b}	257.24 ±1.89^{bc}	259.0±1.69^{bc}
V	Karonda extract	500 mg/kg	252.35±1.50^{a}	256.13±2.29^{ab} (↑0.50 %)	257.58±2.30^{b} (↑ 0.13 %)	259.53±1.59^{bc} (↑ 0.20 %)

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

Normal group of rats body weight was significantly ($p<0.05$) increased on 7th day (1.37 %), 14 th day (2.32 %) and 21th day (3.02 %) as compared to 0 day. The body weight was significantly ($p <0.05$) reduced (4.13 %) on starting 0 day in diabetic control group as compared to normal control group and on 7th day (1.59 %), 14 th day (2.23 %) and 21 th day (3.85 %) as compared to 0 day. The reduction in body weight might be due to muscle wasting (Swanston *et al*.1990). Repeated administration of metformin dose was significantly reduced the body weight in diabetic rats on 7th day (0.58 %), 14 th day (1.04 %) but showed improvement on 21 th day (1.24 %) as compared to 0 day. The reduction in the body weight due to breakdown of protein in diabetic rats (Andulla and Varadacharyulu, 2003).

The effect of repeated karonda methanolic extract (500 mg/kg b.wt) had significantly ($p<0.05$) improved diabetic rats body weight on 7th day (2.51 %), 14 th day (3.39 %) and 21 th day (4.77 %) as compared to 0 day. Repeated oral dose of karonda methanolic extract (500 mg/kg) according to body weight of rats proved very effective to increase the body weight in normal rats on7th day (1.49 %), 14 th day (2.07 %) and 21 th day (2.84 %) as compared to 0 day. This increase in body weight might be due to improved metabolic disturbance by given fruit extract that leads reduction in polyphagia, polyuria and polydipsia. It also helps to control muscle wasting (Whitton and Hems, 1975).

5.5 Formulation of value added products with the substitution of fig

5.5 (a) Bun

5.5 (b) Nutritional composition

The moisture content (**Table 5.15**) of wheat flour bun substituted with fresh fig ranged from 6.47 per cent to 8.41 per cent. In control it was only 6.47 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of moisture content i.e. 8.41 per cent was noted in T4. Similar increase in moisture content i.e. 5.96 per cent was reported in bread substituted with bread fruit flour (Malomo *et al*. 2015). This increase in moisture content might be due to high moisture content in fresh fruit (Raj and Masih, 2014).

The ash content of wheat flour bun substituted with fresh fig ranged from 1.10 per cent to 1.19 per cent. The result of ash content increased non significantly ($p<0.05$) in bun samples substituted with fresh fig. Similar increase in ash content i.e. 1.02 to 1.04 per cent was reported in bread substituted with bread fruit flour (Alice *et al*. 2012). Romjaun and Prakash (2015) also reported similar increase in ash content i.e. 0.82 to 1.31 per cent in bread substituted with carrot powder. This increase in ash content might be due to the high mineral content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.15**) of wheat flour bun substituted with fresh fig ranged from 75.52 per cent to 104.58 per cent. In control it was only 75.52 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of carbohydrate content i.e. 104.58 per cent was noted in T4. Similar increase in carbohydrate content i.e.78.69 per cent was reported in cookies substituted with unripe plantain flour(Chinma*etal*.2012). This increase in carbohydrate content might be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour bun substituted with fresh fig ranged from 6.64 per cent to 7.84 per cent. The result of protein content increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. Similar increase in protein content i.e. 4.39 to 7.25 per cent

was reported in bread substituted with soursop fruit flour (Zabidi *et al*. 2014). This increase in protein content might be due to higher addition of fruits at the time of bun development that leads to increase in protein content (Thorvaldsson and Skjoldebrand, 1998).

Table 5.15 Nutritional composition of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
Moisture (%)	6.47± 0.02[a]	6.84±0.01[c] (5.71%)↑	8.26±0.00[b] (27.66%)↑	8.41±0.01[cd] (29.98%)↑
Ash (%)	1.10±0.05[a]	1.13±0.10[a] (2.27 %)↑	1.16±0.05[a] (5.45%)↑	1.19±0.05[a] (8.18 %)↑
Carbohydrate (%)	75.52±0.01[a]	85.85±0.30[b] (13.67 %)↑	95.6±0.1[c] (26.58%)↑	104.58±0.07[cd] (38.47%)↑
Protein (%)	6.64±0.14[a]	7.44±0.08[a] (12.04 %)↑	7.69±0.95[a] (15.81%)↑	7.84±0.08[a] (18.07%)↑
Fat (%)	1.62±0.07[a]	1.73±0.04[a] (6.79 %)↑	1.80±0.38[a] (11.11%)↑	1.92±0.28[a] (18.51%)↑

Where, T1 (control sample) = 100% wheat flour bun, T2=15 % fig, T3=30% fig, T4 =45 % fig)

The fat content (**Table 5.15**) of wheat flour bun substituted with fresh fig ranged from 1.62 per cent to 1.92 per cent. Similar results, i.e. 1.57 per cent was reported by Michael *et al*. (2013) in wheat flour bread. The result of fat content increased non significantly ($p>0.05$) in bun sample substituted with fresh fig. The fat content was highest in T4 (1.92 %) and lowest in T1(1.62%). Similar increase in fat content i.e. 2.55 per cent was reported in bread substituted with pumpkin flour (See *et al.* 2007). This increase in fat content may be due to relative increase of fat content in fruits (Asp and Bjorck, 1992).

5.5 (c) Dietary fiber

The neutral detergent fiber (**Table 5.16**) of wheat flour bun substituted with fresh fig ranged from 23.73 per cent to 24.83 per cent. Similar results, i.e. 23.16 per cent was reported by Krishan *et al*. (1987) in wheat flour bread. NDF increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. The NDF was highest in T4 (24.83 %) and lowest in T1(23.73 %). Similar increase in dietary fiber i.e. 24.20 per cent was reported in bread substituted with watermelon rind (Ho and Dahri, 2016). Lopez *et al.* (2011) also reported similar increase i.e. 25.2 per cent was reported in bread substituted with orange powder. This increase in dietary fiber might be due to high dietary fiber in fruits (Sudha *et al.*2007).

The acid detergent fiber (ADF) of wheat flour bun substituted with fresh fig ranged from 1.30 per cent to 1.60 per cent. The results of ADF increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. ADF increased with increase in fresh fig fruit substitution. Similar increase in dietary fiber i.e. 0.75 to 1.13 per cent was reported in wheat flour cookie substituted with mango seed kernel (Legesse and Emire, 2012).

Hemicellulose content (**Table 5.16**) of wheat flour bun substituted with fresh fig ranged from 23.39 per cent to 23.22 per cent. Hemicellulose content increased significantly ($p<0.05$) in bun samples substituted with fresh fig. The hemicellulose content was highest in T4 (23.22 %) and lowest in T1(22.39 %).

The cellulose content of wheat flour bun substituted with fresh fig ranged from 2.48 per cent to 2.62 per cent. The result of cellulose increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. The cellulose content increased with increase in fresh fig fruit

substitution. Similar increase in cellulose content i.e. 0.02 to 4.40 per cent was reported in cookies substituted with raspberry pomace fruit (Gorecka *et al.* 2010). This increase in dietary fiber might be due to addition of dietary fiber rich fruits in bun, especially cellulose content (Thorvaldsen and Skjoldebrand, 1998).

Table 5.16 Dietary fiber of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
NDF (%)	23.73±0.05[a]	23.80±0.10[a] (0.29%)↑	24.23±0.05[a] (2.10%)↑	24.83±0.98[a] (4.63%)↑
ADF (%)	1.30±0.34[a]	1.40±0.45[a] (7.69%)↑	1.53±0.23[a] (17.69%)↑	1.60±0.17[a] (23.07%)↑
Hemicellulose (%)	22.39±0.00[a]	22.42±0.00[b] (0.13%)↑	22.56±0.00[c] (0.75%)↑	23.22±0.00[cd] (3.70%)↑
Cellulose(%)	2.48±0.10[a]	2.51±0.07[a] (1.20%)↑	2.56±0.03[a] (3.22%)↑	2.62±0.01[a] (5.64%)↑
Lignin (%)	1.23±0.63[a]	1.60±0.10[a] (30.08%)↑	1.73±0.05[a] (40.65%)↑	1.76±0.05[a] (43.08%)↑

The lignin content (**Table 5.16**) of wheat flour bun substituted with fresh fig ranged from 1.23 per cent to 1.76 per cent. The results of lignin content increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. The lignin content was highest in T4 (1.70 %) and lowest in T1(1.56 %). Similar increase in lignin content i.e. 3.98 per cent was reported in cookies substituted with raspberry pomace fruit (Gorecka *et al.* (2010).

5.5 (d) Mineral composition

The calcium content (**Table 5.17**) of wheat flour bun substituted with fresh fig ranged from 10.80 mg/100gm to 73.61 mg/100gm. Similar results, i.e. 10.70 mg/100gm was reported by Surekha *et al*. (2013) in wheat flour cookies. In control it was only 10.80 mg/100gm and increased significantly with more replacement of fresh fig fruit. Maximum value of calcium content i.e. 73.61 mg/100gm was noted in T4. Similar increase in calcium content i.e. 14.0 per cent was reported in wheat flour muffin substituted with pumpkin (Krishanaprabha and Kiruthiga, 2015). Waghray *et al.* (2011) also reported similar increase i.e. 70.80 per cent in wheat flour chapatti substituted with date pulp. This increase in calcium content might be due to high mineral content in fruits i.e. iron, phosphorus and calcium (Armeu *et al.* 2006; Niemen *et al*. 1992). Zabidi and Yunus (2014) also reported increase in mineral content in bun substituted with fruits.

Table 5.17 Mineral composition of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	10.80 ± 0.00^{a}	14.96 ± 0.00^{b} (38.51%)↑	70.14 ± 0.00^{c} (549.44%)↑	73.61 ± 0.00^{cd} (581.57%)↑
Iron (mg/100gm)	25.83 ± 0.00^{a}	284.91 ± 0.00^{b} (1003.01%)↑	310.75 ± 0.00^{c} (1103.05) ↑	344.83 ± 0.00^{cd} (1234.99%)↑
Phosphorus (mg/100gm)	333.39 ± 0.00^{a}	371.70 ± 0.00^{b} (11.49%)↑	423.54 ± 0.00^{c} (27.04%)↑	444.00 ± 0.00^{cd} (33.18%)↑

The iron content of wheat flour bun substituted with fresh fig ranged from 25.83 mg/100gm to 344.83 mg/100gm. The result of iron content increased significantly ($p<0.05$) in bun samples substituted with fresh fig. The iron content increased with increase in fresh fig fruit substitution. Similar increase in iron content i.e. 21 to 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

The phosphorus content (**Table 5.17**) of wheat flour bun substituted with fresh fig ranged from 333.39 mg/100gm to 444.00 mg/100gm.The results of the phosphorus content increased significantly ($p<0.05$) in bun samples substituted with fresh fig. The phosphorus content was highest in T4 (444.00 mg/100gm) and lowest in T1(333.39 mg/100gm). Similar increase in phosphorus content i.e. 377.15 per cent was reported in wheat flour chapatti substituted with date pulp (Waghray *et al.* 2011).

5.5 (e) Organoleptic analysis of bun

Table 5.18 Organoleptic analysis of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
Appearance	7.4±0.69[a]	7.2±0.63 [a]	7.4±0.69 [a]	7.2 ±0.63 [a]
Colour	7.2±0.42 [a]	7.0±0.47 [a]	7.1±0.31 [a]	7.0 ±0.66 [a]
Texture	7.2±0.63 [a]	7.2±0.63 [a]	7.3±0.48 [a]	7.1 ±0.31[a]
Flavour	7.5±0.52 [a]	7.2±0.42 [a]	7.3±0.67 [a]	7.1 ±0.31 [a]
Overall Acceptability	7.3±0.48 [a]	7.2±0.42 [a]	7.3±0.48 [a]	7.0 ±0.66 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant($p<0.05$)

Where, T1 (control sample) = 100% wheat flour bun, T2=15 % fig, T3=30% fig, T4 =45 % fig)

As shown in Table 5.18, sensory characteristics of wheat flour bun substituted with fresh fig T2, T3 and T4 were non significantly ($p>0.05$) different from wheat flour bun T1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour bun substituted

with fresh fig were not affected by increased concentration of fresh fig. . However, all samples were found to be acceptable.

Fig. 5.9 T1 (control sample) = 100% wheat flour bun,

T2=15 % fig,T3=30% fig, T4 =45 % fig)

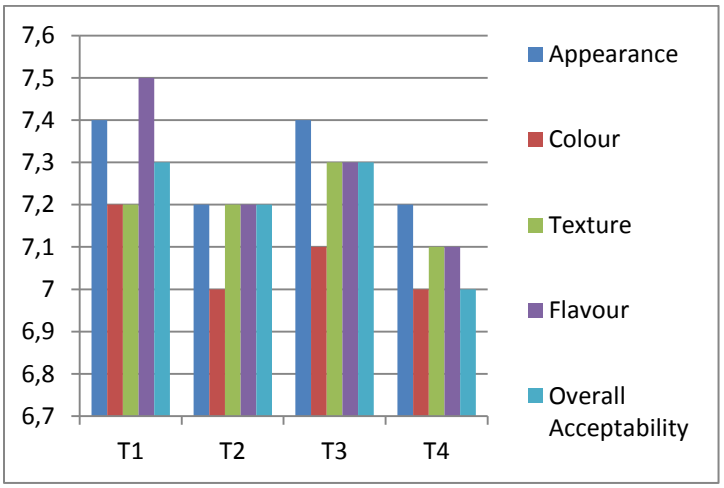

Fig. 5.10 Sensory scores of bun samples

5.6 Muffin

5.6 (a) Nutritional composition

The moisture content (**Table 5.19**) of wheat flour muffin substituted with fresh fig ranged from 10.80 per cent to 20.80 per cent. Similar results, i.e. 10.96 per cent was reported by Uchenna *et al*. (2013) in wheat flour muffin. In control it was only 10.80 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of moisture content i.e. 20.80 per cent was noted in T4. Similar increase in moisture content i.e.20.65 per cent was reported in muffin substituted with young corn powder (Jauharah *et al*. 2014). This increase in moisture content might be due to the presence of fiber content in fruits that leads to enhance the water absorption capacity by hydroxyl group (Rosell *et al.* 2011).

Table 5.19 Nutritional composition of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
Moisture (%)	10.80 ± 0.1^{a}	19.85 ± 0.09^{b} (83.79%)↑	20.15 ± 0.09^{ac} (86.57%)↑	20.80 ± 0.00^{cd} (92.59%)↑
Ash (%)	1.12 ± 0.11^{a}	1.16 ± 0.05^{a} (3.57 %)↑	1.19 ± 0.05^{a} (6.25 %)↑	1.29 ± 0.05^{a} (15.17 %)↑
Carbohydrate (%)	45.45 ± 0.48^{a}	52.48 ± 2.11^{b} (15.46%)↑	62.50 ± 2.54^{c} (37.51%)↑	71.95 ± 2.58^{cd} (58.30%)↑
Protein (%)	6.42 ± 0.12^{a}	6.92 ± 0.11^{a} (7.78%)↑	7.17 ± 0.05^{a} (11.68%)↑	7.38 ± 0.16^{a} (14.95%)↑
Fat (%)	10.33 ± 0.11^{a}	10.73 ± 0.11^{b} (3.87%)↑	11.13 ± 0.11^{c} (7.74%)↑	11.33 ± 0.11^{cd} (9.68%)↑

The ash content of wheat flour muffin substituted with fresh fig ranged from 1.12 per cent to 1.29 per cent. The ash content increased non significantly ($p>0.05$) in muffin samples substituted with fresh fig. Similar increase in ash content i.e. 0.82 to 1.31 per cent was reported in muffin substituted with carrot powder (Romjaun and Prakash, 2014). Mc Clements (2003)

also reported similar increase in ash content in muffin substituted with corn powder. This increase in ash content might be due to high ash content in fruit (Seleem, 2015).

The carbohydrate content (**Table 5.19**) of wheat flour muffin substituted with fresh fig ranged from 45.45 per cent to 71.95 per cent. Similar results, i.e. 45.08 per cent was reported by Krishanaprabha and Kiruthiga (2015) in wheat flour muffin. In control it was only 45.45 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of carbohydrate content i.e. 71.95 per cent was noted in T4. Similar increase in carbohydrate content i.e. 64.81 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).Legesse and Emire (2012) also reported similar increase i.e. 72.12 per cent in wheat flour biscuit substituted with breadfruit flour. Adubofuor and Mensah (2012) also reported increase in carbohydrate content i.e. 51.86 per cent in wheat flour cake substituted with ripe pawpaw pulp. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour muffin substituted with fresh fig ranged from 6.42 per cent to 7.38 per cent. Similar results, i.e. 6.73 per cent was reported by Jauharah *et al.* (2014) in wheat flour muffin. The protein content increased non significantly ($p>0.05$) in protein content was observed in muffin samples substituted with fresh fig. Similar increase in protein content i.e. 6.6 to 7.4 per cent was reported in wheat flour panjiri substituted with potato flour (Kaur and Kochhar, 2014). Jauharah *et al.* (2014) also reported similar increase in protein content in muffin substituted with corn powder. This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.19**) of wheat flour muffin substituted with fresh fig ranged from 10.33 per cent to 11.33 per cent. The fat content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The fat content was highest in T4(11.33 %) and lowest in T1(10.33 %). Similar increase in fat content i.e. 12.50 per cent was reported in muffin substituted with pumpkin powder (Krishanaprabha and Kiruthiga, 2015). Chuen and Aziz (2009) also reported similar increase i.e. 9.23 per cent in muffin substituted with mango pulp flour. This increase in fat content may be due to high fat content in fruits (Seleem, 2015).

5.6 (b) Dietary fiber

The neutral detergent fiber (**Table 5.20**) of wheat flour muffin substituted with fresh fig ranged from 23.66 per cent to 24.46 per cent. NDF increased non significantly ($p>0.05$) in muffin substituted with fresh fig. The NDF was highest in T4 (24.46 %) and lowest in T1(23.66 %). Similar increase in NDF i.e. 24.68 per cent was reported in wheat flour cookie substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to proportionally increase in dietary fiber in fruit mixture (Seleem, 2015).

Table 5.20 Dietary fiber of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
NDF(%)	23.66 ± 0.15^{a}	23.76 ± 0.11^{a} (0.42%)↑	24.06 ± 0.32^{a} (1.69%)↑	24.46 ± 0.86^{a} (3.38%)↑
ADF(%)	5.46 ± 0.63^{a}	5.73 ± 0.56^{a} (4.94%)↑	5.83 ± 0.63^{a} (6.77%)↑	6.03 ± 0.86^{a} (10.43%)↑
Hemicellulose (%)	17.86 ± 0.00^{a}	18.19 ± 0.00^{b} (1.84%)↑	18.32 ± 0.00^{c} (2.57%)↑	18.42 ± 0.00^{cd} (3.13%)↑
Cellulose(%)	4.18 ± 0.19^{a}	4.19 ± 0.19^{a} (0.23%)↑	4.20 ± 0.19^{a} (0.47%)↑	4.24 ± 0.19^{a} (1.43%)↑
Lignin (%)	1.60 ± 0.01^{b}	1.70 ± 0.00^{ab} (6.25%)↑	1.71 ± 0.02^{ac} (6.8%)↑	1.72 ± 0.02^{cd} (7.5%)↑

The acid detergent fiber (ADF) of wheat flour muffin substituted with fresh fig ranged from 5.46 per cent to 6.03 per cent. The ADF increased non significantly ($p>0.05$) in muffin samples substituted with fresh fig. ADF increased with increase in fresh fig fruit substitution. Similar increase in ADF i.e. 1.11 to 8.05 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010).

Hemicellulose content (**Table 5.20**) of wheat flour muffin substituted with fresh fig ranged from 17.86 per cent to 18.42 per cent. Hemicellulose content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The hemicellulose content was highest in T4 (18.42 %) and lowest in T1(17.86 %). Similar increase in dietary fiber i.e.19.00 per cent was reported in wheat flour biscuit substituted with grape pomace (Szkudlarz *et al.* 2013).

The cellulose content of wheat flour muffin substituted with fresh fig ranged from 4.18 per cent to 4.24 per cent. Similar results, i.e. 4.50 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. The cellulose content increased non significantly ($p>0.05$) in muffin samples substituted with fresh fig. The cellulose content increased with increase in fresh fig fruit substitution. Similar increase in dietary fiber i.e. 1.44 to 4.24 per cent was observed in wheat flour cookie substituted with unripe plantain flour (Chinma *et al.* 2012).Similar increase i.e. 0.02 to 4.07 per cent was reported in wheat flour cookie substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to high dietary fiber in fruits(Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.20**) of wheat flour muffin substituted with fresh fig ranged from 1.60 per cent to 1.72 per cent. Similar results, i.e. 1.80 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. Lignin content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The lignin content was highest in T4 (1.72 %) and lowest in T1(1.60 %). Similar increase in dietary fiber i.e. 1.28 per cent was reported in wheat flour mathri substituted with potato flour (Kaur and Kochhar,2014). Gorecka *et al.* (2010) also reported similar increase i.e. 3.98 per cent in wheat flour cookies substituted with raspberry pomace.

5.6 (c) Mineral composition

The calcium content (**Table 5.21**) of wheat flour muffin substituted with fresh fig ranged from 146.79 mg/100gm to 339.29 mg/100gm. In control it was only 146.79 mg/100gm increased significantly with more replacement of fresh fig fruit. Maximum value of calcium content i.e. 339. 29 mg/100gm was noted in T4. Similar increase in calcium content i.e. 148.33 per cent was reported in muffin substituted with carrot powder (Romjaun and Prakash, 2013). This increase in calcium content might be due to high mineral content in fruits (Saunders, 1990).

Table 5.21Mineral composition of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	146.79±0.00^{a}	241.01±0.00^{b} (64.18%)↑	307.95±0.00^{c} (109.78%)↑	339.29±0.00^{cd} (131.13%)↑
Iron (mg/100gm)	10.92±0.00^{a}	16.04±0.00^{b} (46.88%)↑	18.14±0.00^{c} (66.11%)↑	19.88±0.00^{cd} (82.05%)↑
Phosphorus (mg/100gm)	62.40±0.00^{a}	86.65±0.00^{b} (38.86%)↑	120.42±0.00^{c} (92.98%)↑	175.43±0.00^{cd} (181.13%)↑

The iron content of wheat flour muffin substituted with fresh fig ranged from 10.92 mg/100gm to 19.88 mg/100gm. The iron content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The iron content increased with increase in fresh fig fruit substitution. Similar increase in iron content i.e. 21 to 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

The phosphorus content (**Table 5.21**) of wheat flour muffin substituted with fresh fig ranged from 62.40 mg/100gm to 175.43 mg/100gm.The results of the phosphorus content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The phosphorus content was highest in T4 (175.43 mg/100gm) and lowest in T1(62.40 mg/100gm). Similar increase in phosphorus content i.e. 170.22per cent was reported in wheat flour biscuit substituted with date palm fruit (Sharnouby *et al.* 2012). Romjaun and Prakash (2013) also reported similar increase i.e. 119 per cent in wheat flour muffin substituted with carrot powder.

5.6 (d) Organoleptic analysis of muffin

Table 5.22 Organoleptic analysis of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
Appearance	7.9±0.31 [a]	7.4±0.51 [a]	7.7±0.48 [a]	7.4±0.51 [a]
Colour	7.2±0.42 [a]	7.6±0.51 [a]	7.4±0.51 [a]	7.2±0.42 [a]
Texture	7.3±0.48 [a]	7.4±0.51 [a]	7.4±0.51 [a]	7.3±0.48 [a]
Flavour	7.8±0.42 [a]	7.3±0.48 [a]	7.6±0.51 [a]	7.4±0.51 [a]
Overall Acceptability	7.6±0.48 [a]	7.4±0.52 [a]	7.5±0.48 [a]	7.3±0.48 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant($p<0.05$)

Where, T1 (control sample) = 100% wheat flour muffin, T2=15 % fig, T3=30% fig, T4 =45 % fig)

As shown in Table 5.22, sensory characteristics of wheat flour muffin substituted with fresh fig T2, T3 and T4 were non significantly ($p>0.05$) different from wheat flour muffin T1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour muffin substituted with fresh fig were not affected by increased concentration of fresh fig. In conclusion, T2 and T3 was found to be most acceptable as compared to T4, so wheat flour muffin sample was only substituted till 45 per cent.

Fig. 5.11 T1 (control sample) = 100% wheat flour muffin,

T2=15 % fig, T3=30% fig, T4 =45 % fig)

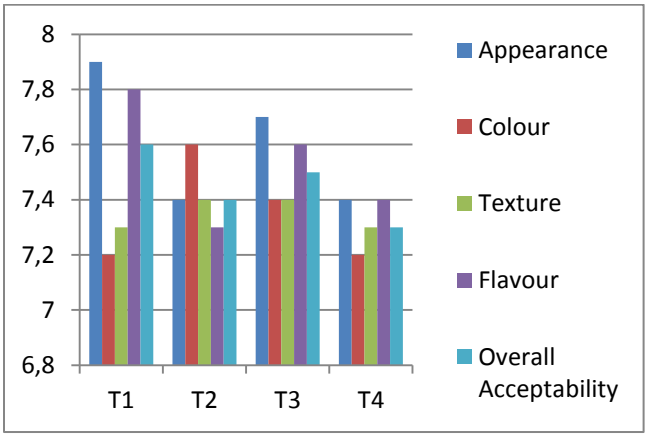

Fig. 5.12 Sensory scores of muffin samples

5.7 Noodles

5.7 (a) Nutritional composition

The moisture content (**Table 5.23**) of wheat flour noodles substituted with dried fig ranged from 6.61 per cent to 8.75 per cent. In control it was only 6.61 per cent increased non significantly with more replacement of dried fig fruit. Maximum value of moisture content i.e. 8.75 per cent was noted in T4. Similar increase in moisture content i.e. 11.35 per cent was reported in noodles substituted with sweet potato powder (Ibitoye *et al*. 2013). Taneya *et al.* (2014) also reported similar increase i.e. 6.27 per cent in wheat flour noodles substituted with potato flour. Similar increase i.e.8.67 per cent was reported in wheat flour noodles substituted with unripe banana flour (Ritthiruangdej *et al*. 2011).This increase in moisture content might be due to high moisture content in fruits (Mansour *et al*. 1999).

Table 5.23 Nutritional composition of noodles substituted with dried fig

Parameters	T1	T2	T3	T4
Moisture (%)	6.61 ± 0.16 [a]	8.26± 0.13 [a] (24.96%)↑	8.45± 0.12 [a] (27.83%)↑	8.75±3.24 [a] (32.37%)↑
Ash(%)	2.13 ± 0.00[a]	2.51± 0.10 [a] (17.84%)↑	2.84 ±0.09 [a] (33.33%)↑	3.67± 1.33 [a] (72.30%)↑
Carbohydrate (%)	85.53±0.01 [a]	95.85±0.30 [b] (12.06%)↑	105.60±0.1 [c] (23.46%)↑	114.58±0.07 [cd] (33.96%)↑
Protein (%)	6.51±0.11 [a]	7.44±0.08 [b] (14.28%)↑	7.48±1.05[bc] (14.90%)↑	7.84±0.08 [cd] (20.43%)↑
Fat (%)	1.56±0.02 [a]	1.62±0.07 [a] (3.84%)↑	1.73±0.04 [ab] (10.89%)↑	1.82±0.05 [bc] (16.66%)↑

The ash content of wheat flour noodles substituted with dried fig ranged from 2.13 per cent to 3.61 per cent. Similar results, i.e. 2.21 per cent was reported by Taneya *et al*. (2014) in wheat flour noodles. The ash content increased non significantly ($p>0.05$)in noodles samples. The ash content increased with increase in dried fig fruit substitution. Similar increase in ash content i.e. 2.21 to 2.44 per cent was reported in wheat flour noodles substituted with potato flour(Taneya *et al*.2014).Similar increase i.e. 0.93 to 1.04 per cent was reported in wheat flour bread substituted with bread fruit flour (Alice *et al.* 2012). Similar increase in ash content i.e. 2.17 to 2.39 per cent was reported in wheat flour cookies substituted with pitaya peel flour (Ho and Latif,2016). This increase in ash content might be due to high ash content in fruit (Brito *et al*.2006).

The carbohydrate content (**Table 5.23**) of wheat flour noodles substituted with dried fig ranged from 85.53 per cent to 114.58 per cent. In control it was only 85.53 per cent increased significantly with more replacement of dried fig fruit. Maximum value of carbohydrate content i.e. 114.58 per cent was noted in T4. Similar increase in carbohydrate content i.e. 97.57 per cent was reported in wheat flour bread substituted with breadfruit flour (Alice *et al.*2012).Ariffin *et al.* (2015) also reported similar increase in carbohydrate content i.e. 86.75 per cent in wheat flour bread substituted with durian flour. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour noodles substituted with dried fig ranged from 6.51 per cent to 7.84 per cent. Similar results, i.e. 6.73 per cent was reported by Ho and Latif (2016) in wheat flour cookies. The protein content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The protein content increased with increase in dried fig fruit substitution. Similar increase in protein content i.e.7.59 to 7.82 per cent was reported in wheat flour cookies substituted with breadfruit flour (Ojinnaka *et al.*2013).Similar increase in protein content i.e. 6.73 to 7.04 per cent was reported in wheat flour cookies substituted with pitaya peel flour (Ho and Latif,2016). This increase in protein content might be due to high protein content in fruits (Brito *et al*.2006).

The fat content (**Table 5.23**) of wheat flour noodles substituted with dried fig ranged from 1.56 per cent to 1.82 per cent. Similar results, i.e. 1.56 per cent was reported by Hardi *et al*. (2007) in wheat flour noodles. The fat content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The fat content was highest in T4 (1.82 %) and lowest in T1(1.56 %). Similar increase in fat content i.e. 1.3 to 3.9 per cent was reported in wheat flour noodles substituted with banana peel (Singh *et al*. 2015). This increase in fat content may be due to high fat content in fruits (Vinod *et al*. 2015).

5.7 (b) Dietary fiber

The neutral detergent fiber (**Table 5.24**) of wheat flour noodles substituted with dried fig ranged from 21.93 per cent to 23.90 per cent. NDF increased non significantly ($p>0.05$) in noodles substituted with dried fig. The NDF was highest in T4 (23.90 %) and lowest in T1(21.93 %). Similar increase in dietary fiber i.e. 24.20 per cent was reported in wheat flour noodles substituted with watermelon rind powder (Ho and Dahri, 2016). This increase in dietary fiber might be due to high dietary fiber in fruit mixture (Nwanekezi *et al.* 2015).

Table 5.24 Dietary fiber of noodles substituted with dried fig

Parameters	T1	T2	T3	T4
NDF (%)	21.93±1.90 [a]	22.50±2.16 [a] (2.59%)↑	23.70±1.70 [a] (8.07%)↑	23.90±0.26 [a] (8.98%)↑
ADF (%)	1.53±0.05 [a]	1.60±0.10 [a] (4.57 %)↑	1.76±0.11 [a] (15.03 %)↑	1.83±0.11 [ab] (19.60%)↑
Hemicellulose (%)	21.4±4.35 [a]	21.90±4.35 [b] (2.33%)↑	22.94±0.00 [c] (7.19%)↑	23.07±4.35 [cd] (7.80%)↑
Cellulose (%)	3.14±0.18 [a]	3.17±0.03 [b] (0.95%)↑	3.21±0.01 [a] (2.22%)↑	3.33±0.10 [a] (6.05%)↑
Lignin (%)	1.46±0.05 [a]	1.50±0.10 [a] (2.73 %)↑	1.53±0.05 [a] (4.79 %)↑	1.63±0.05 [a] (11.64 %)↑

The acid detergent fiber (ADF) of wheat flour noodles substituted with dried fig ranged from 1.53 per cent to 1.83 per cent. The ADF increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The ADF increased with increase in dried fig fruit substitution.

Hemicellulose content (**Table 5.24**) of wheat flour noodles substituted with dried fig ranged from 21.40 per cent to 23.07 per cent. Hemicellulose content increased significantly ($p<0.05$) in muffin samples substituted with dried fig. The hemicellulose content was highest in T4 (23.07%) and lowest in T1(21.40 %).

The cellulose content of wheat flour noodles substituted with dried fig ranged from 3.14 per cent to 3.33 per cent. The cellulose content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The cellulose content increased with increase in dried fig fruit substitution. This increase in dietary fiber might be due to the addition of dietary fiber rich fruits in noodles (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.24**) of wheat flour noodles substituted with dried fig ranged from 1.46 per cent to 1.63 per cent. Similar results, i.e. 1.08 per cent was reported by Gorecka *et al.* (2010) in wheat flour cookies. The results of the lignin content increased non significantly ($p>0.05$) in noodles samples substituted with dried fig. The lignin content was highest in T4 (0.63 %) and lowest in T1(0.46 %). Similar increase in dietary fiber i.e. 3.34 per cent was reported in wheat flour cookies substituted with potato flour (Pratyush *et al*. 2015). Similar increase in dietary fiber i.e. 0.75 per cent was reported in wheat flour biscuits substituted with jackfruit powder (Butool and Butool,2013).

5.7 (c) Mineral composition

The calcium content (**Table 5.25**) of wheat flour noodles substituted with dried fig ranged from 18.96 mg/100gm to 33.91 mg/100gm. In control it was only 18.96 mg/100gm increased significantly with more replacement of dried fig fruit. Maximum value of calcium content i.e. 33.91 mg/100gm was noted in T4. Similar increase in calcium content i.e. 32 per cent was reported in wheat flour cake substituted with beetroot powder (Pinki and Awasthi, 2014).Seleem (2015) also reported increase in calcium content i.e. 20.40 per cent in wheat flour cake

substituted with doum fruit powder. This increase in calcium content might be due to high mineral content in fruits (Seleem, 2015).

Table 5.25 Mineral composition of noodles substituted with dried fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	18.96±0.00 [a]	23.80±0.00 [b] (25.52%)↑	27.89±0.00 [c] (47.09%)↑	33.91±0.00 [cd] (78.85%)↑
Iron (mg/100gm)	10.92± 0.00[a]	14.96 ±0.00 [b] (36.99%)↑	18.14 ±0.00 [c] (66.11%)↑	70.14 ±0.00 [c] (542.30 %)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	333.39±0.00 [b] (2.86 %)↑	444.00±0.00 [c] (36.99%)↑	666.54±0.00 [cd] (105.65%)↑

The iron content of wheat flour noodles substituted with dried fig ranged from 10.92 mg/100gm to 70.14 mg/100gm. The iron content increased significantly ($p<0.05$) in all noodles samples substituted with dried fig. The iron content increased with increase in dried fig fruit substitution. Similar increase in iron content i.e. 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

The phosphorus content (**Table 5.25**) of wheat flour noodles substituted with dried fig ranged from 324.1 mg/100gm to 666.54 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The phosphorus content was highest in T4 (0.16 mg/100gm) and lowest in T1(0.11 mg/100gm).Similar increase in phosphorus content i.e. 467 per cent was reported in wheat flour cakes substituted with beetroot powder (Pinki and Awasthi, 2014).

Fig. 5.13 T1 (control sample = 100% wheat flour noodles,

T2=15 % fig, T3=30% fig, T4 =45 % fig)

5.8 Nugget

5.8 (a) Nutritional composition

The moisture content (**Table 5.26**) of green gram nugget substituted with dried fig ranged from 19.80 per cent to 20.80 per cent. In control it was only 19.80 per cent increased significantly with more replacement of dried fig fruit. Maximum value of moisture content i.e. 20.80 per cent was noted in T4. Similar increase in moisture content i.e.22.98 per cent was reported in composite pulse flour chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in moisture content might be due to high moisture content in fruits (Nwanekezi *et al.* 2015).

Table 5.26 Nutritional composition of nugget substituted with dried fig

Parameters	T1	T2	T3	T4
Moisture (%)	19.80±0.1 [a]	19.85±0.09 [a] (0.25%)↑	20.15±0.09 [b] (1.76%)↑	20.80±0.00 [b c] (5.05%)↑
Ash (%)	1.10±0.05 [a]	1.16±0.05 [a] (5.45%)↑	1.19±0.05 [a] (8.18 %)↑	1.29±0.20 [a] (17.27%)↑
Carbohydrate (%)	65.64±0.22 [a]	72.48±2.11 [b] (10.42%)↑	82.50±1.09 [c] (25.68%)↑	93.78±0.63 [cd] (42.87%)↑
Protein (%)	13.34±0.08 [a]	13.59±0.08 [b] (1.87%)↑	14.39±0.08 [c] (7.87%)↑	14.72±0.08 [cd] (10.34%)↑
Fat (%)	1.85±2.71 [a]	2.20±0.05 [b] (18.91%)↑	2.27±0.02 [bc] (22.70%)↑	2.33± 0.07 [bd] (25.94%)↑

The ash content of green gram nugget substituted with dried fig ranged from 1.37 per cent to 1.77 per cent. The ash content increased non significantly ($p>0.05$) in nugget samples substituted with dried fig. The ash content increased with increase in dried fig fruit substitution. Similar increase in ash content i.e. 1.20 to 1.72 per cent was reported in gram composite flour

chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in ash content might be due to high ash content in fruit(Nwanekezi *et al.* 2015).

The carbohydrate content (**Table 5.26**) of green gram nugget substituted with dried fig ranged from 65.64 per cent to 93.78 per cent. Similar results, i.e. 65.50 per cent was reported by Aziz *et al*. (2012) in nugget. In control it was only 65.64 per cent increased significantly with more replacement of fresh dried fruit. Maximum value of carbohydrate content i.e. 93.78 per cent was noted in T4. Similar increase in carbohydrate content i.e. 65.78 per cent was reported in pulse based weaning food substituted with banana fruit (Mishra *et al.* 2014). Singh *et al.*(2014) also reported similar increase in carbohydrate content i.e. 70.72 per cent in bengal gram dal substituted with kondhara leaves. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of green gram nugget substituted with dried fig ranged from 13.34 per cent to 14.72 per cent. The protein content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The protein content increased with increase in dried fig fruit substitution. Similar increase in protein content i.e. 11.48 to 30.44 per cent protein content was reported in bengal gram dal substituted with kondhara leaves (Sultana *et al.* 2014). Similar increase in protein content i.e. 14.26 to 14.80 per cent was reported in legume composite flour thalipeeth (pan cake like product) substituted with green leafy vegetables (Gupta and Prakash,2011). This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.26**) of green gram nugget substituted with dried fig ranged from 1.85 per cent to 2.33 per cent. Similar results, i.e. 1.30 per cent was reported by Pardeshi *et al*. (2013) in nugget. The fat content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The fat content was highest in T4 (2.33 %) and lowest in T1(1.85 %). Similar increase in fat content i.e. 1.28 per cent was reported in composite gram flour based chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in fat content may be due to high fat content in fruits (Nwanekezi *et al.* 2015).

5.8 (b) Dietary fiber

The neutral detergent fiber (**Table 5.27**) of green gram nugget substituted with dried fig ranged from 23.56 per cent to 24.20 per cent. NDF increased non significantly ($p>0.05$) in nugget samples substituted with dried fig. The NDF was highest in T4 (24.20 %) and lowest in T1 (23.56 %). Similar increase in dietary fiber i.e. 18.15 per cent was reported in composite gram flour chakli (Rosy *et al.* 2015). This increase in dietary fiber might be due to proportionally increase in dietary fiber in fruits (Rupasinghe *et al.* 2008).

Table 5.27 Dietary fiber of nugget substituted with dried fig

Parameters	T1	T2	T3	T4
NDF (%)	23.56±0.11 [a]	23.63±0.11 [a] (3.94%)↑	24.06±0.32 [a] (2.12%)↑	24.20±1.04 [a] (2.71%)↑
ADF (%)	21.06±0.92 [a]	21.33±1.15 [a] (1.28%)↑	21.73±0.23 [a] (3.18%)↑	21.76±1.85 [a] (3.32%)↑
Hemicellulose (%)	1.97±0.00 [a]	2.36±0.00 [b] (19.79%)↑	2.47±0.00 [c] (25.38%)↑	2.50±0.00 [cd] (26.90%)↑
Cellulose (%)	11.88±0.65 [a]	11.51±0.65 [a] (3.11%)↑	11.89±0.61 [a] (0.08%)↑	12.54±0.66 [a] (5.55%)↑
Lignin (%)	1.68±0.00 [b]	1.70±0.00 [a] (1.19%)↑	1.71±0.00 [ac] (1.78%)↑	1.73±0.01 [a] (2.97%)↑

The acid detergent fiber (ADF) of nugget substituted with dried fig ranged from 21.06 per cent to 21.76 per cent. The ADF content increased non significantly ($p>0.05$) in nugget samples substituted with dried fig. The ADF increased with increase in dried fig fruit substitution.

Hemicellulose content (**Table 5.27**) of nugget substituted with dried fig ranged from 1.97 per cent to 2.50 per cent. Hemicellulose content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The hemicellulose content was highest in T4 (2.50 %) and lowest in T1(1.97 %).Similar increase in hemicellulose content i.e.0.38 to 0.51 per cent was reported in gram dal substituted with bathua leaves (Singh *et al.* 2007). Singh *et al.*(2014) also reported similar increase i.e. 0.25 to 5.75 per cent dietary fiber in bengal gram dal substituted with kondhara leaves.

The cellulose content of nugget substituted with dried fig ranged from 11.88 per cent to 12.54 per cent. The cellulose content increased non significantly ($p<0.05$) in cellulose content was observed in all nugget samples substituted with dried fig. The cellulose content increased with increase in dried fig fruit substitution. This increase in cellulose content might be due to addition of dietary fiber rich fruits in nugget (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.27**) of nugget substituted with dried fig ranged from 1.68 per cent to 1.73 per cent. The results of the lignin content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The lignin content was highest in T4 (1.73 %) and lowest inT1(1.68 %). Similar increase in dietary fiber i.e. 1.82 per cent was reported in gram composite flour khakara substituted with carrot powder (Surekha and Naik, 2014).Verma and Singh (2014) also reported similar increase in lignin content i.e. 1.28 per cent in besan laddu substituted with mushroom powder.

5.8 (c) Mineral composition

The calcium content (**Table 5.28**) of nugget substituted with dried fig ranged from 146.79 mg/100gm to 333.29 mg/100gm.In control it was only 146.79 mg/100gm increased significantly with more replacement of dried fig fruit. Maximum value of calcium content i.e. 333.29 mg/100gm was noted in T4. Similar increase in calcium content i.e. 335.0 per cent was

reported in bengal gram dal substituted with kondhara leaves (Singh *et al.*2014).This increase in calcium content might be due to high mineral content in fruits (Armeu *et al.* 2006).

Table 5.28 Mineral composition of nugget substituted with dried fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	146.79± 0.00 [a]	241.01±0.00 [b] (64.18%)↑	307.95±0.00 [c] (109.78%)↑	339.29±0.00 [cd] (131.13%)↑
Iron (mg/100gm)	10.92±0.00 [a]	16.04±0.00 [b] (46.61%)↑	18.14±0.00 [c] (66.11%)↑	19.88±0.00 [cd] (82.05%)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	666.54±0.00 [b] (105.65%)↑	704.27±0.00 [c] (117.30%)↑	754.35±0.00 [cd] (132.75%)↑

The iron content of nugget substituted with dried fig ranged from 10.92 mg/100gm to 19.88 mg/100gm. The iron content significantly increase ($p<0.05$) in nugget samples substituted with dried fig. The iron content increased with increase in dried fig fruit substitution. Similar increase in iron content i.e. 3.90 to 8.99 per cent was reported in legume composite flour thalipeeth (pan cake like product) substituted with green leafy vegetables (Gupta and Prakash, 2011). Singh *et al.*(2014) also reported similar increase in iron content i.e. 7.25 to 28.77 per cent in bengal gram dal substituted with kondhara leaves. Similar increase in iron content i.e. 6.10 to 6.34 per cent was reported in gram composite flour khakara substituted with carrot powder (Surekha and Naik, 2014).

The phosphorus content (**Table 5.28**) of nugget substituted with dried fig ranged from 324.1 mg/100gm to 754.35 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$)in nugget samples substituted with dried fig. The phosphorus content increased with increase in dried fig fruit substitution. The phosphorus content was highest in T3 (754.35 mg/100gm) and lowest in T1(324.1 mg/100gm). Similar increase in phosphorus content i.e. 320 to 378 per cent was reported in gram composite flour roti substituted with methi powder (Kadam *et al*.2012).

Fig. 5.14 T1 (control sample = 100% green gram nugget,

T2=15 % fig, T3=30% fig, T4 =45 % fig)

5.9 Formulation of value added products with the substitution of karonda

5.9 (a) Bun

5.9 (b) Nutritional composition

The moisture content (**Table 5.29**) of wheat flour bun substituted with fresh karonda fruit ranged from 6.47 per cent to 9.87 per cent. In control it was only 6.47 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of moisture content i.e. 9.87 per cent was noted in B4. Similar increase in moisture content i.e. 9.50 per cent was reported in biscuit substituted with date palm fruit (Sharnouby *et al.* 2012). This increase in moisture content might be due to high moisture content in fresh fruit (Rosell *et al.* 2011).

The ash content of wheat flour bun substituted with fresh karonda ranged from 1.10 per cent to 1.29 per cent. The ash content increased non significantly ($p>0.05$) in bun samples substituted with fresh karonda. The ash content increased with increase in fresh karonda fruit substitution. Similar increase in ash content i.e. 1.30 to 1.60 per cent was reported in wheat flour bun substituted with ripe pawpaw pulp (Adubofuor and Mensah, 2012). See *et al.* (2007) also reported similar increase in ash content i.e.1.83 to 2.43 per cent in bread substituted with pumpkin flour. This increase in ash content might be due to the high ash content in fruit (El-Sharnouby *et al.* 2012).

The carbohydrate content (**Table 5.29**) of wheat flour bun substituted with fresh karonda ranged from 75.52 per cent to 107.56 per cent. In control it was only 75.52 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of carbohydrate content i.e. 107.56 per cent was noted in B4. Similar increase in carbohydrate content i.e. 78.69 per cent was reported in cookies substituted with unripe plantain flour (Chinma *et al*. 2012). This increase in carbohydrate content may be due to high carbohydrate content in fruits (Kulkarni and Joshi, 2014).

Table 5.29 Nutritional composition of bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
Moisture (%)	6.47± 0.02[a]	7.45±0.01[b] (15.14%) ↑	8.24±0.66[cd] (52.55%)↑	9.87±0.02[c] (27.35%)↑
Ash (%)	1.10±0.05[a]	1.16±0.05[a] (3.59 %)↑	1.19±0.05[a] (7.91 %)↑	1.29±0.20[a] (23.74 %)↑
Carbohydrate (%)	75.52±0.01[a]	89.58±0.07[b] (18.61%)↑	98.05±0.05[c] (29.83%)↑	107.56±0.05[cd] (42.42%)↑
Protein (%)	6.64±0.14[a]	6.79±0.08[a] (2.25%)↑	7.10±0.1[b] (6.92%)↑	7.52±0.08[bc] (13.25%)↑
Fat (%)	1.62±0.07[a]	1.73±0.04[a] (6.79%)↑	1.82±0.05[a] (12.34%)↑	1.92±0.28[a] (18.52%)↑

Where, B1 (control sample) = 100% wheat flour bun, B2= 15% karonda, B3=30% karonda, B4= 45% karonda)

The protein content of wheat flour bun substituted with fresh karonda ranged from 6.64 per cent to 7.52 per cent. The protein content significantly increase ($p<0.05$) in all bun samples substituted with fresh karonda. The protein content increased with increase in fresh karonda fruit substitution. Similar increase in protein content i.e. 7.01 to 7.69 per cent was reported in bread substituted with bread fruit flour (Alice *et al*. 2012). Youssef *et al.* (2012) also reported similar increase in protein content i.e. 7.01 to 7.69 per cent in wheat flour biscuit substituted with citrus peels powder. This increase in protein content might be due to high protein content in fruits (Thorvaldsson and Skjoldebrand, 1998).

The fat content (**Table 5.29**) of wheat flour bun substituted with fresh karonda ranged from 1.62 per cent to 1.92 per cent. Similar results, i.e. 1.57 per cent was reported by Michael *et al*. (2013) in wheat flour bread. The fat content non significantly increase ($p>0.05$) in bun samples substituted with fresh karonda. The fat content was highest in B4 (1.92 %) and lowest in B1(1.62 %). Similar increase in fat content i.e. 1.41 per cent was reported in wheat flour cookie substituted with unripe plantain flour (Chinma *et al*. 2012). This increase in fat content may be due to relative increase in fat content in fruits (Kulkarni and Joshi, 2014).

5.9 (c) Dietary fiber

The neutral detergent fiber (**Table 5.30**) of wheat flour bun substituted with fresh karonda ranged from 23.73 per cent to 25.66 per cent. Similar results, i.e. 23.16 per cent was reported by Krishan *et al.* (1987) in wheat flour bread. NDF increased significantly ($p<0.05$)in bun samples substituted with fresh karonda. The NDF was highest in B4 (25.66 %) and lowest in B1(23.73 %). Similar increase in dietary fiber i.e. 24.20 per cent was reported in bread substituted with watermelon rind (Ho and Dahri, 2016). Lopez *et al.* (2011) also reported similar increase i.e. 25.20 per cent in bread substituted with orange powder (Lopez *et al.* 2011). This increase in dietary fiber might be due to high dietary fiber in fruits (El- Sharnouby *et al.* 2012).

The acid detergent fiber (ADF) of wheat flour bun substituted with fresh karonda ranged from 1.30 per cent to 1.66 per cent. The ADF content increased non significantly ($p>0.05$)in bun samples substituted with fresh karonda. ADF increased with increase in fresh karonda fruit substitution. Similar increase in dietary fiber i.e. 0.75 to 1.13 per cent was reported in wheat flour cookie substituted with mango seed kernel (Legesse and Emire, 2012).

Table 5.30 Dietary fiber of bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
NDF (%)	23.73±0.10[a]	24.23±0.05[a] (2.10%)↑	24.83±0.98[a] (4.63%)↑	25.66±0.23[ab] (8.13%)↑
ADF (%)	1.30±0.45[a]	1.56±0.20[a] (20.0%)↑	1.60±0.17[a] (23.07%)↑	1.66±0.11[a] (27.69%)↑
Hemicellulose (%)	22.39±0.00[a]	22.69±0.00[a] (1.33%)↑	23.22±0.00[a] (3.70%)↑	23.99±0.00[a] (7.14%)↑
Cellulose (%)	2.48±0.10[a]	2.59±0.04[a] (4.43%)↑	2.64±0.05[a] (6.45%)↑	2.83±0.10[b] (14.11%)↑
Lignin (%)	1.23±0.63[a]	1.63±0.05[a] (32.52%)↑	1.66 ±0.05[a] (34.95 %)↑	1.73±0.05[a] (40.65 %)↑

Hemicellulose content (**Table 5.30**) of wheat flour bun substituted with fresh karonda ranged from 23.39 per cent to 23.99 per cent. Hemicellulose content increased non significantly ($p>0.05$) in bun samples substituted with fresh karonda. The hemicellulose content was highest in B4 (23.99 %) and lowest in B1(22.39 %).

The cellulose content of wheat flour bun substituted with fresh karonda ranged from 2.48 per cent to 2.83 per cent. The cellulose content significantly increased ($p<0.05$) in bun samples substituted with fresh karonda. The cellulose content increased with increase in fresh karonda fruit substitution. Similar increase in cellulose content i.e. 0.02 to 7.66 per cent was reported in

cookies substituted with raspberry pomace fruit (Gorecka *et al.* 2010). This increase in dietary fiber might be due to addition of cellulose rich fruits (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.30**) of wheat flour bun substituted with fresh karonda ranged from 1.23 per cent to 1.73 per cent. The results of the lignin content increased non significantly ($p>0.05$)in bun samples substituted with fresh karonda. The lignin content was highest in B4 (0.75 %) and lowest in B1(0.56 %). Similar increase in lignin content i.e.3.98 per cent was reported in wheat flour biscuits substituted with raspberry pomace fruit (Gorecka *et al.* (2010).

5.9 (d) Mineral composition

The calcium content (**Table 5.31**) of wheat flour bun substituted with fresh karonda ranged from 10.80 mg/100gm to 94.05 mg/100gm. Similar results, i.e. 10.70 mg/100gm was reported by Surekha *et al*. (2013) in wheat flour cookie. In control it was only 10.80 mg/100gm increased significantly with more replacement of fresh karonda fruit. Maximum value of calcium content i.e. 94.05 mg/100gm was noted in B4. Similar increase in calcium content i.e. 32 per cent was reported in wheat flour cake substituted with beetroot powder (Pinki and Awasthi, 2014). Seleem (2015) also reported similar increase in calcium content i.e. 20.40 per cent in wheat flour cake substituted with doum fruit powder. This increase in calcium content might be due to high mineral content in fruits (Kulkarni and Joshi, 2013).

The iron content of wheat flour bun substituted with fresh karonda ranged from 25.83 mg/100gm to 369.12 mg/100gm. The iron content significantly increase ($p<0.05$) in bun samples substituted with fresh karonda. The iron content increased with increase in fresh karonda fruit substitution. Similar increase in iron content i.e. 21 to 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

Table 5.31 Mineral composition of bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
Calcium (mg/100gm)	10.80 ± 0.00^{a}	49.57 ± 0.00^{b} (358.98%)↑	57.40 ± 0.00^{c} (431.48%)↑	94.05 ± 0.00^{cd} (770.83%)↑
Iron (mg/100gm)	25.83 ± 0.00^{a}	307.61 ± 0.00^{b} (1090.90%)↑	355.43 ± 0.00^{c} (1276.03%)↑	369.12 ± 0.00^{cd} (1329.0%)↑
Phosphorus (mg/100gm)	333.39 ± 0.00^{a}	416.77 ± 0.00^{b} (25.0%)↑	443.73 ± 0.00^{c} (33.09%)↑	501.13 ± 5.77^{cd} (50.31%)↑

The phosphorus content (**Table 5.31**) of wheat flour bun substituted with fresh karonda ranged from 333.39 mg/100gm to 501.13 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in bun samples substituted with fresh karonda. The phosphorus content was highest in B4 (501.13 mg/100gm) and lowest in B1(333.39 mg/100gm). Similar increase in phosphorus content i.e.377.15 per cent was reported in wheat flour chapatti substituted with date pulp (Waghray *et al.*2011). Similar increase in phosphorus content i.e. 540 per cent was reported in wheat bran biscuit substituted with palm fruit (El- Sharnouby *et al*. 2012).

5.9 (e) Organoleptic Analysis

Table 5.32 Bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
Appearance	7.4±0.69[a]	7.5±0.52 [a]	7.4±0.51 [a]	7.2±0.42 [a]
Colour	7.2±0.42 [a]	7.4±0.51 [a]	7.6±0.52 [a]	7.2±0.42 [a]
Texture	7.2±0.63 [a]	7.5±0.52 [a]	7.5±0.52 [a]	7.2±0.42 [a]
Flavour	7.5±0.52 [a]	7.4±0.51 [a]	7.6±0.51 [a]	7.3±0.48 [a]
Overall Acceptability	7.3±0.48 [a]	7.5±0.52 [a]	7.5±0.52 [a]	7.2±0.63 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant($p<0.05$)

Where, B1 (control sample) = 100% wheat flour bun, B2=15 % karonda, B3=30% karonda, B4 =45 %karonda)

As shown in Table 5.32, sensory characteristics of wheat flour bun substituted with fresh karonda B2, B3 and B4 were non significantly ($p>0.05$) different from wheat flour bun B1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour bun substituted with fresh karonda were not affected by increased concentration of fresh karonda. However, all samples were found to be acceptable.

Fig. 5.15 B1(control sample) = 100% wheat flour bun,

B2=15 % karonda,B3=30% karonda, B4 =45 % karonda)

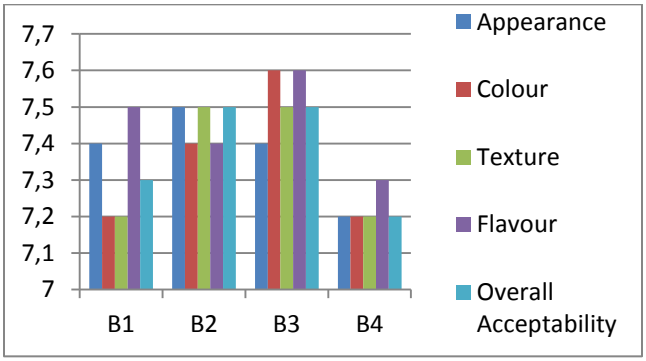

Fig. 5.16 Sensory scores of bun samples

5. 10 Muffin

5.10 (a) Nutritional composition

The moisture content (**Table 5.33**) of wheat flour muffin substituted with fresh karonda ranged from 10.80 per cent to 20.80 per cent. Similar results, i.e. 10.96 per cent was reported by Uchenna *et al*. (2013) in wheat flour muffin. In control it was only 10.80 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of moisture content i.e. 20.80 per cent was noted in B4.Similarincrease in moisture content i.e. 9.50 per cent was reported in wheat bran biscuits substituted with date palm powder (El- Sharnouby *et al.* 2012). Mansour *et al.* (1999) also reported similar increase in moisture content in wheat flour muffin substituted with pumpkin powder. This increase in moisture content might be due to high moisture content in fruits (Rosell *et al.* 2011).

Table 5.33 Nutritional composition of muffin substituted with fresh karonda

Parameters	B1	B2	B3	B4
Moisture (%)	10.80 ± 0.1^{a}	20.66 ± 0.05^{b} (91.29%)↑	19.68 ± 0.09^{c} (102.12%)↑	21.83 ± 0.00^{ad} (82.22%)↑
Ash(%)	1.12 ± 0.11^{a}	1.13 ± 0.10^{a} (0.89 %)↑	1.19 ± 0.05^{a} (6.25 %)↑	1.28 ± 0.19^{a} (14.28 %)↑
Carbohydrate (%)	45.45 ± 0.48^{a}	52.29 ± 2.22^{b} (15.04%)↑	61.16 ± 3.20^{c} (34.56%)↑	70.07 ± 0.02^{cd} (54.16%)↑
Protein (%)	6.42 ± 0.12^{a}	7.16 ± 0.05^{a} (11.52%)↑	7.52 ± 0.08^{b} (17.13%)↑	7.76 ± 0.08^{bc} (20.87%)↑
Fat (%)	10.33 ± 0.11^{a}	11.53 ± 0.11^{b} (11.61%)↑	12.53 ± 0.11^{c} (21.29%)↑	12.73 ± 0.11^{cd} (23.23%)↑

The ash content of wheat flour muffin substituted with fresh karonda ranged from 1.12 per cent to 1.28 per cent. The ash content non significantly increase ($p>0.05$) in muffin samples substituted with fresh karonda. The ash content increased with increase in fresh karonda fruit

substitution. Similar increase in ash content i.e.1.42 to 1.52 per cent was reported in muffin substituted with apple skin powder (Rupasinghe *et al.* 2008). Lopez *et al.* (2011) also reported similar increase in ash content i.e. 2.20 to 3.70 per cent in muffin substituted with orange powder. This increase in ash content might be due to high ash content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.33**) of wheat flour muffin substituted with fresh karonda ranged from 45.45 per cent to 70.07 per cent. Similar results, i.e. 45.08 per cent was reported by Krishanaprabha and Kiruthiga (2015) in wheat flour muffin. In control it was only 45.45 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of carbohydrate content i.e. 70.07 per cent was noted in B4. Similar increase in carbohydrate content i.e. 64.81 per cent was reported in wheat flour biscuit substituted with pumpkin powder (Kulkarni and Joshi, 2013). This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour muffin substituted with fresh karonda ranged from 6.42 per cent to 7.76 per cent. Similar results, i.e. 6.73 per cent was reported by Jauharah *et al.* (2014) in wheat flour muffin. The protein content significantly increase ($p<0.05$) in muffin samples substituted with fresh karonda. The protein content increased with increase in fresh karonda fruit substitution. Similar increase in protein content i.e.6.10 to 7.0 per cent was reported in wheat flour cake substituted with beetroot powder (Pinki and Awasthi, 2014). Jauharah *et al.* (2014) also reported similar increase in protein content in muffin substituted with corn powder. This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.33**) of wheat flour muffin substituted with fresh karonda ranged from 10.33 per cent to 12.73 per cent. The fat content significantly increase ($p<0.05$) in muffin samples substituted with fresh karonda. The fat content was highest in B4 (12.73 %) and lowest in B1(10.33 %). Similar increase in fat content i.e. 12.80 per cent was reported in wheat flour cookies substituted with mango kernel seed (Legesse and Emire,2012). Waghray *et al.* (2011) also reported similar increase in fat content i.e. 7.54 per cent in wheat flour chapatti substituted with dates. This increase in fat content may be due to high fat content in fruits (Asp and Bjorck, 1992).

5. 10 (b) Dietary fiber

The neutral detergent fiber (**Table 5.34**) of wheat flour muffin substituted with fresh karonda ranged from 23.66 per cent to 25.30 per cent. NDF increased non significantly ($p>0.05$) in muffin samples substituted with fresh karonda. The NDF was highest in B4 (25.30 %) and lowest in B1(23.66 %). Similar increase in NDF i.e. 24.68 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to relative increase of fiber content in fruits (Sadiq*et al.* 2003).

Table 5.34 Dietary fiber of muffin substituted with fresh karonda

Parameters	B1	B2	B3	B4
NDF(%)	23.66 ± 0.15^{a}	24.10 ± 0.34^{a} (1.85%)↑	24.46 ± 0.86^{a} (3.38%)↑	25.30 ± 0.86^{a} (6.93) ↑
ADF(%)	5.46 ± 0.63^{a}	6.06 ± 0.63^{a} (10.98%)↑	6.20 ± 1.10^{a} (13.55%)↑	6.56 ± 0.63^{a} (20.14%)↑
Hemicellulose (%)	17.86 ± 0.00^{a}	18.03 ± 0.00^{b} (0.95%)↑	18.25 ± 0.00^{c} (2.18%)↑	18.32 ± 0.00^{cd} (2.57%)↑
Cellulose(%)	4.18 ± 0.19^{a}	4.22 ± 0.19^{a} (0.95%)↑	4.26 ± 0.19^{a} (1.91%)↑	4.27 ± 0.19^{a} (2.15%)↑
Lignin (%)	1.60 ± 0.01^{b}	1.72 ± 0.02^{a} (7.50%)↑	1.73 ± 0.01^{a} (8.12%)↑	1.74 ± 0.01^{ab} (8.75%)↑

The acid detergent fiber (ADF) of wheat flour muffin substituted with fresh karonda ranged from 5.46 per cent to 6.56 per cent. The ADF content non significantly increase ($p>0.05$) in muffin samples substituted with fresh karonda. ADF increased with increase in fresh karonda fruit substitution. Similar increase in ADF i.e. 1.11 to 8.05 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010).

Hemicellulose content (**Table 5.34**) of wheat flour muffin substituted with fresh karonda ranged from 17.86 per cent to 18.32 per cent. Hemicellulose content increased significantly ($p<0.05$) in muffin samples substituted with fresh karonda. The hemicellulose content was highest in B4 (18.32 %) and lowest in B1(17.86 %). Similar increase in dietary fiber i.e. 19.00 per cent was reported in wheat flour biscuit substituted with grape pomace (Szkudlarz *et al.* 2013).

The cellulose content of wheat flour muffin substituted with fresh karonda ranged from 4.18 per cent to 4.27 per cent. Similar results, i.e. 4.50 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. The cellulose content non significantly increase ($p>0.05$) in cellulose content was observed in muffin samples substituted with fresh karonda. The cellulose content increased with increase in fresh karonda fruit substitution. Similar increase in dietary fiber i.e. 1.44 to 4.24 per cent was observed in wheat flour cookies substituted with unripe plantain flour (Chinma *et al.* 2012). Similar increase in cellulose content i.e. 0.02 to 4.07 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to addition of dietary fiber rich fruits in muffin, especially cellulose content (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.34**) of wheat flour muffin substituted with fresh karonda ranged from 1.60 per cent to 1.74 per cent. Similar results, i.e. 1.80 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. The results of lignin content increased significantly ($p<0.05$) in muffin samples substituted with fresh karonda. The lignin content was highest in B4 (1.74 %) and lowest in B1(1.60 %). Similar increase in dietary fiber i.e. 1.28 per cent was reported in wheat flour mathri substituted with potato flour (Kaur and Kochhar,2014).

5.10 (c) Mineral composition

The calcium content (**Table 5.35**) of wheat flour muffin substituted with fresh karonda ranged from 146.79 mg/100gm to 234.41 mg/100gm. In control it was only 146.79 mg/100gm increased significantly with more replacement of fresh karonda fruit. Maximum value of calcium content i.e. 234.41 mg/100gm was noted in B4. Similar increase in calcium content i.e. 148.33 per cent was reported in muffin substituted with carrot powder (Romjaun and

Prakash, 2015). This increase in calcium content might be due to high mineral content in fruits (Waghray *et al.* 2011).

Table 5.35 Mineral composition of muffin substituted with fresh karonda

Parameters	B1	B2	B3	B 4
Calcium (mg/100gm)	146.79±0.00^{a}	148.16±0.00^{a} (0.93%)↑	172.97±0.00^{a} (17.83%)↑	234.41±51.96^{ab} (59.69%)↑
Iron (mg/100gm)	10.92±0.00^{a}	11.33±0.00^{b} (3.75%)↑	12.07±0.00^{c} (10.53%)↑	13.31±0.00^{cd} (21.88%)↑
Phosphorus (mg/100gm)	62.40±0.00^{a}	72.28±0.00^{b} (15.83%)↑	76.86±0.00^{c} (23.17%)↑	81.74±0.00^{cd} (30.99%)↑

The iron content of wheat flour muffin substituted with fresh karonda ranged from 10.92 mg/100gm to 13.31 mg/100gm. The result of iron content significantly increase ($p<0.05$) in muffin samples substituted with fresh karonda. The iron content increased with increase in fresh karonda fruit substitution. Seleem (2013) also reported similar increase in iron content i.e. 4.80 to 5.03 per cent in wheat flour muffin substituted with doum fruit powder.

The phosphorus content (**Table 5.35**) of wheat flour muffin substituted with fresh karonda ranged from 62.40 mg/100gm to 81.74 mg/100gm.The results of the phosphorus content increased significantly ($p<0.05$)in muffin samples substituted with fresh karonda. The phosphorus content was highest in B4 (81.74 mg/100gm) and lowest in B1(62.40 mg/100gm).

5.10 (d) Organoleptic analysis

Table 5.36 Muffin substituted with fresh karonda

Parameters	B1	B2	B3	B4
Appearance	7.9±0.31 [a]	7.4±0.51 [a]	7.4±0.48 [a]	7.2±0.42 [a]
Colour	7.2±0.42 [a]	7.4±0.51 [a]	7.6±0.51 [a]	7.1±0.56 [a]
Texture	7.3±0.48 [a]	7.7±0.48 [a]	7.5±0.52 [a]	7.4±0.51 [a]
Flavour	7.8±0.42 [a]	7.5±0.52 [a]	7.4±0.51 [a]	7.3±0.48 [a]
Overall Acceptability	7.6±0.51 [a]	7.6±0.51 [a]	7.5±0.52 [a]	7.4±0.51 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant ($p<0.05$)

Where, B1 (control sample) = 100% wheat flour bun, B2=15 % karonda, B3=30% karonda, B4 =45 % karonda)

As shown in Table 5.36, sensory characteristics of wheat flour muffin substituted with fresh karonda B2, B3 and B4 were non significantly ($p>0.05$) different from wheat flour muffin B1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour muffin substituted with fresh karonda were not affected by increased concentration of fresh karonda. However, all samples were found to be acceptable.

Fig. 5.17 B1 (control sample) = 100% wheat flour muffin,

B2 =15 % karonda, B3 =30% karonda, B4 =45 % karonda)

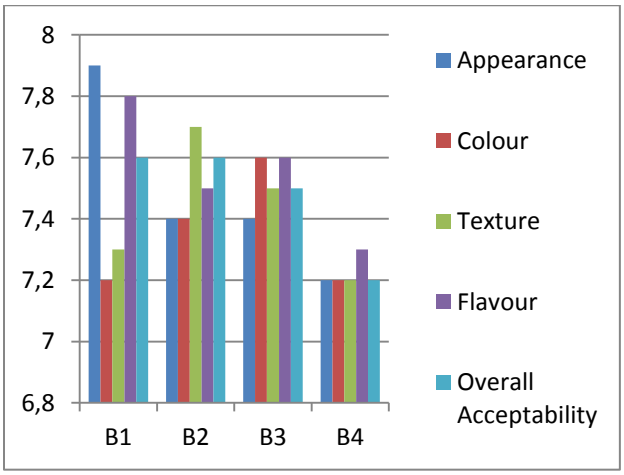

Fig. 5.18 Sensory scores of muffin samples

5.11 Noodles

5.11 (a) Nutritional composition

The moisture content (**Table 5.37**) of wheat flour noodles substituted with dried karonda ranged from 6.61 per cent to 9.88 per cent. In control it was only 6.61 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of moisture content i.e. 9.88 per cent was noted in B4. Similar increase in moisture content i.e. 9.73 per cent in wheat flour pasta substituted with orange fiber (Crizel *et al.* 2015). Similar increase in moisture content i.e. 8.67 per cent was also reported in wheat flour noodles substituted with unripe banana flour (Ritthiruangdej *et al*. 2011). This increase in moisture content might be due to relative increase of moisture content in fruits (Raj and Masih, 2014).

The ash content of wheat flour noodles substituted with dried karonda ranged from 2.00 per cent to 2.13 per cent. Similar results, i.e. 2.21 per cent was reported by Taneya *et al*. (2014) in wheat flour noodles. The ash content non significantly increase ($p>0.05$) in noodles samples substituted with dried karonda. The ash content increased with increase in dried karonda fruit substitution. Similar increase in ash content i.e. 0.87 to 1.64per cent was reported in wheat flour spaghetti substituted with banana flour (Diaz *et al.*2014). This increase in ash content might be due to high ash content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.37**) of wheat flour noodles substituted with dried karonda ranged from 85.53 per cent to 112.56 per cent. In control it was only 85.53 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of carbohydrate content i.e. 112.56 per cent was noted in B4. Similar increase in carbohydrate content i.e. 97.57 per cent was reported in wheat flour bread substituted with breadfruit flour (Alice *et al.* 2012). Ariffin *et al.* (2015) also reported similar increase in carbohydrate content i.e. 86.75 per cent in wheat flour bread substituted with durian fruit flour. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

Table 5.37 Nutritional composition of noodles substituted with dried karonda

Parameters	B1	B2	B3	B4
Moisture (%)	6.61 ± 0.16 [a]	7.44± 0.01 [b] (12.56%)↑	7.65 ± 0.99 [cd] (49.47%)↑	9.88 ± 0.04 [c] (15.73%)↑
Ash(%)	2.00± 0.05 [a]	2.04 ± 0.10 [a] (2.00%)↑	2.11 ± 0.05 [a] (5.50%)↑	2.13 ± 0.00[a] (6.50%) ↑
Carbohydrate (%)	85.53±0.01 [a]	94.58±0.07 [b] (10.58%)↑	103.05±0.05[c] (20.48%)↑	112.56±0.05 [cd] (31.60%)↑
Protein (%)	6.51±0.11 [a]	6.79±0.08 [b] (4.30%)↑	7.10±0.1 [c] (9.06%)↑	7.52±0.08 [cd] (15.51%)↑
Fat (%)	1.56±0.02 [a]	2.20±0.07 [b] (41.02%)↑	2.70±0.39[bc] (73.07%)↑	3.59±0.03 [cd] (130.12%)↑

The protein content of wheat flour noodles substituted with dried karonda ranged from 6.51 per cent to 7.52 per cent. Similar results, i.e. 6.73 per cent was reported by Ho and Latif (2016) in wheat flour cookies. The protein content significantly increase ($p<0.05$) in noodles samples substituted with dried karonda. The protein content increased with increase in dried karonda fruit substitution. Similar increase in protein content i.e. 6.73 to 7.04 per cent was reported in wheat flour cookies substituted with pitaya peel flour (Ho and Latif, 2016). This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.37**) of wheat flour noodles substituted with dried karonda ranged from 1.56 per cent to 3.59 per cent. Similar results, i.e. 1.56 per cent was reported by Hardi *et al*. (2007) in wheat flour noodles. The fat content significantly increase ($p<0.05$) in noodles samples substituted with dried karonda. The fat content was highest in B4 (3.59 %) and lowest in B1(1.56 %). Similar increase in fat content i.e. 5.20 per cent was reported in wheat flour noodles substituted with banana peel (Singh *et al.* 2015). This increase in fat content may be due to relative increase of fat content in fruits (Vinod *et al*. 2015).

5.11 (b) Dietary fiber

The neutral detergent fiber (**Table 5.38**) of wheat flour noodles substituted with dried karonda ranged from 21.93 per cent to 25.16 per cent. NDF increased non significantly ($p>0.05$) in noodles substituted with dried karonda. The NDF was highest in B4 (25.16 %) and lowest in B1 (21.93 %). Similar increase in dietary fiber i.e. 24.2 per cent was reported in wheat flour noodles substituted with watermelon rind powder (Ho and Dahri, 2016). This increase in dietary fiber might be due to high dietary fiber in fruits (Vinod *et al*. 2015).

Table 5.38 Dietary fiber of noodles substituted with dried karonda

Parameters	B1	B2	B3	B4
NDF (%)	21.93±1.90 [a]	23.36±1.53 [a] (6.52%)↑	23.70±1.70 [a] (8.07%)↑	25.16±0.77 [a] (14.72%)↑
ADF (%)	1.53±0.05 [a]	1.63±0.11 [a] (6.53 %)↑	1.70±0.20 [a] (11.11%)↑	1.83±0.11 [a] (19.60%)↑
Hemicellulose (%)	21.4±4.35 [a]	21.73±0.00 [a] (1.54%)↑	23.00±0.00 [a] (7.47%)↑	24.33±0.00 [a] (13.69%)↑
Cellulose (%)	3.14±0.18 [a]	3.18±0.22 [a] (1.27%)↑	3.20±0.02 [a] (1.91%)↑	3.23±0.00 [a] (2.86%)↑
Lignin (%)	1.46±0.05 [a]	1.56±0.05 [a] (6.84%)↑	1.63±0.05 [ab] (11.64 %)↑	1.76±0.05 [b] (20.54 %)↑

The acid detergent fiber (ADF) of wheat flour noodles substituted with dried karonda ranged from 1.53 per cent to 1.83 per cent. The ADF non significantly increase ($p>0.05$) in ADF was observed in noodles samples substituted with dried karonda. The ADF increased with increase in dried karonda fruit substitution.

Hemicellulose content (**Table 5.20**) of wheat flour noodles substituted with dried karonda ranged from 21.40 per cent to 24.33 per cent. Hemicellulose content increased non significantly ($p>0.05$) in noodles substituted with dried karonda. The hemicellulose content was highest in B4 (24.33%) and lowest in B1 (21.40 %).

The cellulose content of wheat flour noodles substituted with dried karonda ranged from 3.14 per cent to 3.23 per cent. The cellulose content non significantly increase ($p>0.05$) in noodles samples substituted with dried karonda. The cellulose content increased with increase in dried karonda fruit substitution. This increase in dietary fiber might be due to addition of dietary fiber rich fruits (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.38**) of wheat flour noodles substituted with dried karonda ranged from 1.46 per cent to 1.76 per cent. Similar results, i.e. 1.08 per cent was reported by Gorecka *et al.* (2010) in wheat flour cookies. The results of the lignin content increased significantly ($p<0.05$) in noodles samples substituted with dried karonda. The lignin content was highest in B4 (0.76 %) and lowest in B1(0.46 %). Similar increase in dietary fiber i.e. 0.75 per cent was reported in wheat flour biscuits substituted with jackfruit powder (Butool and Butool, 2013).

5.11 (c) Mineral composition

The calcium content (**Table 5.39**) of wheat flour noodles substituted with dried karonda ranged from 18.96 mg/100gm to 22.67 mg/100gm. In control it was only 18.96 mg/100gm increased significantly with more replacement of dried karonda fruit. Maximum value of calcium content i.e. 22.67 mg/100gm was noted in B4. Similar increase in calcium content i.e. 20.40 per cent was reported in wheat flour cake substituted with doum fruit powder. This increase in calcium content might be due to high mineral content in fruits (Niemen *et al*. 1992).

Table 5.39 Mineral composition of noodles substituted with dried karonda

Parameters	B1	B2	B3	B4
Calcium (mg/100gm)	18.96±0.00 [a]	19.71±0.00 [b] (3.95%)↑	22.19±0.00 [c] (17.03%)↑	22.67±0.00 [cd] (19.56%)↑
Iron (mg/100gm)	10.92±0.00 [a]	16.04±0.00 [b] (11.11%)↑	19.88±0.00 [cd] (33.33%)↑	23.80±0.00 [b] (77.77%)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	344.83±0.00 [cd] (9.09%)↑	423.54±0.00 [c] (36.36%)↑	513.20±0.00 [b] (45.45%)↑

The iron content of wheat flour noodles substituted with dried karonda ranged from 10.92 mg/100gm to 23.80 mg/100gm. The iron content significantly increase ($p<0.05$) in noodles samples substituted with dried karonda. The iron content increased with increase in dried karonda fruit substitution.

The phosphorus content (**Table 5.39**) of wheat flour noodles substituted with dried karonda ranged from 324.1 mg/100gm to 513.20 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in noodles samples substituted with dried karonda. The phosphorus content was highest in B4 (0.16 mg/100gm) and lowest in B1(0.11 mg/100gm). Similar increase in phosphorus content i.e. 467 per cent was reported in wheat flour cakes substituted with beetroot powder (Pinki and Awasthi, 2014).

Fig. 5.19 B1 (control sample = 100% wheat flour noodles, B2 =15 % karonda, B3 =30% karonda, B4 =45 % karonda)

5.12 Nugget

5.12 (a) Nutritional composition

The moisture content (Table 5.40) of green gram nugget substituted with dried karonda ranged from 19.68 per cent to 21.83 per cent. In control it was only 19.68 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of moisture content i.e. 21.83 per cent was noted in B4. Similar increase in moisture content i.e. 22.98 per cent was reported in composite pulse flour chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in moisture content might be due to high moisture content in fruits (Raj and Masih, 2014).

Table 5.40 Nutritional composition of nugget substituted with dried karonda

Parameters	B1	B2	B3	B4
Moisture (%)	19.68±0.09 ^{ac}	19.80±0.1 ^{a} (0.60%)↑	20.66±0.05 ^{b} (4.97%)↑	21.83±0.00 ^{c} (10.92%)↑
Ash (%)	1.10±0.05 ^{a}	1.13±0.10 ^{a} (2.72 %)↑	1.16±0.05 ^{a} (5.45 %)↑	1.19±0.05 ^{a} (8.18 %)↑
Carbohydrate (%)	65.64±0.22 ^{a}	74.53±0.40 ^{b} (13.54%)↑	82.99±0.24 ^{c} (26.43%)↑	93.30±1.04 ^{cd} (42.13%)↑
Protein (%)	13.34±0.08 ^{a}	14.00±0.1 ^{b} (4.94%)↑	14.10±0.1 ^{bc} (5.69%)↑	14.37±0.12 ^{cd} (7.72%)↑
Fat (%)	1.85±2.71 ^{a}	2.74±0.05 ^{b} (48.10%)↑	3.31±0.24 ^{c} (78.91%)↑	3.96±0.30 ^{cd} (114.05%)↑

The ash content of green gram nugget substituted with dried karonda ranged from 1.10 per cent to 1.19 per cent. Similar results, i.e. 1.64 per cent was reported by Sharma and Chopra (2015) in nugget. The ash content non significantly increase ($p>0.05$) in nugget samples substituted with dried karonda. The ash content increased with increase in dried karonda fruit substitution. Similar increase in ash content i.e. 0.76 to 2.30 per cent was reported in green gram

dal substituted with bathua leaves (Singh *et al.* 2007). This increase in ash content might be due to high ash content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.40**) of green gram nugget substituted with dried karonda ranged from 65.64 per cent to 93.30 per cent. Similar results, i.e. 65.50 per cent was reported by Aziz *et al*. (2012) in nugget. In control it was only 65.64 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of carbohydrate content i.e. 93.30 per cent was noted in B4. Similar increase in carbohydrate content i.e. 70.72 per cent was reported in bengal gram dal substituted with kondhara leaves (Singh *et al.* 2014). This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of green gram nugget substituted with dried karonda ranged from 13.34 per cent to 14.37 per cent. Similar results, i.e. 12.86 per cent was reported by Singh and Sharma (2003) in bengalgram roll. The protein content significantly increase ($p<0.05$) in nugget samples substituted with dried karonda. The protein content increased with increase in dried karonda fruit substitution. Similar increase in protein content i.e. 11.48 to 30.44 per cent was reported in bengal gram dal substituted with kondhara leaves (Sultana *et al.* 2014). This increase in protein content might be due to high protein content in fruits (Waghray *et al.* 2011).

The fat content (**Table 5.40**) of green gram nugget substituted with dried karonda ranged from 1.85 per cent to 3.96 per cent. Similar results, i.e. 1.30 per cent was reported by Pardeshi *et al*. (2013) in nugget. The fat content significantly increase ($p<0.05$) in fat content was observed in nugget samples substituted with dried karonda. The fat content was highest in B4 (3.96%) and lowest in B1(1.85 %). Similar increase in fat content i.e. 1.28 per cent was reported in gram flour based chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in fat content may be due to high fat content in fruits (Vinod *et al*. 2015).

5.12 (b) Dietary fiber

The neutral detergent fiber (**Table 5.41**) of green gram nugget substituted with dried karonda ranged from 23.56 per cent to 25.30 per cent. NDF increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The NDF was highest in B4 (25.30 %) and lowest in B1 (23.56 %). This increase in dietary fiber might be due to high dietary fiber in fruits (Choo and Aziz, 2010).

Table 5.41 Dietary fiber of nugget substituted with dried karonda

Parameters	B1	B2	B3	B4
NDF (%)	23.56±0.11 [a]	23.93±0.32 [a] (1.57%)↑	24.30±0.95 [a] (3.14%)↑	25.30±0.86 [ab] (7.38%)↑
ADF (%)	21.06±0.92 [a]	21.73±0.23 [a] (3.18%)↑	21.76±1.85 [a] (3.32%)↑	22.63±1.45 [a] (7.45%)↑
Hemicellulose (%)	1.97±0.00 [a]	2.20±0.00 [b] (11.67%)↑	2.33±0.00 [c] (18.27%)↑	2.54±0.00 [cd] (28.93%)↑
Cellulose (%)	11.88±0.65 [a]	12.23±0.00 [a] (2.94%)↑	12.67±0.58 [a] (6.64%)↑	12.97±0.63 [a] (9.17%)↑
Lignin (%)	1.68±0.00 [a]	1.72±0.01 [a] (1.17%)↑	1.73±0.01 [a] (1.76%)↑	1.74±0.01 [ab] (2.35%)↑

The acid detergent fiber (ADF) of nugget substituted with dried karonda ranged from 21.06 per cent to 22.63 per cent. The ADF increased non significantly ($p>0.05$) in nugget samples substituted with dried karonda. The ADF increased with increase in dried karonda fruit substitution.

Hemicellulose content (**Table 5.41**) of nugget ranged from 1.97 per cent to 2.54 per cent. Hemicellulose content increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The hemicellulose content was highest in B4 (2.54 %) and lowest in B1(1.97

%). Similar increase in hemicellulose content i.e. 0.25 to 5.75 per cent was reported in dietary fiber in bengal gram dal substituted with kondhara leaves (Singh *et al.* 2014). Singh *et al.* (2007) also reported similar increase i.e. 0.38 to 0.51 per cent in green gram dal substituted with bathua leaves.

The cellulose content of nugget ranged from 11.88 per cent to 12.97 per cent. The cellulose content non significantly increase ($p>0.05$) in all nugget samples substituted with dried karonda. The cellulose content increased with increase in dried karonda fruit substitution. This increase in dietary fiber might be due to presence of high dietary fiber in fruits (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.41**) of nugget ranged from 1.68 per cent to 1.74 per cent. The results of the lignin content increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The lignin content was highest in B4 (1.74 %) and lowest in B1(1.68 %). Similar increase in lignin content i.e. 1.28 per cent was reported in besan laddu substituted with mushroom powder (Verma and Singh, 2014).

5.12 (c) Mineral composition

The calcium content (**Table 5.42**) of nugget ranged from 146.79 mg/100gm to 204.41 mg/100gm. In control it was only 146.79 mg/100gm increased significantly with more replacement of dried karonda fruit. Maximum value of calcium content i.e. 204.41 mg/100gm was noted in B4. Similar increase in calcium content i.e.116.93 per cent was reported in legume based pan cake (thalipeeth) substituted with shepu dried greens (Gupta and Prakash, 2011).

The iron content of nugget ranged from 10.92 mg/100gm to 13.31mg/100gm. The iron content significantly increase ($p<0.05$) in nugget samples substituted with dried karonda. The iron content increased with increase in dried karonda fruit substitution. Similar increase in iron content i.e. 3.90 to 8.99 per cent was reported in legume composite flour thalipeeth (pan cake like product) substituted with green leafy vegetables (Gupta and Prakash, 2011). Singh *et al.*(2014) also reported similar increase in iron content i.e. 7.25 to 28.77 per cent in bengal gram dal substituted with kondhara leaves .

Table 5.42 Mineral composition of nugget substituted with dried karonda

Parameters	B1	B2	B3	B4
Calcium (mg/100gm)	146.79± 0.00 [a]	148.16±0.00 [b] (0.93%)↑	172.97±0.00 [c] (16.74%)↑	204.41±0.00 [cd] (39.25%)↑
Iron (mg/100gm)	10.92±0.00 [a]	11.33±0.00 [b] (3.75%)↑	12.07±0.00 [c] (210.53%)↑	13.31±0.00 [cd] (21.88%)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	422.81±0.00 [b] (30.45%)↑	468.62±0.00 [c] (44.59%)↑	517.43±0.00 [cd] (59.65%)↑

The phosphorus content (**Table 5.42**) of nugget ranged from 324.1 mg/100gm to 517.43 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The phosphorus content was highest in B4 (517.43 mg/100gm) and lowest in B1(324.1 mg/100gm). Similar increase in phosphorus content i.e. 320 to 378 per cent was reported in gram composite flour roti substituted with methi powder (Kadam *et al*.2012).

Fig. 5.20 B1 (control sample) = 100% green gram nugget,

B2 =15 % karonda, B3 =30% karonda, B4 =45 % karonda)

6. SUMMARY AND CONCLUSIONS

Fruits are important source of vitamins, minerals and fibers. Fresh fruits are classified as perishable commodities due to presence of higher moisture content (Orsat *et al.* 2006). Nowadays, perishable crops are dried in the world (Grabowski *et al.* 2003) and due to their international trade, consumers have access to various unseasonable fruits around the world. In comparison of imported fruits, locally available fruits are very cheap, fresh but short life span. Therefore, processing methods must be use to enhance their shelf life.

So, present investigation entitled **"Influence of processing on nutritional and phytochemical composition of Fig (*Ficus carica*) and Karonda (*Carissa spinarum*)"** was undertaken the thesis work on locally available two underutilized fruits, fig and karonda with following objectives:

1. To evaluate proximate, nutritional, physical and phytochemical composition of fresh fig and karonda fruits.
2. To assess the influence of processing methods viz. sun drying, microwave drying and freezing on physicochemical, nutritional and phytochemical composition of selected fruits.
3. To evaluate the effect of fruit extract of fig and karonda on FBG level of normoglycemic and diabetic wistar rats.
4. To develop various value added products from the selected fruits and analyze their nutritional composition during 6 months of storage.

These two local varieties of fruits were procured from Bilaspur (Himachal Pradesh), India and processed under the influence of freezing, sun drying and microwave drying method and studied for physical composition, nutritional composition, anti- nutritional composition and mineral composition. Results demonstrated a wide variation in the nutrient composition of fresh and processed fruit. Drying method reduced the length, width and density in fruits. Drying method increased significantly ($p<0.05$) the ash content, carbohydrate content, fat content, protein content and dietary fiber (NDF, ADF, hemicellulose, cellulose, lignin) and showed reduction in the moisture content. After processing, microwave dried method

exhibited significantly ($p<0.05$) higher phytochemical composition (phenolic content and flavonoid content). The antioxidant activity was also found to be increased in microwave dried method. Drying method decreased significantly ($p<0.05$) the tannin content, alkaloid content, anthocyanin content and increased the calcium content, iron content and phosphorus content.

Underutilized fruits also proved beneficial to control many diseases. Traditional point of view these fruits are popular with hypoglycemic activities (Perez *et al.* 1999). So, present study examined the influence of these selected fruits (fig and karonda) on FBG level in normoglycemic and diabetic rats.

Animal trial was carried out by using fourty two male albino rats. The rats were weighed and allotted twelve for toxicity test and after that distributed into seven groups (n=6) for further study purpose. Group I as normoglycemic rat group, group II as diabetic group having 35 mg streptozotocin according to body weight of rat, group III as diabetic group having 50 mg metformin according to body weight of rat, group IV as diabetic group having 500 mg fig methanolic extract according to body weight of rat , group V as diabetic group having 500 mg karonda methanolic extract according to body weight of rat, group VI as normoglycemic group having 500 mg fig methanolic extract, group VII as normoglycemic group having karonda methanolic extract (500 mg/kg b.wt.). Fasting blood glucose (FBG) level and body weight of rats were measured after 0 day, 7^{th} day, 14^{th} day and 21^{th} day. In result, methanolic extract of fig and karonda extract decreased significantly ($p<0.05$) higher FBG level on 21^{th} day as compared to 0 day in diabetic control group as well as in normoglycemic group of rats. And, also proved effective to improve higher body weight of rats on 21^{th} day as compared to 0 day in diabetic control group as well as in normoglycemic group of rats.

This study also proved beneficial to explored the possibilities of the utilization of nutrient rich under-utilized fruits to make innovative food products. According to objectives of the study these underutilized fruits were selected for the development of value added products because of their higher nutritional quality and easy availability. Different value added products such as bun, muffin, noodles and nuggets were formulated with the substitution of

15 per cent, 30 per cent and 45 per cent of karonda and fig to improve the overall nutritional quality. And, increased significantly ($p<0.05$) the moisture content, ash content, carbohydrate content, protein content, fat content, dietary fiber (ADF, NDF, hemicellulose, cellulose, lignin), iron content, calcium content and phosphorus content. The value added products, bun and muffin were also evaluated organoleptically for appearance, colour, texture, flavour, overall acceptability and accepted well by panel of judges. Thus, these underutilized fruits could be successfully used in the production of the value added products and proved to be nutritious convenience products for the human consumption.

The study concludes that drying method proved to be more effective for nutrient retension and significantly ($p<0.05$) reduced FBG level in diabetic control group as well as in normoglycemic group of rats. Further, the substitution of fruits showed significant effect to increase the nutritional quality in developed value added products.

7. BIBLIOGRAPHY

Abou ElHana, N. H. (2008). Microwave drying of apple. *Misr Journal of Agriculture Engineering, 25*, 980-1003.

Abou-Zaid, A. A., Ramadan, M. T., and Al-Asklany, S. A. (2011). Utilization of faba vegetables. *Biochemistry, 18*(2), 121–125. www.bioline.org.br/request

Abu-Goukh, A. A., Shattir, A. E., and Balla, M. M. E. (2003). Effect of harvesting method on quality and storability of dry dates in Sudan. *Tropical Science, 43*, 53-56.

Adubofuor, J., and Mensah, M. A. (2012). Sensory evaluation and proximate composition of rock buns and cakes prepared from partially- dried ripe pawpaw pulp incorporated into wheat flour. *Journal Agriculture Food Technology, 2*(11),172-177.

Agent (1994). *A survey of the market for fruits and vegetables in the hotel and restaurant industry*. Agent's business production, processing and marketing information centre,19,Colombo, 25.

Agoreyo, B. O., Akiroroh, O., Orukpe, O. A., Osaweren, O. R., and Owabor, C. N. (2011). The effects of various drying methods on the nutritional composition of *Musa paradisiacal, Dioscorea rotundata* and *Colocasia esculenta. Asian Journal of Biochemistry, 6*(6),458-464.

Ahmad, F., and Raj, A. (2012). Buckwheat: a legacy on the verge of extinction a Ladakh. *Current. Science,103*(1),13.

Ahmad, M. Z., Ali, M., and Mir, S. R. (2013). Anti- diabetic activity of *Carissa spinarum* L. stem barks and isolation of two new flavonol esters from the plant by using spectroscopic techniques. *Asian Journal of Biomedical and Pharmaceutical Sciences, 3*(18),22-28.

Ahuja, M. M. S. (1979). *Epidemiological studies on diabetes mellitus in India*. In :Ahuja MMS, Editor, Epidemiology of diabetes in developing countries. New Delhi: Imprint, 29-38.

Akhijahani, H. S., and Khodaei, J. (2011). Some physical properties of strawberry (Kurdistan Variety). *World Applied Science Journal,13*(2),206-212.

Akinhanmi, T. F., Atasie, V. N., and Akintokun, P. O. (2008). "Chemical composition and physicochemical properties of cashew nut (*Anacardium occidentale*) oil and cashew nut shell liquid." *Journal of Agricultural, Food and Environmental Sciences, 2*(1), 1–10.

Alam, M. J., Talukder, M. U., and Rahman, M. N. (2013). Evaluation of the nutritional and sensory quality of functional breads prepared from whole wheat and soyabean flour. *Annals. Food Science and Technology,14* (2),171-175.

Albers, S., Muchova, Z., and Fikselova, M. (2009). The effects of different treated brans additions on bread quality. *Scientia Agriculture Biochemica,40*(2),67-72.

Aleid, S. M., Elansari, A. M., Tang, Z. X., and Sallam, A. A. (2014). Effect of cold storage and packing type on Khalas and Sukkary dates quality. *Advance Journal of Food Science and Technology,6*(5),603-608.

Alfaro, S., Mutis, A., Quiroz, A., Seguel, I., and Scheuermann, E. (2014). Effects of drying on murtilla fruit polyphenols and antioxidant activity. *Journal of Food Research,3*(5),73-82.

Al-Farsi, M., Alsavar, C., Morris, A., Baron, M., and Shahidi, F. (2005). Comparison of antioxidant activity, anthocyanin, carotenoids and phenolics of three native fresh and sun dried date (*Phoenix dactylifera L.)* varieties grown in Oman. *Journal of Agriculture and Food Chemistry,53*, 7592-7599.

Alice, A. O., Oshundahunsi, O. F., Rahman, A., Kayode, A., Abiodun, A. et al. (2012). Proximate composition and sensory qualities of snacks produced from breadfruit flour. *Global Journal of Science Frontier Research Biological Sciences,12*(7),2249-4626.

Aljane, F., Toumi, I., and Ferchichi, A. (2007). HPLC determination of sugars and atomic absorption analysis of mineral salts in fresh figs of Tunisian cultivars. *African Journal of Biotechnology,6*(5),599-602.

Al-Ogaidi, H. K., and Mutlak, H. H. (1986). The phenolic compounds of four date cultivars during maturity stages. *Date Palm Journal,4*(4),191-196.

Al-Yahayai, R., and Al-kharusi, L. (2012). Physical and chemical quality attributes of freeze-stored dates. *International Journal Agriculture Biology, 14*, 97-100.

Amalina, N. I., Nordin, A., Ariffin, H., Andou, Y., Hassan, M. A., Shirai, Y. et al. (2013). Modification of oil palm mesocarp fiber characteristics using superheated steam treatment. *Molecules,18*, 9132-9146.

Amreen, F., Prem, P. S., Parul, A., Raghuveer, I., Shashi, A. *et al.* (2013). Treatment of various diseases by *Carissa spinarum* L. promising shrub. *International Journal Pharma Science Research,*4 (7), 2489-2495.

Anantawat, V. (2015). Effects of spray drying conditions on characteristics, nutritional value and antioxidant activity of gac fruit aril powder. *Integrated Business and Economic Resource,4,*1-11.

Ancos, B., Gonza, E. M., and Cano, M. P. (2000). Ellagic acid, vitamin C and total phenolic contents and radical scavenging capacity affected by freezing and frozen storage in raspberry fruit. *Journal Agriculture Food Chemistry, 48,* 4565-4570.

Andulla, B., and Varadacharyulu, N. C. H. (2003). Antioxidant role of mulberry leaves in streptozotocin – diabetic rats. *Clinica Chimica Acta, 338,*3-10.

Anon (2011). The general information about figs. www.erbeyliincir.gov.tr *(Accessed 4 June 2)(Turkish).*

Anonymous (1950). In the wealth of India : A Dictionary of Indian raw materials and industrial products, *CSIR NEW DELHI,3,*22.

Anonymous (1999). The wealth of India: *A dictionary of India raw materials and industrial products*. Council of Scientific and Industrial Research New Delhi, 4.

Anonymous (2001). The Wealth of India*: A dictionary of Indian raw materials and industrial products, first supplemented series.* National Institutes of Science Communicaton, *New* Delhi,2 CI-CY XXXV.

AOAC, Official method of analysis international. (2010). *Spectrophotometric method,7* (2), 161-4.

Ara, R., Jahan, S., Abdullah, A. T. M., Fakruddin, A. N. M., and Saha, B. K. (2014). Physico-chemical properties and mineral content of selected tropical fruits in Bangladesh. *Bangladesh Journal of Scientific and Industrial Research ,49*(3),131-136.

Aremu, M. O., Olaofe, O., and Akintayo, T. E. (2006). A comparative study on the chemical and amino acid composition of some Nigerian under-utilized legume flours. *Pakistan Journal of Nutrition, 5,* 34-38.

Ariffin, F., Baharom, M. A., Kaur, B., and Maurd, M. (2015). The physicochemical properties and sensory evaluation of bread made with a composite flour from wheat and Tempoyak (fermented Durian). *American Journal of Applied Sciences, 12* (11), 775.784.

Ariffin, H., Hassan, M. A., Kalsom, M. S. U., Abdullah, N., and Shirai, Y. (2000). Effect of physical, chemical and thermal pretreatments on the enzymatic hydrolysis of oil palm empty fruit bunch (OPEFB). *Journal of Tropical Agriculture and Food Science,36*(2), 000-000.

Arslan, D. (2015). Effects of degradation preventive agents on storage stability of anthocyanins in sour cherry concentrate. *Agronomy Research,13*(4), 892–899.

Asp, N. G., and Bjorck, I.(1992).Resistant starch. *Trends in Food Science and Technology, 3*,111-114.

Association of Official Analytical Chemists. (1975). *Official methods of analysis (12th editio*n). The Assocation: Washington, D.C.

Atlabachew, M., Chandravanshi, B. S., Abshiro, M. R., Torto, N., Chigome, S. et al .(2013). Evaluation of the effect of various drying techniques on the composition of the psychoactive phenylpropylamino alkaloids of Khat *(Catha Edulis for SK)* chewing leaves. *Bull. Chemical Society Ethiopa,27*(3), 347-358.

Avila, P. A., Namiesnik, J., Toledo,F., Werner, E., Ayala, A. L. M., Guzman, N. E. R., Infante, J. A. G. et al. (2012). The influence of different time durations of thermal processing on berries quality. *Food Control, 26* ,587-593.

Ayadi, A., Mechlouch, R. F., Bessaoud, C., Bennour, H., and Debouba, M. (2014). Effect of microwave and solar drying methods on the physicochemical properties of kiwifruit. *Journal of Agricultural Technology,10* (4),365-379.

Aydin, C. (2002). Physical properties of hazel nuts. *Biosystems Engineering, 82* (3), 297-303.

Aziz, N., Noor, M. A., and Ho, L. H. (2012). Physico-chemical and organoleptic properties of cookies incorporated with legume flour. *International Food Research Journal*,19(4),1539-1543.

Babiker, W. A. M., Abdel, M. E. S., Sirekhatim, B. E., and Elamin, A. K. (2013). Physicochemical properties of wheat bread supplemented with orange peel by-products. *International Journal of Nutrition and Food Sciences,2*(4),1-4.

Badola, H. K., and Aitken, S. (2010). Biological resources and poverty alleviation in the Indian Himalayas. *Biodiversity, 11*(3), 8-18.

Baker, A. A. and Gawish, R. A. (1997). Trials to reduce nitrate and oxalate content in some leafy vegetables. Interactive effects of the manipulating of the soil nutrient supply, different blanching media and preservation methods followed by cooking process. *Journal of Science, Food and Agriculture, 42*, 169-178.

Balasubramanian, D. (2001). Physical properties of raw cashew. *Nutrition Journal of Agricultural Engineering Research,78* (3),291-297.

Baliga, M., Bhat, H., Pai, R., Boloor, R., and Palatty, P. (2011). The chemistry and medicinal uses of the underutilized Indian fruit tree *Garcinia Indica Choisy* (kokum): A review. *Food Research International. In Press.*

Bernard, R., Issah, A. P., and Emmanuel, M. (2014). Effect of drying methods on phytochemical composition of orange fruit (*Citrus sinesis, L.)* peel flour in biscuit making. *Journal of Environmental Science, Toxicology and Food Technology,8*(10),72-75.

Bey, M. B., and Louaileche, H. (2015). A comparative study of phytochemical profile and *in vitro* antioxidant activities of dark and light dried fig (*Carissa spinarum* L.) varieties. *The Journal of Psychopharmacology, 4*(1), 41-48.

Bhogaonkar, P. Y., Chauhan, V. N., and Kanerkar, U. R. (2014). Nutritional potential of *Ficus racemosa L.* fruits. *Bioscience Discovery,5*(2),150-153.

Blois, M. S. (1958). Antioxidant determination by the use of stable free radicals. *Nature, 181*, 1199-2000.

Boca, S., Galoburda, R., Skrupskis, I., and Skrupska, D. (2014). The effect of freezing and hydrocolloids on the physical parameters of strawberry mass- based desserts. *Proc. Latvia University Agriculture, 31*(326), 12-24.

Boonsumrej, S., Chaiwanichsiri, S., and Tantratian, S. (2007). Effect of freezing and thawing on the quality changes of tiger shrimp (*Penaeus monodon*) frozen by air-blast and cryogenic freezing. *Journal of Food Engineering, 80,*292–299.

Borchani, C., Besbes, S., Masmoudi, M., Blecker,C., and Paquot, H. A. (2011). Effect of drying methods on physico-chemical and antioxidant properties of date fiber concentrates. *Food Chemistry, 125,*1194–1201.

Bouzari, A., Hilstege, D., and Barrett, D. M. (2015). Mineral, fiber and total phenolic retention in eight fruits and vegetables: A comparison of refrigerated and frozen storage. *Journal of Agriculture and Food Chemistry, 63*, 951-956.

Brackmann, A., Mazaro, S. M., and Saquet, A. A. (1997). Cold storage of persimmons *(Diospyros kaki L.)* cultivars Fuyu and Rama Forte. *Ciencia-Rural, 27,* 561 - 565.

Brito, B., Rodriguez, M., Samaniego, I., Jaramillo, M. I., and Valliant, F. (2006). Characterizing polysaccharides in cherimoya (*Annona cherimola Mill*) pure and their enzymatic liquefaction. *Europe Food Resource Technology, 115*(4),377-378.

Brooker, D. B., Bakker, A. F. W., and Hall, C. W. (1974). Drying cereal grains. *The AVI publishing company, Inc*, Westport,Co,USA,265.

Burke, J. L., Waghorn, G. C., Brookes, I. M., and Attwood, G. T. (2000). Formulating total mixed rations from forages- defining the digestion kinetics of contrasting species. *Proceedings of New Zealand Society of Animal Production 60*,9-14.

Butool, S., and Butool, M. (2013). Nutritional quality on value addition to jack fruit seed flour. *International Journal of Science and Research, 4* (4),2406-2411.

Candrawinata, V. I., Golding, J. B., Roach, P. D. and Stathopoulos, C. E. (2014). Total phenolic content and antioxidant activity of apple pomace aqueous extract: effect of time, temperature and water to pomace ratio. *International Food Research Journal, 21*(6), 2337-2344.

Caprez, A., Arrigoni, E., Amado, R., and Neucom, H. (1986). Influence of different types of thermal treatment on the chemical composition and physical properties of wheat bran. *Journal Cereal Science, 4*, 233–239.

Chaparzadeh, N., and Yavari, B. (2013). Antioxidant responses of Golden delicious apple under cold storage conditions. *Iranian Journal of Plant Physiology,4* (1), 907-915.

Chauhan, K., Sharma, S., Chawla, E., and Chauhan, B. (2010). Development of food products on corporating dry powdered figs to explore their hypercholestrolemic potential. *Food Science Research Journal, 2*(1), 196-201.

Chawla, A., Kaur, R., and Sharma, A. K. (2012). *Carissa spinarum* Linn. : A Review on its pharmacognostical, phytochemical and pharmacological aspects. *International Journal of Pharmaceutical and Phytopharmacological Research,1*(4),215-232.

Cheftel, J. C., Cheftel, H., and Besancon, P. (1989). Methods de conservation. In: Cheftel, J. C., Cheftel, H., Besancon, P., (Ed). Introduction a la bioquimica tecnologia de los alimentos. *Zaragoza: Acribia, cap,7,*173-299.

Chen, M. L., and Morris, W. C. (1990). Effect of heat treatments on the chemical analysis of dietary fiber. *Journal of Food Science, 55,* 1647-1650.

Cheng, M. (2011). Effects of drying temperature on the flavonoid, phenolic acid and antioxidative capacities of the methanol extract of citrus fruit (*Citrus sinensis* L.) peel. *International Journal of Food Science and Technology, 46*(6),1179-1185.

Chinma, C. E., Igbabul, B. D., and Omotayo, O. O. (2012). Quality characteristics of cookies prepared from unripe and defatted sesame flour blends. *American Journal of Food Technology,7*(7),398-408.

Chinyere, G.C. and Obasi, N. A. (2013). Vitamins and phytochemical contents in four leafy vegetable subjected to different processing methods. *African Journal of Biotechnology,12* (26),4168-4173.

Chism, G. W., and Haard, N. F. (1996). Characteristics of edible plant tissues. In: Food Chemistry. OR *Fennema New York*: *Dekker,* 943-1011.

Chobanian, A. V., Bakris, G. L., Black, H. R., Cushman, W. C., Green, 1. L. A., Izzo, J. L. J. et al. (2003). National Heart, Lung and Blood Institute Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure; National High Blood Pressure Education Program Coordinating Committee. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA, 289,* 2560-72.

Chomnawang, C., Nantachai, K., Yongsawatdigul, J., Thawornchinsombut, S., and Tungkwa-chara, S. (2007). Chemical and biochemical changes in hybrid catfish fillet stored at 4°C and its gel properties. *Food Chemistry, 103*,420–427.

Choo, C. L., and Aziz, N. A. (2010). Effects of banana flour and β- glucan on the nutritional and sensory evaluation of noodles. *Food Chemistry, 119*, 34–40.

Choudhary, S., Pathak, A. K., Khare, S., and Kushwah, S. (2011). Evaluation of antidiabetic activity of leaves and fruits of *Ficus religiosa* Linn. *International Journal of Pharmacy and Life Sciences,2* (12),1325-1327.

Chuen, Y. S., and Aziz, N., A. A. (2009). Chemical and physical properties of muffin prepared from different levels of mango (*Mangifera indica)* variety Chokanan pulp flour. Food Technology Division, School of Industrial Technology, University Sains Malaysia,11800 Minden, Penang, Malaysia.

Chumyam, A., Wangchai, K., Jungklang, J., and Faiyue, B. (2013). Effects of heat treatments on antioxidant capacity and total phenolic content of four cultivars of purple skin eggplants. *Science Asian*, *39*,246-251.

Clary, C. D., Meza, M. E., Wang, S., and Petrucci, V. E. (2007). Improving grape quality using microwave vacuum drying associated with temperature control. *Journal of food science,72*(1),23-28.

Crizel, T. M., Rios, A. O., Thys, R. C. S., and Flores, S. H. (2015). Effects of orange by-product incorporation on the functional and technological properties of pasta. *Food Science Technology, campinas, 35*(3), 546-551.

Dalal, R. P. S., Thakur, N. A. and Singh, A. (2010). Nutritional value of Karonda *(Carissa carandas* Linn*).* A non- conventional fruit under semi- arid condition of Punjab. *Indian Journal of Agroforestry,12*(2),102-104.

Damiani, C., Silva, F. A. D., Lage, M. E., Pereira, D. E. P., Becker, F. S. et al. (2013). Stability of frozen marolo pulp during storage. *Food Science Technology Campinas*, *33*(4),713-721.

Dangcham, S., Bowen, J., Ferguson, I. B., and Ketsa, S. (2008). Effect of temperature and low oxygen on pericarp hardening of mangosteen fruit stored at low temperature. *Postharvest Biology and Technology 50*,37–44.

Darjazi, B. B. (2011). Morphological and pomological characteristics of fig (*Carissa spinarum*) cultivars from varamin, Iran. *African Journal of Biotechnology, 10* (82), 19096-19105.

Davey, M. W. V., Montagu, M., Inzé, D., Sanmartin, M., Kanellis, A. et al. (2000). Plant L-ascorbic acid: Chemistry, function, metabolism, bioavailability and effects of processing. *Journal of the Science of Food and Agriculture*, *80*(7), 825–860.

De- Ancos, B., Gonzáles, E. M., and Cano, M. P. (2000a). Ellagic acid, vitamin C and total phenol contents and radical scavenging capacity affected by freezing and frozen storage in raspberry fruit. *Journal Agriculture Food Chemistry*, 48,4565-4570.

Diaz, P. O., Hernansezl, J. J. I., Avevedol, E. A., Ambrizl, S. L. R., Pardo, M. E. S. et al. (2014). Chemical, starch digestibility and sensory characteristics of durum wheat/ unripe whole banana flour blends for spaghetti formulation. *Food and Nutrition Sciences, 5*, 264-270.

Din, K. (2008). Physico-chemical properties fruit Karonda *(Carissa carandas)* Dans fat works Pastilnya, (QK495K452008 FRB).

Donovan, J. L., Meyer, A. S., and Waterhouse, A. L. (1998). Phenolic composition and antioxidant activity of prunes and prune juice (*Prunus domestica*). *Journal of Agriculture and Food Chemistry*,*46*(4),1247-1252.

Duen, M., Alonso, J. J., Buelga, C. S., and Bailo, T. E. (2008). Anthocyanin composition in (*Carissa spinarum*). *Journal of Food Composition and Analysis, 21*, 107–115.

Dunas, W., Jin, S., Zhao, G., and Sun, P. (2015). Microwave-assisted extraction of anthocyanin from Chinese bayberry and its effects on anthocyanin stability. *Food Science Technology, Campinas, 35*(3),524-530.

El- Sharnouby, G. A., Aleid, M. S., and Otaibi, M. M. (2012). Nutritional quality of biscuit supplemented with wheat bran and date palm fruits (*Phoenix dactylifera* L.). *Food and Nutrition Sciences, 3*, 322-328.

Elhana, N. H. A. (2008). Microwave drying of apple. Misr. *Journal of Agriculture, 25*(3),980-1003.

Elizabeth, K. G., and Poojara, R. H. (2014). Organoleptic attributes of garden cress seed incorporated snacks suitable for adolescents. *International Journal of Food and Nutritional Sciences,3*(6),126-129.

Embaby, H. E. S. (2011). Effect of heat treatment on certain antinutrient and *vivo* protein digestibility of peanut and sesame seeds. *Food Science Technology Research, 17*(1),31-38.

Ertekin, C., Gozlekci, S., Heybeli, N., Gencer, A., Adak, N., and Sengul, B. (2014). Drying of strawberry with infrared dryer. *International Conference of Agriculture Engineering,* C0689,1-7.

Eze, J., and Akubor, P. (2012). Effect of drying methods and storage on the physicochemical properties of Okra. *Journal of Food Processing and Technology*,3,8,177.

Famurewa, J. A. V. and Olumofin, K. M. (2015). Drying kinetics and influence on the chemical characteristics of dehydrated okra (*Abelmoschuesculentus*) using cabinet dryer. *European Journal of Engineering and Technology,3*(2),7-19.

FAO. (2003). State of food insecurity in the world: Monitoring progress towards the World Food Summit and Millenium Development Goals. FAO, Rome.

FAO. (2014). State of food insecurity in the world 2003: Monitoring progress towards the World Food Summit and Millenium Development Goals. FAO, Rome.

Farsi, M. A., Alasalvar, C., Morris, A., Baron, M., and Shahidi, F. (2005). Comparison of antioxidant activity, anthocyanins, carotenoids and phenolics of three native fresh and sun dried

date(*Phoenix dactylifera L.*) varieties grown in Oman. *Journal of Agriculture and Food Chemistry,1*-9.

Fatima, A., Singh, P. P., Irchhaiya, and R., Agarwal, P. (2013). Effect of leaves of *Carissa spinarum* linn. on blood glucose and lipid profile in alloxan induced diabetic rats. *American Journal of Phytomedicine and Clinical Therapeutics,* 4,385-394.

Fedha, M. S., Mwasaru, M. A., Njoroge, C. K., Ojijo, N. O., and Ouma, G. O. (2010). Effect of drying on selected proximate composition of fresh and processed fruits and seeds of two pumpkin species. *Agriculture and Biology Journal of North America,1*(6),1299-1302.

Fennema (1976). Principles of food science. Food chemistry. New York: Marcel Dekker Inc.

Gajanana, T. M., Gowda, I. N. D., and Reddy, B. M. C. (2010). Exploring market potential and developing linkages– A case of underutilized fruit products in India. *Agricultural Economics Research Review,* 23, 437- 443.

Galoburda, R., Boca, S., Skrupskis, I., and Seglina, D. (2014). Physical and chemical parameters of strawberry puree. *Foodbalt,* 172-177.

Garcia, J. M., Infante, J. A., Guzman, N. E. R., Baca, P. R., Cadillo, M. G. C., and Laredo, R. F. G. (2013). Drying parameters of half-cut and ground figs (*Carissa spinarum L.)* var. Mission and the effect on their functional properties. *Journal of Engineering,*10830,1-8.

Garmakhany, A. D., Kashaninejad, M., Amiri, S. S., and Nikoo, M. A. R. (2013). Effect of moisture content on biophysical properties of pomegranate seeds. *Minerva Biotechnologica, 25* (1), 9-16.

Geeta, K., and Sharda, K. (2013). Nutritional evaluation of Giloe (*Tinospora cordifolia*) extract incorporated energy dense food product. *Indian Journal of Research Paripex, 2*(9),41-43.

Gezer, I., H. H., and Demir, F. (2002). Some physical properties of Hacihaliloglu apricot pit and kernel. *Journal of Food Engineering, 56,* 49–57.

Gilani, A. H., Mehmood, M. H., Janbaz, K. H., and Khan, A. U. (2008). Ethnopharmacological studies on antispasmodic and antiplatelet activities of *Ficus carica*. *Journal of Ethnopharmacology, 119*, 1-5.

Girija, k., Lakshman, K., Udaya , C., Sachi, G. S., Divya, T.(2011). Anti- diabetic and anti-cholesterolemic activity of methanol extracts of three species of *Amaranthus*. *Asian Journal of Tropical Biomedicine;2* (1), 133-138.

Giusti, M. M., and Wrolstad, R. E. (2001). Characterization and measurement of anthocyanins by UV-visible spectroscopy. Unit F1.2. In Current Protocols in Food Analytical Chemistry. New York*:* John Wiley and Sons, Inc.

Gorecka, D., Pacholek, B., Dziedzic, K., and Gorecka, M. (2010). Raspberry pomace as a potential fiber source for cookies enrichment. *ACTA, Scientarium Polonorium Technologia Alimenariat, 9*(4),451-462.

Guesmi, F., Ferchichi, A., Fares, K., and Touil, L. (2006). Identification and differentiation of *Carissa spinarum L.* cultivars using inter simple sequence repeat markers. *African Journal Biotechnology, 5*(15), 1370-1374.

Gupta, P., Bhatnagar, I., Kim, K. S., Verma, A. K., and Sharma, A. (2014). *In-vitro* cancer cell cytotoxicity and alpha amylase inhibition effect of seven tropical fruit residues. *Asian Pacific of Tropical Biomedicine*,*4*(2),S665-S671.

Gupta, S., and Prakash, J. (2011). Nutritional and sensory quality of micronutrient-rich traditional products incorporated with green leafy vegetables. *International Food Research Journal, 18,* 667-675 .

Guvenc, M., Tuzcu, M., and Yilmaz, O. (2009). Analysis of fatty acid and some lipophilic vitamins found in fruits of the *Carissa spinarum* variety picked from the Adiyaman district. *Research Journal of Biological Sciences*,*4* (3),320-323.

Hakkinen, S. H., and Torronen, A. R. (2000). Content of flavonols and selected phenolic acids in strawberries and *Vaccinium* species: influence of cultivar, cultivation site and technique. *Food Research International Journal,33*, 517–24.

Hakkinen, S., Heinonen, M., Karewlampi, S., Mykkanen, H., and Torronen, A. R. (2000). Influence of domestic processing and storage on flavonols contents in berries. *Journal of Agriculture Food Chemistry, 48* (7), 2960-2965.

Hanwate, B. D., Kadam, R. M., and Yadav, D. N. (2005). Utilization of Karonda (*Carissa caranda*) juice in the manufacture of flavoured milk. *Department of Animal Husbandry and Dairy Science,*21-22.

Harborne, J. B. (1973). Phytochemical methods. *Chapman and Hall Ltd. London,* 11-113.

Hardi, Z. U., Zukic, M., Komlenic, D. K., Sabo, M., and Hardi, J. (2007). Quality parameters of noodles made with various supplements. *Czech Journal of Food Science,25*(3),151-157.

Hassan, S.W., Umar, R.A., Maihanu, H. M., Matazu, I. K., Faruk, U.Z., and Sani, A.A. (2007). The effect of drying methods on the nutrients and non- nutrients composition of leaves of *Gynandropsis gynandra* (*Capparaceae*). *Asian Journal of Biochemistry,*2, 349-353.

Hayat, K., Zhang, X., Farooq, U., Abbas, S., Xia, S., Jia, C. et al. (2016). Effect of microwave treatment on phenolic content and antioxidant activity of citrus mandarin pomace. *Food chemistry, 123,*423-429.

Hazbavi, E., Khoshtaghaza, M. H., Mostaan, A., and Banakar, A. (2014). Effect of storage duration on some physical properties of date palm (cv. Stamaran). *Journal of the Saudi Society of Agricultural Sciences, XXX,* XXX-XXX.

Hedge, J. E., and Hofreiter, B. T. (1962). In carbohydrate chemistry its stability in model systems. New York Academic Press. *Journal of Food Science and Technology, 30* (4), 246-8.

Heshe, G. G., Haki, G. D. and Woldegiorgis, A. Z. (2015). Effect of refined milling on the nutritional value and antioxidant capacity of wheat types common in Ethiopia and a recovery attempt with bran supplementation in bread. *Journal Food Process Technology,6*,11.

Ho, L. H., and Dahari, N. C. (2016). Effect of watermelon rind powder on physicochemical, texture and sensory properties of wet noodles. CyTA-*Journal of Food*, 14(3),465-472.

Ho, L. H., Latif, N. W. B. A. (2016). Nutritional composition, physical properties, and sensory evaluation of cookies prepared from wheat flour and pitaya (*Hylocereus undatus*) peel flour blends. *Cogent Food and Agriculture*, 2, 1-10.

Holland, N., Menezes, H. C., and Lafuente, M. T. (2002). Carbohydrate as related to the heating induced chilling tolerance and respiratory rate of 'Fortune' mandarin fruit harvested at different maturity stages. *Postharvest Biological Technology, 25*, 181–191.

Hosseinaei, O., Wang, S., Enayati, A. A., and Rials, T. G. (2012). Effects of hemicellulose extraction on properties of wood flour- plastic composites. *Composite Part A , 43*,686-694.

Hui, Y. H., Puil, C., Isabel, G. L., Miang, H. L., Murrell, K. D. et al. (2004). Hand book of frozen foods. *Marcel Dekker Incorporated*, 74 – 75.

Hultman, L., and Rustard, T. (2004). Iced storage of Atlantic salmon (*Salmo salar*) effects on endogenous enzymes and their impact on muscle proteins and texture. *Food Chemistry, 87*,31–34.

Hussain, I., Amjad, S. A. M., and Ahmeed, R. (2015).Effect of modified sun drying techniques on fruit quality characters of dates harvested at rutab stage. *Journal of Agriculture Research,52*(3),415-423.

Ibitoye, W. O., Afolabi, M. O., Otegbayo, B. O., and Akintola, A. C. (2013). Preliminary studies of the chemical composition and sensory properties of sweet potato starch- flour blend noodles. *Official Journal of Nigerian Institute of Food Science and Technology,31*(2),48-51.

Ibrahim, K. M., Shawi, N. A., and Juboury, A. A. (2014). A Study on the Hypoglycemic effect of *Carissa spinarum* L. leaves aqueous extract against alloxan-induced diabetes in rabbits. *Medical Journal of Babylon, 6*,1-3.

Incedayi, B., Tamer, C. E., Sinir, G. O., Suna, S., and Copur, O. U. (2016). Impact of different drying parameters on colour, beta carotene, antioxidant activity and minerals of apricot *(Prunus armeniaca L.).Food Science and Technology, 36*(1), 171-178.

Intankar, P. R., Lokhande, S. J., Verma, P. R., and Arora, S. K. (2011). Antidiabetic potential of unripe *Carissa carandas* linn. fruit extract. *Journal of Ethanopharmacology, 135*,430-433.

Ioannou, I., Hafsam, I., Hamdi, S., Charbonnel, C., and Ghoul, M. (2012). Review of the effects of food processing and formulation on flavonoid and anthocyanin behavior. *Journal of Food and Engineering,111*, 208-217.

Irondi, A. E., Anokam, K. K., and Ndidi, U. S. (2013). Effect of drying methods on the phytochemicals composition and antioxidant activities of *Carica papayas* seed. *International Journal of Biosciences,3*(11),154-163.

Islam, M. S. (2011). Effects of the aqueous extract of white tea (*Camellia sinensis*) in a streptozotocin- induced diabetic model rats. *Phytomedicine*, 19, 25- 31.

Itankar, P. R., Lokhande, S. J., Verma, P. R., Arora, S. K., and Patil, A. T. (2011). Antidiabetic potential of unripe *Carissa carandas* Linn. fruit extract. *Journal of Ethanopharmacology,17*, 135(2),430-433.

Jahromi, G., Shahdadi, A., and Nasabpour, R. (2014). Composition of phenolic- compounds antioxidant activity and microbial quality of two varieties of fresh and frozen date-palm fruit during eight months storage in freezer. *International Journal of Farming and Allied Sciences, 3* (9),1025-1030.

Jan, I., and Rab, A. (2012). Influence of storage duration on physico-chemical changes in fruit of apple cultivars. *The Journal of Animal and Plant Science,22*(3),708-714.

Jauharah, M. Z., Rosli, W. I., and Robert, D. S. (2014). Physicochemical and sensorial evaluation of biscuit and muffin incorporated with young corn powder. *Sains Malaysian, 43*(1), 45-52.

Jayakumar, S. P., Seni, M., Jagadeesan, M., and Sundararajan, R. (2014). Antidiabetic and antioxidant effects of ethanolic extract of Anjir leaves *(Ficus carica)* in alloxan induced diabetic rat. *Asian Journal of Phytomedicine and Clinical Research, 2*(1), 1 - 10.

Jeong, S. M., Kim, S. Y., Kim, D. R., Jo, S. C., Nam, K. C. et al. (2004). Effect of heat treatment on the antioxidant activity of extracts from citrus peels. *Journal of Agriculture and Food Chemistry,52*,11, 3389-3393.

Jha, S. N., Kingsly, A. R. P., and Chopra, S. (2006). Physical and mechanical properties of mango during growth and storage for determination of maturity. *Journal of Food Engineering, 72*,73-76.

Jin, P., Wang, S. Y., Wang, C. Y., and Zheng, Y. (2011). Effect of cultural system and storage temperature on antioxidant capacity and phenolic compounds in strawberries. *Food Chemistry, 124*,262-270.

Johnson, J. T., Iwang, E. U., Hemen, J. T., Odey, M. O., Efiong, E. E., and Eteng, O. E. (2012). Evaluation of anti-nutrient of watermelon *Citrullus lanatus*. *Annals of Biological Research,3*(11),5145-5150.

Joseph, B., and Raj, S. J. (2011). Pharmacognostic and phytochemical properties of *Carissa spinarum* Linn- An overview. *International Journal of Pharm Tech Research, 3* (1),8-12.

Juan, J. M. G., Alberto, G. I., Nuria, E. R. G., Patricia, R. B., Maria, G. C. C. et al. (2013). Drying parameters of half-cut and ground figs *(Ficus carica)* var. Mission and the effect on their functional properties. *Journal of Engineering*, 1-8,710830.

Juhaimi, F. A., Uslu, N., Bozkurt, D., Ghafoor, K., Babiker, E. E. et al. (2015). Effects of oven and microwave drying on phenolic contents and antioxidant activities in four apple cultivars. *Quality Assurance and Safety of Crops and Foods, Article in Press*, 1757-837X.

Jung, S. T., Park, S. Y., Zachwieja, M. F., Barton, H., Piotrowicz, E. K. et al. (2005). Some essential phytochemical and the antioxidant potential in fresh and dried persimmon. *International Journal of Food Science and Nutrition, 65*(2),105-113.

Kadam, M. L., Salve, R. V., Mehrajfatema, Z. M., and More, S. G. (2012). Development and evaluation of composite flour for missi roti /chapatti. *Journal Food Processing Technology, 3*,134,2-7.

Kamiloglu, S., and Capanoglu, E. (2015). Polyphenol content in Figs (*Carissa spinarum* L.). Effect of sun drying. *International Journal of Food Properties, 18*,521–535.

Kamiloglu, S. (2012). Effect of sun- drying on polyphenols and in vitro bioavailability of Sarilop and Bursa Siyahi figs *(Carissa spinarum L.).* Istanbul Technical University. *Graduate School of Science Engineering and Technology,* 1-140.

Kamiloglu, S., Serali, O., Unal, N., and Capanoglu, E. (2013). Antioxidant activity and polyphenol composition of black mulberry *(Morus nigra L.)* products. *Journal of Berry Research,3*,41-51.

Kanuur, C., and Khandelwal, K. (2014). Pharmacognostical investigation and evaluation of *Carissa spinarum* fruit extract for adaptogenic activity. *International Journal of Pharmaceutical Sciences and Research,* 5 (5), 2022-2032.

Kar, D. M., Maharana, L., Pattnaik, S., and Dash, G. K. (2006). Studies on hypoglycemic activity of *Solanum xanthocarpum* Schrad. And wendl. fruit extract in rats. *Journal of Ethnopharmacology ,108*, 251 - 56.

Kashaninejad, M., Mortazavi, A., Safekori, A., and Tabil, L. G. (2006). Some physical properties of pistachio *(Pistacia vera L.)* nut and its kernel. *Journal Food Engineering*,72,30-38.

Kaur, A., and Kochhar, A. (2014).Sensory and nutritional evaluation of value added products using potato flour for nutritional and health benefits. *International Journal of Medical Sciences, 7*(1),1-6.

Kawka, A., Gorecka, D., and Gasiorowski, H. (1999). The effects of commercial barley flakes on dough characteristic and bread composition. *Food Science and Technology,2*(2).

Khan, M. N., Sarwar, A., Adeel, M., and Wahab, M. F. (2011). Nutritional evaluation of *Carissa spinarum* indigenous to Pakistan. *African Journal of Food Agriculture, Nutrition and Development, 11*(5),1684-5374.

Khan, M. N., Sarwar, A., Adeel, M., and Wahab, M. F. (2011). Nutritional evaluation of *Carissa spinarum* on the contents of sugars,organic acid and phenolic compounds. *Journal of Agriculture and Food Chemistry, 59,*11696 -11702.

Khan, A., and Vincet, J. F. V. (1996). Mechanical damage induced by controlled freezing in apple and potato. *Journal Texture Studies*, 27,143-153.

Khanal, R. C., Howard, L. R., and Prior, R. L. (2010). Effect of heating on the stability of grape and blueberry pomace procyanidins and total anthocyanins. *Food Research International,43,*1464-1469.

Khapre, A. P., Satwadhar, P. N., and Deshpande, H. W. (2015). Studies on standardization of fig fruits (*Ficus carica*) powder enriched cookies and its composition. *Asian Journal of Dairy and Food Research,4*, 71-74.

Khapre, A. P., and Satwadhar, P. N. (2010). Physico-chemical characteristics of fig fruits (*Ficus carica)* cv Dinkar and its cabinet dried powder. *Food Science Resources Journal,2*(1),23-25.

Kojic, A. B., Planinic, M., Tomas, S., Jokic, S., Bilic, M., and Velic, D. (2011). Effect of extraction condition on the extractability of phenolic compounds from lypophilised fig fruits (*Ficus carica). Polish Journal of Nutritional Science,61*(3),195-199.

Komolka, P., Gorecka, D., and Dziedzic, K. (2012).The effect of thermal processing of cruciferous vegetables on their content of dietary fiber and its fractions. *Acta Scientarium Polonorum Technologia Alimentaria,11*(4),347-354.

Krishan, P. G., Chang, K. C., and Brown, G. (1987). Effect of commercial oat bran on the composition of bread. *Cereal Chemistry,64*(1),55-58.

Krishanprabha, V., and Kiruthiga, V.(2015). Development and analysis of nutrients, antioxidants in sweet potato and pumpkin powder incorporated value added products. *International Journal of Advanced Research in Biological Sciences, 2*(4),65-71.

Kshetrimayum, R., Shukla, R. N., and Mishra, A. (2015). Study on drying and quality characteristics of tray and microwave dried guava slices. *International Journal of Science, Engineering and Technology, 3*(4),965-969.

Kulkarni, A.S., and Joshi, D.C.(2013). Effect of replacement of wheat flour with pumpkin powder on textural and sensory qualities of biscuit. *International Food Research Journal, 20*(2), 587-591.

Kulkarni, S. S., Deasai, A. D., Ranveer, R. C., and Sahoo, A. K. (2012). Development of nutrient rich noodles by supplementation with malted ragi flour. *International Food Research Journal,19(1*),309-313.

Kumar, S., Kumar, V., Parkash, M. (2012). Antidiabetic and hypolipidemic activities of kigelia pinnata flowers extract in a streptozotocin induces diabetic rats. *Asian Journal of Tropical Biomedicine;2* (7), 543-546.

Kumari, V. P., and Sangeeta, N. (2014). Process development and evaluation of quality characteristics of multilegume pasta. *Asian Journal Dairy and Food Research*, 33 (3) ,190-196.

Kwok, B. H. L., Durance, H. C., and Kitts, D. D. (2004). Dehydration techniques affects phytochemical contents and free radical scavenging activities of Saskatoon berries *(Amelanachier alnifolia Nutt.). Journal of Food Science,69*(3),122-126.

Laleh, G. H., Frydoonfar, H., Heidary, R., Jameei, R., and Zare, S. (2006). The effect of light, temperature, pH and species on stability of anthocyanin pigments in four *Berberis* Species. *Pakistan Journal of Nutrition, 5*(1), 90-92.

Lee, S. C., Kim, J. H., Jeong, S. M., Kim, D. R., Ha, J. U. et al. (2003). Effect of far- infrared radiation on the antioxidant activity of rice hulls. *Journal Agriculture Food Chemistry, 51,* 4400-4403.

Legesse, M. B., and Emire, S. A. (2012). Functional and physicochemical properties of mango seed kernels and wheat flour and their blends for biscuit production. *African Journal of Food Science and Technology*,3(9),193-203.

Leong, S. Y., and Oey, I. (2012). Effect of processing on anthocyanins, carotenoids and vitamin C in summer fruits and vegetable. *Food Chemistry,133,*1577-1587.

Lisa, A., and Felicetti, L. (2002). Fiber digestibility and nitrogen requirements of Blue Duikers. *Journal of Zoology Biology, 21*,123-134.

Lisa, L. P. (1997). Wild plant food in agricultural environment: A study of occurrence, management and gathering rights in North East Thailand. *Human Organization, 56,* 209-221.

Liu, S. C., and Tsai, C. W. (2012). Effect of heating time on the antioxidative capacities of citrus fruit *(Citrus sinesis)* by products. *Food Science Technology Resources,18*(4),505-513.

Lohchoompol, V., Srzednicki, G., and Craske, J. (2004). The change of total anthocyanin in blueberries and their antioxidant effect after drying and freezing. *Journal of Biomedicine and Biotechnology,5,*248-252.

Lopez, J., Galvez, A. V., Torres, M. J., Mondaca, L. R., Quispe, I. F., and Scala, K. D. (2013).Effect of dehydration temperature on physico-chemical properties and antioxidant capacity of goldenberry (*Physalis peruviana* L.). *Chilean Journal of Agricultural Research,73*,1-3.

Lopez, M. R. R., Diaz, P. O., Perez, L. A. B., Tovar, J., and Nicanor, A. B. (2011). Fiber concentrates from orange (*Citrus sinesis* L.) Bagase: Characteristics and application as backery product ingredients. *International Journal of Molecular Science*, 12, 2174-2186.

Lutz, M., Hernandez, J., and Henriquez, C. (2015). Phenolic content and antioxidant capacity in fresh and dry fruits and vegetables grown in Chile. *CyTA Journal of Food*, *13*(4), 541-547.

Macias, M. A., Martinez, A, C., Mounir, S., Gaitan, G. M., and Allaf, K. (2013). Comparative study of the effects of drying methods on antioxidant activity of dried strawberry (*Fragaria* Var. *Camarosa*). *Journal of Food Research*, *2*(2),92-107.

Mahapatra, A. K., Mishra, S., Basak, U. C., and Panda, P. C. (2012). Nutrient analysis of some selected wild fruits deciduous forests of India: an explorative study towards non conventional bio-nutrition. *Advance Journal of Food Science and Technology 4*(1),15-21.

Mahmoud, M. H., Qura, A. Z. E., Badawy, I. H., Yehya, A., Hady, A. et al. (2013). Hypocholesterolemic effect of antioxidant containing fruits in rats fed on high cholesterol and fat diet. *Journal of Applied Sciences Research, 9* (7), 4233-4244.

Malomo, S. A., Eleyinmi, A. F., and Fashakin, J. B. (2011). Chemical composition, rheological properties and bread making potentials of composite flours from breadfruit, breadnut and wheat. *African Journal of Food Science, 5*(7), 400 – 410.

Manach, C., Scalbert, A., Moorand, C., Remesy, C., and Jimenez, L. (2004). Polyphenols: food sources and bioavailability. *American Journal Clinical Nutrition,79,*727-747.

Mansour, E. H., Dworschak, E., Pollhamer, Z., Gergely, A., Matazu, I. K. et al. (1999). The effect of drying method on the nutrients and non-nutrients composition of the front of *Hibiscus esculentus*(Okra). *Nigeria Journal Renewable Energy, 11,* 9-13.

Mansour, E. H., Dworschak, E., Pollhamer, Z., Gergely, A., and Hovari, J. (1999). Pumpkin and canola seed proteins and bread quality. *Acta Alimentaria*,28,59-70.

Matazu, I.K. and Haroun, A. A. (2004). The effect of drying method on the nutrients and non-nutrients composition of the fruits of *Hibiscus esculentus* (Okra). *Nigerian Journal Renewable Energy*, 11, 9-13.

Matsuo, T., and Itoo, S. (1978). The chemical structure of kaki - Tannin from immature fruit of the persimmon *(Diospyros kaki L.). Agricultural Biological Chemistry, 42,*1637 - 1643.

Mc Clement, D. J. (2003). Analysis of Food Products. Accessed July 26,2012. http:// people.u.mass.edu/-mcclemen/581Ash$Minerals.html.

Mc Donald, J. k., Caflin, N. A., Sommano. S., and Cocksedge, R. (2006). The Effect of post analysis of food Products. Accessed July26,2012.http://people.umass.edu/mcclemen/581Ash and minerals.html.

Mechlouch, R. F., Elaskesh, E. O., Elfalleh, H. H. W., and Thabet, A. A. G. (2015). Changes in the physico-chemical properties of palm date using different drying methods. *University, Bulletin,17*(1),59-78.

Meda, V., Gupta, M., and Opoku, A. (2008). Drying kinetics and quality characteristics of microwave–vacuum dried Saskatoon berries. *Journal of Microwave Power and Electromagnetic energy, 42*(4),42-44.

Mehraj, H., Sikder, R. K., Haider, M. N., Hussain, M.S., and Uddin, A. F. M. J. (2013). Fig (*Ficus carica*). A new crop in Bangladesh. *International Journal of Buisness, Social and Scientific Research, 1*(1),2309-7892.

Mehta, S. (1995). *Evaluation of different cultivars of Anola (Emblica officinalis Garten) for processing* . MSc. Thesis.CCS HAU, Hisar.

Mhalaskar, S. R., Lande, S. B., Satwadhar, P. N., Deshpande, H. W., and Babar, K. P. (2012). Development of technology for fortification of fig (*Ficus carica*) fruit into its value added product- fig toffee. *International Journal of Processing and Post Harvest Technology,3* (121),176-179.

Michael, O. A., Gernah, D. I., and Igbabul, D. (2013). Physico-chemical and sensory evaluation of wheat bread supplemented with stabilized undefatted rice bran. *Food and Nutrition Sciences*, 4, 43-48 .

Mihajer, S., Taha, R. M., and Mohajer, M. (2016). Effects of cryopreservation and relative humidity on viability and nutritional composition of sainfoin (*Onobrychis vicifolia scop*.). *Journal of Animal and Plant Science, 26* (2),116-122.

Miletic, N., Popovic, B., Mitrovic, O., Kandic, M., and Leposavic, A. (2014). Phenolic compounds and antioxidant capacity commonly consumed in Serbia. Czech. *Journal of Food Science,32* (4),360-368.

Ministry of Health and Family Welfare. (2008). Department of Ayurveda yoga and neuropathy, Unani siddha homoeopathy, *New Delhi, First edition (AYUSH),VI* (1),340.

Mishra, G., Mishra, A. A., and Shukla, R. N. (2014). Development of pulse, banana and pineapple pomace based weaning food and its quality evaluation during storage. *International Journal of Development Research,* 4 (6),1257-1262.

Mishra, D. K., Dolan, K. D., and Yang, L. (2008). Confidence intervals for modeling anthocyanin retention in grape pomace during non isothermal heating. *Journal of Food Science, 73,* E9–E15.

Mishra, R. M., and Gupta, P. (2005). Frugivory and seed dispersal of *Carissa spinarum (* L.*)* in a tropical deciduous forest of central India. *International Society for Tropical Ecology*,46(2),151-156.

Mithanka, D. M. T. (2012). Polyphenol content and antioxidant analysis of *Pseudolachinostylis Maprouneifolia Pax* Var Dikindtii used as livestock feed farmers from Eastern Botswana. *Journal of Pharmaceutical and Scientific Innovation,1*(5),51-57.

Mohammadian, M. A., Mobrami, Z., and Sajedi, R. H. (2011). Bioactive compounds and antioxidant capacities in the flavedo tissue of two citrus cultivars under low temperature. *Brazilian Society of plant physiology, 23*(3), 203-208.

Mohsenin, N. N. (1986). Physical Properties of Plant and Animal Materials, New York: Gordon and Breach Science Publishers.

Mohsenin, N. N. (1970). Physical Properties of Plant and Animal Materials. Gordon and Breach Science Publishers, New York, USA.

Moldovan, B., and David, L. (2014). Studied the temperature and preserving agents on the stability of cornelian cherries anthocyanins. *Molecules, 19*, 8177-8188.

Monica, A., Madeau, E., Piscopo, A. E., Sanguinetti, E., Caro, A. D., Poiana, M. E., Romeo, V. et al. (2009). *European Food Resources, 228*,441-448.

Mori, K., Yamamoto, N. G., Kitayama, M., and Hashizume, K. (2007). Loss of anthocyanins in red- wine grape under high temperature. *Journal of Experimental Botany, 58*(8),1935–1945.

Morris, A., Barnett, A., and Burrows, O. (2004). Effect of processing on nutrient content of foods. *Cajarticles, 37*,160-164.

Morton, J. (1987). Fruits of warm climates. (Book. Fl. Ig. Miami, 2005), 47-50.

Morton, J. F. (1987). Fruits of warm climates. Creative Resources Systems, *Inc. Winterville*, N.C.,USA,503.

Mrabet, A., Gutierrez, G. R., Bejarano, R. G., Arcos, R. R., Ferchichi, A., Sindic, M., and Araujo, A. J. (2015). Valorization of Tunisian secondary date varieties (*Phoenix dactylifera L*.) by hydrothermal treatments: New fiber concentrates with antioxidant properties. *LWT-Food Science and Technology, 60*,518-524.

Mule, P. R., Barbind, R. P., Korake, R. L., and Gavit, D. P. (2014). Proximate composition, sensory evaluation and production cost of fig milk shake prepared from buffalo milk. *Animal Science, 8*(2),43-47.

Mullen, W., Stewart, A. J., Michael, E., Jean, J., Gardner, P., Garry, G. D. et al. (2002). Effect of freezing and storage on the phenolic, ellagitannins, flavonoids and antioxidant capacity of red raspberries. *Journal of Agriculture and Food Chemistry, 50*,5197-5201.

Musa, A. (2013). Effect of freezing on some plant toxins and micronutrients in the leaves of *Amaranthus Cruenthus*. *Journal of Food Studies,2*(1),75-92.

Musa, K. H., Abdullah, A., Jusoh, K., and Subramaniam, V. (2011) Antioxidant activity of pink-flesh guava (*Psidium guajava* L.): effect of extraction techniques and solvents. *Food Analytical Method, 4*, 100–7.

Mutso, M., and Satrino, M. L. (2010). Fruit responses to postharvest heat treatment time: characterization of heat-treated strawberry (*Fragaria x ananassa*) cv. 'Candonga' fruits. *Agronomy Research 8*, (1), 815–826.

Nackilcioglu, E., and Hisil, Y. (2013). Research on the phenolic compounds in Sarilop (*Carissa spinarum* L.) fig variety. *GIDA, 38*(5), 267-274.

Nakamura (2008). Preliminary studies on the removal of astringency by freezing in Japnese persimmons. *Journal of the Japnese Society for Horticultural Science, 30*(1),73-76.

Nandan, U., and Bhardwaj, R. (2014). The role of underutilized fruits in nutritional and economic security of tribals: a review. *Critical Reviews in Food Science and Nutrition*,54 (7),880-890.

National Sample Survey Office. (2012). Ministry and Statistics and Programme Implementation, New Delhi Government of India.

Neal, M. C. (1965). In Gardens of Hawaii, University of Hawaii and Bishop Museum, Honolulu, Hawaii, USA, 40.

Nermin, B. (2008). Utilization of buckwheat flour in gluten-free noodles production. *Journal of Food, Agriculture environment, 62* (20),113-115.

Ngueguim, T. F., Dimo, T., Dzeufiet, D. P. D., Vouffo, B., Dongo, E., Renaud, B. et al. (2007). Antidiabetic activities of methanol-derived extract of *Dorstenia picta* twigs in normal and streptozotocin-induced diabetic rats. *Asian Journal of Traditional Medicines,2* (4), 140 - 148.

Nicoli, M. C., Anese, M., and Parpinel, M. (1999). Influence on processing on the antioxidant properties of fruits and vegetables. *Trends in Food Science and Technology,10*, 94-100.

Nieman, D. C., Butterworth, D. E., and Nieman, C. N. (1992) Nutrition. *WmC. Brown Publishers*, Dubugye, 237-312.

Nilsson, J. S., Stegmark, R., and Akesson, B. (2004). Total antioxidant capacity in different pea *(Pistum sativum)* varieties after blanching and freezing. *Food Chemistry,86,*501-507.

Nimkar, P. M., and Chattopadhyay, P. K. (2001). Some physical properties of green gram. *Journal of Agricultural Engineering Resources*, *80* (2), 183-189.

Nithiyanantham, S., Varadharajan, S., and Siddhuraju, P. (2012). Differential effects of processing methods on the total phenolic content, antioxidant and antimicrobial activities of three species of Solanum. *Journal of Food and Drug Analysis,20*(4),844-854.

Njiida, A. A. (2010). Chemical composition, fiber fraction and anti-nutritional substances of semi arid browse forages of North- Eastern Nigeria. *Nigerian Journal of Basic and Applied Science, 18* (2),181-188.

Noonan, S. C., and Savage, G. P. (1999).Oxalate content of foods and its effect on humans. *Asia Pacific Journal Clinical Nutrition,8,*64-74.

Nordin, N. I. A. A., Ariffin, H., Andou, Y., Hassan, M. A., Shirai, Y., Nishida, H. et al. (2013). Modification of oil palm mesocarp fiber characteristics using superheated steam treatment. *Molecules, 18*, 9132-9146.

Noutchogoue, V. K., Kapseu, C., Tchiegang, C., Piffaut, B., and Parmentier, M. (2005).Textural and Biochemical changes associated with the hardening phenomenon in aiele fruit (*Canarium Schweinfurthi Eng). Journal of Food Technology,3*(2),143-148.

Nwanekezi, E. C., and Agbugba, R. U. (2015). Effect of substitution of sucrose with date palm (*Phoenix dactylifera*) fruit on quality bread. *Food Processing and Technology,6*(9),484.

Nwaogwe, J. O., and Adejumo, B. A. (2015). Qualities of African breadfruit (*Treculia Africana*) seed flour influenced by thermal processing methods and duration. *International Journal of Technology Enhancement and Emerging Engineering Research, 3*(4),102-104.

Oancea, S., Moiseenco, F., and Traldi, O. P. (2014). Effects of freezing and oven drying of Romanian wild and cultivated red raspberries on total anthocyanins and total antioxidant capacity. *Romanian Biotechnological Letters, 19*(2), 9241-9247.

Obiegbuna, J. E., Akubor, P. I., Ishiwu, C. N., and Ndife, J. (2013). Effect of substituting sugar with date palm pulp meal on the physicochemical, organoleptic and storage properties of bread. *African Journal of Food Science*,7(6),113-119.

Oboh, G., Ademosun, A. O., Olasehinde, T. A., Oyeleye, S. I., and Ehiakhamen, E. O. (2015). Effect of processing methods on the antioxidant properties and inhibition of alpha amylase and alpha glucosidase by African pear (*Dacryodes edulis*) fruit. *Nutra foods*, *14*, 19-26.

Ogbadoyi, E. O., and Musa, A. (2013). Effect of freezing on some plant toxins and micronutrients in the leaves of *Amaranthus cruentus. Journal of Food Science,2* (1),75-92.

Ogunbanwo, S. T., Azinat, S., Olufunke, A., and Fadahunsi, I. F. (2013). Microbiological and nutritional evaluation of water melon juice (*Citrullus lanatus*). *Academia Arena,5*(3),36-41.

Ojinnaka, M. C., Anyanwu, F. A., and Ihemeje, A. (2013). Nutritional evaluation of cookies produced from African breadfruit (*Treculia africana)* starch and wheat flour. *International Journal of Agricultural and Food Science*, 3(3), 95-99.

Olajire, A. A., and Azeez, L. (2011). Total antioxidant activity, phenolic, flavonoid and ascorbic acid contents of Nigerian vegetables. *African Journal of Food Science and Technology, 2*(2), 022-029.

Omer, U. C., and Canan, E. T. (2014). Fruit processing. Strategies for quality assessment. *Food Engineering Series*, DOI 10.1007/978-1-4939-1378-7-2.

Oyaizu, M. (1986). Studies on products of browning reaction: antioxidative activities of products of browning reaction prepared from glucosamine. *Jap*nese *Journal ofNutrition,44*, 307-315.

Ozcan, M., Arslan, D., and Unver, A. (2004). Effect of drying methods on the mineral content of basil (*Ocimum basilicum L.*). *Journal of Food Engineering, 69,* 375-379.

Oztekin, S., Erdem, T., and Karaaslan, S. (2011). Effect of hot air and microwave drying on some physical properties of laurel berry. *African Journal of Agricultural Research*, 6(12), 2676-2679.

Pacco, H. C., and Menegalli, F. (2004). Drying of sliced figs of 'Gigante de Valinhos' variety (*Carissa spinarum*). In Silva, M. A. and Rocha, S.C.S. (eds.) *Drying. Proceeding of the 14 th International Drying Symposium*, Sao Paulo, Brazil, 1851- 1858.

Pacco, H. C., Vigneault, C., Castro, L. R., Menegalli, F. C., and Cortez, L. A. B. (2007). Temperature effect on drying kinetics of 'Gigante de Valinhos' figs. *Journal of Food and Environment, 5*(2),70-75.

Padulosi, S., Hoeschle- Zeledon, I., and Bordoni, P. (2008). Minor crops and underutilized species: lessons and prospects In: N. Maxted, B.V. Ford-Lloyd, S.P. Kell, J.M. Iriondo, M.E. Dulloo, J. Turok eds. *Crop wild relatives, conservation and use.* Wallingford, UK: CAB International.

Pandey, A. K., Ojhav, V., Yadav, S., and Sandhu, S. K. (2011). Phytochemical evaluation and radical scavenging activity of *Bauhinia variegate, Saraca asoka* and *Terminalia arjuna* barks. *Resource Journal Phytochemistry,2*,89-97.

Pandey, A. K., Dubey, A. K., Singh, R. K., and Vida, E. (2014). Addressing the problem of micronutrient malnutrition in Neh region- underutilized vegetables as a source of food. *International Journal of Food and Nutritional Science, 3*(3),75-83.

Papu, S., Singh, A., Javir, S., Sweta, S., Arya, A. M., and Singh, B. R. (2014). Effect of drying characteristics of garlic – a review. *Journal Food Process Technology,5*(4),1-6.

Pardeshi, I. L., Bhuskade, S. A., and Kalmegh, V. B. (2013). Development of cold extruded ready to cook (*Vigna radiate L.)* nuggets. *Journal of Food Research and Technology,1*(1),21-28.

Parmar, C., and Kaushal, M. K. (1982). *In: Wild Fruits.* Kalyani Publishers, New Delhi, India,15-18.

Patel, D. K., Kumar, R., Prasad, S. K., Sairam, K., and Hemalatha, S. (2011). Antidiabetic and *in vitro* antioxidant potential of *Hybanthus enneaspermus* (Linn) F. Muell in streptozotocin-induced diabetic rats. *Asian Pacific Journal of Tropical Biomedicine*,1,316-22.

Pathak, P. K., Preeti, D., and Kumar, S. (2009). Effect of post-harvest treatments on shelf-life of aonla (*Emblica officinalis*) fruits damaged during harvesting. *Journal of Food Science Technology, 46*, 283–285.

Patras, A., Brunton, N. P., Donnell, C. O., and Tiwari, B. K. (2010). Effects of thermal processing on anthocyanin stability in foods; mechanisms and kinetics of degradation. *Trends in Food Science and Technology 21*,3-11 .

Perez, C., Dominquez, E., Canal, J. R., Campillo, J. E., and Tarres, M. D. (2000). Hypoglycemic activity of aqueous extract from *Carissa spinarum* fig tree leaves in streptozotocin diabetic rats. *Pharm Biology*,38(3),181-186.

Pewlong, W., Sajjabut, S., Eamsiri, J., and Chookaew, S. (2014). Evaluation of antioxidant activities, anthocyanins, total phenolic content, vitamin C content and cytotoxicity of *Carissa carandas* Linn. *Food and Applied Biosciences,13*(1),509-517.

Piga, A., Del, C. A., and Corda, G. (2003). From plums to prunes: Influence of drying parameters on polyphenols and antioxidant activity. *Journal of Agriculture and Food Chemistry, 51*,3675-3681.

Pimia, R. P., Hakkinen, S. T., Aarni, M., Suortti, T., Lampi, A. M., Eurola, M. et al. (2003). Blanching and long term freezing affect various bioactive compounds of vegetables in different ways. *Journal Science Food Agriculture,83*,1389-1402.

Pinki and Awasthi, P. (2014). Sensory and nutritional evaluation of value added cakes formulated by incorporating beetroot powder. *International Journal of Food and Nutrition Science,3*(6),145-148.

Planinic, M., Aliakbarian, B., Perego, P., Greganic, K., Tomas, S., and Kojic, A. B. (2015). Influence of temperature and drying time on extraction yield of phenolic compounds from grape pomace variety "Portogizac". *Chemical and Biochemical Engineering Quarterly,29*(3),343-350.

Poiana, M. E., Moigradean, D., and Alexa, E. (2010). Influence of home- scale freezing and storage on antioxidant properties and colour quality of different garden fruits. *Bulgarian Journal of Agriculture Science, 16* (2),163-171.

Pradhan, R. C., Naik, S. N., Bhatnagar, N., and Vijay, V. K. (2009). Moisture dependent physical properties of jatropa fruit. *Industrial Crops and Products, 29,* 341-347.

Pragati, D., and Dhawan, S. S. (2003). Effect of drying methods on nutrition composition of dehydrated aonla fruit (*Emblica officinalis Garten*) during storage. *Plant Foods for Human Nutrition, 58,* 1–9.

Pragati, S., Dahiya, S., and Dhawan, S. S. (2003). Effect of drying methods on nutritional composition of dehydrated anola fruit (*Emblica officinalis Garten*) during storage. *Plant Foods for Human Nutrition, 58*,1-9.

Prakash, D., Upadhyay, G., and Pushpangadna, P. (2011). Antioxidant potential of some under-utilized fruits. *Indo-Global Journal of Pharmaceutical Sciences, 1*(1), 25-32.

Pratyush, K., Masih, D., and Sonkar, C. (2015). Development and quality evaluation of pumpkin powder fortified cookies. *International Journal of Science, Engineering and Technology, 3*(4),1034-1038.

Price, M. L., Socoyoc, S. V. and Butler, L. G. (1978). A Critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. *Journal Agriculture Food Chemistry,* 26, 1214-1218.

Price, K. R., and Rhodes, M. J. C. (1997). Analysis of the major flavonoid glycosides present in four varieties of onion and changing in composition resulting from autolysis. *Journal of Science, Food and agriculture,74*,331-335.

Rabeta, M. S. and Lin, S. P. (2015). Effect of different drying methods on the antioxidant activities of leaves and berries of *Cayratia trifolia*. *Sains Malaysian, 44*(2),275-280.

Raffo, A., Leonardi, C., Fogliano, V., Ambrosino, P., Salucci, M., Gennaro, L. et al. (2002). Nutritional value of cherry tomatoes (*Lycopersicon esculentum* cv. Naomi F1) harvested at different ripening stages. *Journal Agriculture Food Chemistry,50,* 6550–6.

Rahman, S., M., Islam, M., R., Rahman, S., Mosaiab, T., Ahmed, F. K., Nusratun, N., Ahsan, S. et al. (2011). Antihyperglycemic studies with methanol Extract of *Annona reticulata* L. (Annonaceae) and *Carissa carandas* L. (Apocynaceae) leaves in swiss albino mice. *Advances in Natural and Applied Sciences, 5*(2),218-222.

Rai, N., Asati, B. S., Patel, R. K., and Yadav, D. S. (2005). Underutilized horticultural crops in North Eastern region. *ENVIS Bulletin: Himalayan Ecology, 13*(1),1-11.

Raj, A., and Masih, D. (2014). Physico chemical and rheological properties of wheat flour muffin supplemented with orange peel powder. *International Journal of Science and Research,3*(8),2319-7064.

Raji, A. O., Akinoso, R., and Raji, M. O. (2016). Effect of freeze- thaw cycles on the nutritional quality of some selected Nigerian soups. *Food Science and Nutrition, 4*(2),163-180.

Ramaswamy, H. S., and Tung, M. A. (1981). Thermophysical properties of apples in relation to freezing. *Journal of Food Science, 46,*724-728.

Rani, B., and Kawatra, A. (1994). Fiber constituents of some foods. *Plant Foods for Human Nutrition,45,*343-347.

Rashidi, A. A., and Noureddini, M. (2011). Hypoglycemic effect of the aromatic water of leaves of *Carissa spinarum* in normal and streptozotocin induced diabetic rats. *International Journal of Current Pharmaceutical Research,1,*372-379.

Ratti, C. (1994). Shrinkage during drying of foodstuffs. *Journal of Food Engineering, 23*(1),91-105.

Raupp, D. S., Rodrigues, E., Rockenbach, I. I., Carbonar, P. F. C., and Borasto, R. F. (2011). Effect of processing on antioxidant potential and total phenolic in beet(*Beta vulgaris L.). Cien. Technology Aliment. Campinas*,*31*(30),688-693.

Razavi, S. M. A., Pourfarzad, A., Sourky, H., and Jahoromy, S. H. R. (2010).The physical properties of fig *(Ficus carica)* as a function of moisture content and variety. *The Philippine Agricultural Scientist,41*,896-904.

Redddy, D. K., Jangabelli, M., and Singh, J. K. (2014). Utilization of an underexploited fruit (*Ficus carica*) as a preserved product. *Journal of Agroecology and Natural Resource Management,1*(2),78-81.

Rehman, S., Nandeem, M., Ahmad, F., Mushtaq, Z. (2013). Biotechnological production of xylitol rom banana peel and its impact on physicochemical properties of rusks. *Journal Agriculture Science Technology,15*,747-756.

Reyes, Y. C., Alvarez, L. D., Baez, D. A., Esquivel, O. O., and Moreno, A. O. (2013). Polyphenol oxidase inactivation by microwave oven and its phenolic profile of loquat (*Eriobotrya Japonica)* fruit. *Food and Nutrition Science*,4 (9B),87-94.

Rickman, J. C., Barrett, D. M., and Bruhn, C. M. (2007). Nutritional comparison of fresh,frozen and canned fruits and vegetables. Part1. Vitamins C and B and phenolic compounds. *Journal of the Science of Food and Agriculture,87*, 930-944.

Rickman, J. C., Bruhn, C. M., and Barrett, D. M. (2007). Nutritional comparison of fresh, frozen and canned fruits and vegetables II. Vitamin A and carotenoids, vitamin E, minerals and fiber. *Journal of Science of Food and Agriculture*, 0022-5142.

Rithiruangdej, P., Parnbankled, S., Donchedee, S., Wongsagonsup, R. (2011). Physical, chemical, textural and sensory properties of dried wheat noodles supplemented with unripe banana flour. *Kasetstar Journal (Natural Science),45*(3),500-509.

Rodríguez, R., Jiménez, A., Fernández-Bolaños, J., Guillén, R., and Heredia, A. (2006). Dietary fiber from vegetable products as source of functional ingredients. *Trends Food Science Technology, 17*, 3-15.

Romjaun, Z. Z., and Prakash, J. (2013). Development and assessment of fiber- enriched muffins. *Advances in Food Science,* 35(4), 159165.

Rosell, C. M., Rojas, J. A., and Benedita, B. C. (2011). Influence of hydrocolloids on dough rheology and bread quality. *Food Hydro-colloid,15*,75-81.

Rossetti, L., Fronzo, R. A., and Gharezi, R. (1990). Effect of metformin treatment on insulin action in diabetic rats: *in vivo* and *in vitro* correlations. *Metabol*, 39, 425-435.

Rosy, K., Gupta, A., and Sarita, S. (2015). Development and sensory optimization of low cost micronutrient rich nutritious product by using locally available food resources. *International Journal of Food and Nutritional Science,5*(1).

Rout, S. P., Kar, D. M., Mohapatra, S. B., and Swain, S. P. (2013). Anti-hyperglycemic effect *Annona Reticulata* L. leaves on experimental diabetic rat model. *Asian Journal of Pharmaceutical and Clinical Research, 6*(1),56-60.

Rozier, A., Lean, M. E. J., McDonald, M. S., and Black, C. (1995). Quantitative analysis of the flavonoid content of commercial tomatoes, onion, lettuice and celery. *Journal of Agriculture Food Chemistry, 42*, 281-285.

Rukayah, A. (1992). Buahbuahan Nadir Semonanjung Malaysia, Dewan Bahasadan Pustaka, Kuala Lumpur, Malaysia.

Rupasinghe, H. P. V., Wang, L., Huber, G. M., and Pittis, N. L. (2008). Effect of baking on dietary fiber and phenolics of muffins incorporated with apple skin powder. *Food Chemistry, 107*,1217-1224.

Ryder, J. M., Fletcher, G. C., Stec, M. G. and Seelye, R. J. (1993). Sensory, microbiological and chemical changes in hake stored in ice. *International Journal of Food Science Technology,28,* 169-180.

Sachin, A., Shreesh, K. O., and Divya, V. (2009). Characterization of streptozotocin induced diabetes mellitus in swiss albino mice. *Global Journal of Pharmacology, 3* (2),81-84.

Sadiq, I. S., Izugaize, T., Shiaibu, M., Dogoyaro, A. L., Garba, A. et al. (2013). The nutritional evaluation and medicinal value of date palm (*Phoenix dactylifera*). *International Journal of Modern Chemistry,4*,147-154.

Sae-kang, V., and Suphantharika, M. (2006). Influence of P^H and xanthan gum addition on freeze thaw stability of tapioca starch pastes. *Carbohydrate polymer,* 65,371-380.

Safy, F. S. E. (2014). Drying characteristics of laquot slices using different dehydration methods by comparative evaluation. *World Journal of Dairy and Food Sciences, 9* (2), 272-284.

Sakhale, B. K., Chalwad, R. U., and Pawar, V. D. (2012). Standardization of process for preparation of fig- mango mixed toffee. *International Food Research Journal,19*(3), 889-891.

Salgado, S. M., Guerra, N. B., and Filho, A. B. (1999). Frozen fruit pulps: Effects of the processing on dietary fiber contents. *Revista de Nutrico,50*,281-285.

Salim, N., Quatmane, A., Latrache, H., Ennhali, S., Zinelabidine, L. H. et al . (2014). Bioactive components and antioxidant activity of Morrocan Paprika (*Capscium annuum L.)* under different storage time and conditions. *Turkish Journal of Agricultural and Natural Sciences*, 1734-742.

Salmanian, S., Mahoonak, S. A. R., Alami, M., and Ghorbani, M. (2014). Phenolic Content, antiradical, antioxidant and antibacterial properties of Hawthorn (*Crataegus elbursensis*) seed and pulp extract. *Journal of Agricultural Science and Technology, 16*(2), 343-354.

Sandhu, M. K. (1990).“Fig’’ in fruits tropical and subtropical, T.K. Bose and Mitra, S. K, Eds, *Naya Prokash, Calcutta, India,* 650-663.

Sangeeta, S., and Mahanta, C. L. (2013). Effect of steaming, boiling and microwave cooking on the total phenolics, flavonoids and antioxidant properties of different vegetables of Assam, India. *International Journal of Food and Nutritional Science,2*(3)47-52.

Sanwal, R., and Chaudhary, A. K. (2011). Wound healing and antimicrobial potential of *Carissa spinarum* Linn. in albino mice. *Journal Ethnopharmacology,*135(3),792-6.

Sarkis, J. R., Jaeschke, D. P., Tessaro, I. C., and Marczak, D. F. (2013). Effects of ohmic and conventional heating on anthocyanin degradation during the processing of blueberry pulp. *Food Science and Technology, 51,* 79-85.

Saunders, R. M. (1990). "The Properties of Rice Bran as a Food Stuff," *Cereal Foods World, 35,* (7), 632-639.

Scheirber, A., Keller, P., and Carle, R. (2001). Determination of phenolic acids and flavonoids of apple and pear by high- performance liquid chromatography. *Journal of Chromatography A, 910,* 265-273.

Schmidt, B. M., Erdman, J. W., and Lila, M. A. (2005). Effects of food processing on blueberry antiproliferation and antioxidant activity. *Journal of Food Science,70* (6), S389-S394.

Schutz, H. G., and Cardello, A. V. (2001). A labeled affective magnitude (LAM) scale for assessing food liking/disliking. *Journal of Sensory Studies, 16,* 117–159.

Scibisz, I., and Mitek, M. (2007).The changes of antioxidant properties in high bush blueberries (*Vaccinium corymbosum* L.). During freezing and long –term frozen storage. *Acta Scientarium Polonrum Technologia Alimentaria, 6* (4),75-82.

See, E. F., Nadiah, W. A., Aziah, N. A. A. (2007). Physico chemical and sensory evaluation of breads supplemented with pumpkin flour. *Asian Food Journal,14*(2),123-130.

Seeminska, M.D., Najda, A., Dyduch, J., Gantner, M., and Klimek, K. (2015). The content of secondary metabolites and antioxidant activity of wild strawberry fruit (*Freagaria vesca* L.). *Journal of Analytical Methods in Chemistry, 83,*1238,1-8.

Seleem, H. A. (2015). Effect of blending doum (*Hyphaene thebacia*) powder with wheat flour on the nutritional value and quality of cake. *Food and Nutrition Science,6*,622-632.

Shaheel, S. K., Swami, D. V., Prasanna, B. K., and Krishna, U. K. (2015). Effect of blending of karonda (*Carissa caranda*) juice with guava, papaya and pineapple juice on its quality and organoleptic evaluation. *Plant archives,15*,187-192.

Sharifian, F., Motlagh, A. M., and Nikbakht, A. M. (2012). Pulsed microwave drying kinetics of fig fruits(*Carissa spinarum L*). *Australian Journal of Crop Science,6*(10),1441-1447.

Sharma, A., and Gupta, A. P. (2013). Evaluation of antioxidant activity and validated method for analysis of polyphenols from non – edible parts of Indian tropical fruits by using microwave assisted extraction and LC-MS/MS. *International Journal of Bio Science and Pharma,4,*(1),227-241.

Sharma, S. and Chopra, R. (2015). Formulation, chemical and textural analysis of biscuits prepared with malted green gram (*Vigna radiata*). *International Journal of Agricultural and Food Science,* 5(3),98-103.

Sharma, V., and Chawla, P. (2011). Development and nutrient evaluation of oat supplementated products for old age people with constipation. *Ethno Medicine*,5(3),161-164.

Sharnouby, G. A., Aleid, M. S., and Otaibi, M. A. (2012). Nutritional quality of biscuit supplemented with wheat bran and date palm fruits (*Phoenix dactylifera* L.). *Food and Nutrition Science,3*,322-328.

Shen, Y., Fukushima, M., Ito, Y., Murak, E., Honsono, T., Seki, T., Ariga, T. (2010). Verification of the antidiabetic effects of cinnamon (*Cinnamomum zeylancium*) using insulin uncontrolled type 1 diabetic rats and cultured adipocytes. Biosciences Biotechnology Biochemistry,74, 2418- 2425.

Shivasharanappa, K., and Londonkar, R . (2014). Evaluation of total phenolic content and free radical scavenging activity of *Ficus glomerata Roxb. International Journal of Pharmaceutical and Clinical Research, 6*(2), 133-137.

Shobaki, F. A., Bahay, A. M., and Esmail, R. S. A. (2010). Effect of fig fruits (*Ficus carica)* and its leaves on hyperglycemia in alloxan diabetic rats. *World Journal of Diary and Food Sciences,5*(1),47-57.

Sikora, E., Bieniek, M. I., and Borczak, B. (2013). Composition and antioxidant properties of fresh and frozen stored blackthorn fruits (*Prunus Spinosa L.). Acta Scientarium Polonorum Technologia,12*(4),365-372.

Silva, E. P., Cardoso, A. F. L., and Fante, C. (2013). Effect of postharvest temperature on the shelf life of gabiroba fruit (*Campomanesia pubescens*). *Food Science and Technology,33*(4),632-637.

Simonyan, K. J., Yiljep, Y. D., Oyatoyan, O. B., and Bawa, G. S. (2009). "Effects of Moisture Content on Some Physical Properties of *Lablab purpureus* (L.) Sweet Seeds". *Agricultural Engineering International,* 1279,(XI).

Singh, A., Grover, K., and Sharma, N. (2014). Nutritional evaluation of value added products using dehydrated greens for security of haematinic nutrient. *Food Science Research Journal,5* (2),168-173.

Singh, L., Yadav, N., Kumar, A. R., Gupta, A. K., Chacko, J. et al. (2007). Preparation of value added products from dehydrated bathua leaves (*Chenopodium album Linn*.). *Natural Product Radiance,6*(1),6-10.

Singh, S., Bala, N., Verma, A., and Srivastava, S. (2015). Development of noodles using banana peels as a functional ingredient. *International Journal of Pure Applied and Bio Science, 3* (1),87-91.

Singh, P., and Sharma, H. R. (2003). Nutritional and organoleptic evaluation of *Colocasia* leaf rolls supplemented with different protein sources. *Journal of Human Ecology,*14(6),467-469.

Singh, S., Singh, A. K., Joshi, H. K., Bagle, B. G., and Dhandar. D. G. (2009). Evaluation of packages for transportation and storability of aonla (*Emblica officinalis*) under semi-arid environment of Western India. *Journal of Food Science Technology, 46,*127–131.

Singleton, V. L., Orthofer, R., and Raventos, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-ciocalteau reagent. *Methods in Enzymology*, *299*,152-178.

Siriwattananon, L., and Maneerate, J. (2016). Effect of drying methods on dietary fiber content in dried and vegetable from non-toxic agricultural field. *International Journal of Geomate,11*(28),2896-2900.

Skrede, G. (1996). Fruits. In *Freezing Effects on Food Quality*; Jeremiah, L. E., Ed.; Dekker: New York.

Skupien, K. (2006). Evaluation of chemical composition of fresh and frozen blueberry fruit (*Vaccinium corymbosum* L.*). Acta. Sci.Pol. Hortorum Cultus,5*(1),19-25.

Slatnar, A., Klancar, U., Stampar, F., and Veberic, R. (2011). Effect of drying of figs (*Carissa spinarum* L.*)*on the contents of sugars, organic acid and phenolic compounds. *Journal of Agriculture Food Chemistry,9* (59),21,11696-702.

Sobota, A., and Luczak, J. (2010). Badania skladu chemicnego makaronow instant, Bromat. *Chem. Toksykol., XLIII*(4),515-522.

Solomon, A., Golubowicz, S., Yablowicz, Z., Grossman, S., Bergman, M., Gottlieb, H. E., Altman, A., Kerem, Z. et al. (2006). Antioxidant activities and anthocyanin content of fresh fruits of common fig *(Carissa spinarum L.). Journal of Agricultural and Food Chemistry, 54*(20),7717-7723.

Sonasong, P., Srzednicki, G., and Lohachoompol, V. (2010). Effects of preconditioning on quality of dried blueberries, 10th International Working Conference on Stored Product Protection, Julius-Kühn-Archiv, 425, 264-269.

Soni, N., Mehta, G. S., and Gupta, R. K. (2014). Estimation of nutritional, phytochemical, antioxidant and anti-bacterial activity of dried *Ficus carica*. *Journal of Pharmacy and Phytochemistry*, *32* (2), 158-165.

Sozzi, G. O., Abrajan-Villasenor, M. A., Trinchero, G. D., and Fraschina, A. A. (2005). Post harvest response of 'Brown Turkey' figs *(Carissa spinarum* L.*)* to the inhibition of ethylene perception . *Journal of the Science of Food and Agriculture,85*,2503-2508.

Stanley, M., Prince, P., Kamalakkannan, N., Venugopal, P., and Menon,V. P. (2004). Antidiabetic and antihyperlipidemic effect of alcoholic *Syzigium cumini* seeds in alloxan induced diabetic albino rats. *Journal Ethanopharmacology,91*,209-213.

Statin, C., Dineshkumar, P., and Nithiyananthan, K. (2012). Evaluation of antidiabetic activity of methanolic leaf extract of *Carissa spinarum* in alloxan- induced diabetic rats. *Asian Journal of Pharmaceutical and Clinical Research, 5* (3),85-87.

Stumvoll, M., Nurjhan, N., and Perriello, G. (1995).Metabolic effects of metformin in non-insulin-dependent diabetes mellitus. *The New England Journal of Medicine*, 333,550-554.

Sudha, M. L., Baskaran, V., and Leelavathi, K. (2007). Apple pomace as a source of dietary fiber and polyphenols and its effect on the rheological characteristics and cake making. *Food* Chemistry, *104*(2), 686-692.

Sudha, N. L., Vertrimani, L., and Leelavathi, K. (2007). Influence of fiber from different cereals on the rheological characteristics of wheat flour dough and biscuit quality. *Food Chemistry,100*,1365-1370.

Sultana, B., Anwar, F., Ashraf, M., and Saari, N. (2012). Effect of drying techniques on the total phenolic contents and antioxidant activity of selected fruits. *Journal of Medicinal Plants Research, 6* (1),161-167.

Sultana, A., Rahman, T. R., Islam, M., Rahman, M., and Alim, M. A. (2014). Evaluation of quality of chapatti enriched with jackfruit seed flour and bengal gram flour. *Journal of Environmental Science, Toxicology and Food Technology, 8(*5),73-78.

Sunmola, A. I., David, M. G., Olanrewaju, and Chizea, O. T. V. (2011). Biochemical effect of some food processing methods on the health promoting properties of under-utilized *Carissa papaya* seed. *Journal of Natural Products, 4*,17-24.

Surekha, N., and Naik, R. S. (2014). Development of value added khakara from barn yard millet consumer acceptability, nutritional and shelf- life evaluation. *Asian Journal of Home Science*,9(1),60-65.

Swami, G., Nagpal, N., Rahar, S., and Singh, P. (2010). Effect of aqueous leaves extract of *Carissa* linn. on blood glucose levels of normoglycemic and alloxan- induced diabetic wister rats. *International Journal of Current Pharmaceutical Research*, *2*(3),65-67.

Swanston, F. S. K., Day, C., Bailey, C. J., and Flat, P. R. (1990). Traditional plant treatment for diabetes. Studies in normal and streptozotocin diabetic mice. *Diabetologia*, 33,462-4.

Szczesniak, A. S. (1998). *Effect on storage on texture*. In I. A. Taub and R.P. Singh. Food storage stability . Boca Raton: CRC Press.

Szkudlarz, S. M., Bajerska, J., Wojtasiak, R. Z., and Gorecka, D. (2013). White grape pomace as a source of dietary fiber and polyphenols and its effect on physical and nutraceutical characteristics of wheat biscuits. *Journal Science Food and Agriculture,93*,389-395.

Taneya, M. L. J., Biswas, M. M. H., and Din, S. U. (2014). The studies on the preparation of instant noodles from wheat flour supplementing with sweet potato flour. *Journal of Bangladesh Agriculture University,12*(1),135-142.

Tanwar, B., Andallu, B., and Modgil, B. (2014). Influence of processing on physicochemical, nutritional and phytochemical composition of *Carissa spinarum* products. *Asian Journal Dairy and Food Resources,33*(1),37-43.

Thakur, M. (2014). Underutilized food crops: treasure for the future India. *Food Science Resource Journal*, 5(2),174-183.

Thimmaiah, S. K. (1999). Standard Methods of Biochemical Analysis, Kalyani Publishers.

Thomas, L. R., William, E., Connor, D. S., and Warner, S. (2015). The interaction of dietary fibers and cholesterol upon the plasma lipids and lipoproteins, sterol balance and bowel function in human subjects. *The journal of clinical investigation,60*,1429-1437.

Thoravaldson, K., and Skjoldebrand, C. (1998).Water diffusion in bread during baking. *Lebensmittel Wissenchatt and Technologies,31*,658-663.

Tiwari, B. K., Brennan, C. S., Jaganmohan, R., Surbhi, A. and Alagusundaram, K. (2011). Utilization of pigeon pea (*Cajanus cajan L*) by product in biscuit manufacture. *LWT-Food Science and Technology,44,*153-159.

Turkmen, N., Sari, F., Sedat, Y., and Velioglu, S. (2005). The effect of cooking methods on total phenolics and antioxidant activity of selected green vegetables. *Food Chemistry, 93*,713-718.

Uchenna, O. A., Nkiruka, I. V., Eze, E. P., and Chinazaekpere, O. C. (2013). Nutrient, phytochemical composition and sensory evaluation of formulated diabetic snacks made from Nigeria foods, *Afzelia Africana* and *Detarium Microcapium* seed flour. *Pakistan Journal of Nutrition, 12*(2),108-113.

Uchenna, O.A., Nikiruka, I. V., Eze, E. P., and Chinazaekpere, O. C. (2013). Nutrient, phytochemical composition and sensory evaluation of formulated diabetic snacks made from Nigeria foods, *Afzelia Africans* seed flour and *Detarium Microcapium* seed flour. *International Journal of Basic and Applied Sciences,13*(2),40-44.

Udomkun, P., Argyropoulous, D., Nagle, M., and Mahayothee, B. (2015). Sorption behavoiur of papayas as affected by compositional and structural alterations from osmotic pretreatment and drying. *Journal of Food Engineering,157*,14-23.

Updegroff, D.M. (1969). *Anal. Biochemistry,* 32, 420.

Van der Piji, L. (1972). Principles of dispersal in higher plants . Springer- Verlag, New York.

Van, K. H. H., de Boer, B. C. J., and Tijuburg, L. B. M . (2000). Carotenoid bioavailability in humans from tomatoes processed in different ways determined from the carotenoids response in the triglyceride- rich lipoprotein fraction of plasma after a single consumption and in plasma after four days of consumption. *Journal Nutrition,130*,1189-1196.

Van, P. J., and Robertson, J. B. (1977).What is fiber and fiber in food? *Nutrition Review,35*, 12.

Vankatartanam, L. (1988). Packing of figs. A souvenir on packing of fruits and vegetables in India; Agriculture Horticultural Society Public Gardner: Hyderabad, India.

Vasisthala, H., and Srivastava, N. A. (2013). Effect of soaking and cooking on dietary fiber components of different type of chickpea genotypes. *Journal of Food Science Technology,50* (3),579-584.

Vazhacharickal, P. J., Mathew, J. J., Kumar, N. K., and Sebastin, M. (2015). A study on the vitamin C contents of various neglected and underutilized fruits from western ghat region in Kerala. *International Journal of Food, Agriculture and Veterinary Sciences, 5*(1),94-105.

Verma, A., and Singh, V. (2014). Nutritional value and organoleptic evaluation of mushroom powder fortified Indian recipe: Besan laddu. *Asian Journal of Home Science,* 9(1),78-81.

Verma, I., and Gupta, R. K. (2015). Estimation of phytochemical, nutritional, antioxidant and antibacterial activity of dried fruit of sacred figs (*Ficus religiosa*) and formulation of value added product(Hard candy). *Journal of Pharmacognosy and Phytochemistry,4*(3),257-267.

Vidal, V., and Frias, C. (1991). Legumes processing effects on dietary fiber components. *Journal Food Science, 56*,1350-1352.

Vinod, D., Nandkule, D. M., Chitra, S., and Devendrasing, D. P. (2015). Development and quality evaluation of Jackfruit seed and soy flour noodles. *International Journal of Science, Engineering and Technology, 3*(3),802-806.

Vinson, J. A. (1999). Functional food properties of figs. *Cereal Foods World, 44*(2),82-87.

Vinson, J. A., Zubik, L., Bose, P., Samman, N., and Proch, J. (2005). Dried fruits: excellent *in vitro and in vivo* antioxidants. *Journal of American College of Nutrition, 24* (1),44-50.

Waghray, K., Gulla, S., and Bhanuteja, K. (2011). Sensory attributes of wheat (*Triticum species*) flour based chapatti incorporated with soy flour (*Glycine max*) and dates (*Pheonix dactylifera*). *Journal of Dairying, Foods and Home Science, 30* (4), 262 – 266.

Wang, R., Ding, S., Zhao, D., Wang, Z., Wu, J., and Hu, X. (2016). Effect of dehydration methods on antioxidant activities, phenolic content, cyclic nucleotides and volatiles of jujube fruits. *Food Science and Biotechnology*, *25*(1),137-143.

Wang, C. Y., Chen, C., T., and Wang, S. Y. (2009). Changes of flavonoid content and antioxidant capacity in blueberries after illumination with UV-C. *Food Chemistry, 117*,426–431

Wang, G., Wang, H., Song, Y., Jia, C., Wang, Z. et al. (2004). Studies on anti-HSV effect of *Carissa spinarum* leaves. *Journal of Chinese Medicinal Materials*, 27,754-6.

Wang, S. Y., Zheng, W., and Galletta. G. J. (2002) Cultural system affects fruit quality and antioxidant capacity in strawberries. *Journal Agriculture Food Chemistry, 50,* 6534–42.

Wani, R. A., Prasad, V. M., Hakeem, S. A., Sheema, S., Anguchuk, S. *et al.* (2013). Shelf life of Karonda jams (*Carissa caranda*) under ambient temperature. *African Journal of Agriculture Research, 8* (21),2447-2449.

Wetwitayaklung, P., Sarunyakasitharin, K., and Phaechamud, T. (2008). Total phenolic content and antioxidant activity of fresh and preserved fruits of *Ellaeocarpus hygrophilus Kurz*. *Thai Pharmaceutical Health Science Journal,4* (1),21-28.

Whitton, P. D., and Hems, D. A. (1975). Glycogen synthesis in perfused liver of streptozotocin diabetic rats. *Biochemical Journal*,21,150-153.

Wich, A., and Prasad, M. (2012). Drying of Karonda (*Carissa spinarum*) pomace and its tablet product. *KKU Science Journal, 40* (3),887-889.

Williams, J. T., and Haq, N. (2002). Global research on underutilized crops - an assessment of current activities and proposals for enhanced cooperation.

Wilson, V., Shetye, S. S., Kaur, K., and Shetty, S. (2016). Study of synergistic effects on antioxidant activity and antimicrobial activity of polyherbal formulations containing *Ficus* species. *International Journal of Pharmacy and Pharmaceutical Sciences, 8*(4),51-53.

Wojdylo, A., Figiel, A., and Oszmianski, J. (2007). Influence of temperature and time of apple drying on phenolic compounds content and their antioxidant activity. *Polish Journal of Food and Nutrition Sciences,57*,(4), 601-605.

Wojdylo, A., Figiel, A., Lech, K., Nowicka, P., and Oszmianski, J. (2014). Effect of convective and vacuum- microwave drying on the bioactive compounds, colour and antioxidant capacity of sour cherries. *Food Bioprocess Technology,7*, 829-841.

Wojdylo, A., Figiel, A., and Oszmianski, J. (2009). Effect of drying methods with the application of vacuum microwaves on the bioactive compounds, colour and antioxidant activity of strawberry fruits. *Journal Agriculture Food Chemistry*,*57*(4),1337-1343.

World Health Organization. (2003). Diet, nutrition and prevention of chronic disease, World Health Organization, *Genevia,* 89.

Wrolstad, R. E. (2004). Interaction of natural colour with other ingredients: anthocyanin pigments-bioactivity and colouring properties. *Journal of Food Science,69,* C419-425.

Wu, X., Gu, L., Holden, J., Haytowitz, D. B., Gebhardt, S. E., Beecher, G. et al. (2004) Development of a database for total antioxidant capacity in foods: a preliminary study. *Journal Food Composition Anal., 17,* 407–22.

Xu, G., Ye, X., Chen, J., and Liu, D. (2007). Effect of heat treatment on the phenolic compounds and antioxidant capacity of citrus peel extract. *Journal of agriculture and Food Chemistry,55,*330-335.

Yadav, D.N., Gaikwad, R. P., Kadam, R. M., Bhambure, C. V., and Joshi, S. V. (2005). Incorporation of Karonda (*Carissa carandas*) pulp in ice-cream. *Department of Animal Husbandry and Dairy Science,*21-22.

Yamaguchi, T., Taeko, M., Rie, K., Hiroko, M. F., Junji, T., Hitoshi, T. et al. (2001). "Radical-scavenging activity of vegetables and the effect of cooking on their activity." *Food Science and Technology Research*, 7(3), 250-257.

Yan, L. Y., Teng, L. T., and Jhi, T. J. (2006). Antioxidant properties of guava fruit: comparison with some local fruits. *Sunway Academic Journal*, *3*, 9–20.

Yanardag, R., Ozsoy- Sacan, O., and Bolkent, S. (2005). Protective effects of metformin treatment on the liver injury of the streptozotocin-diabetic rats. *Human and Experimental Toxicology*, 24,129-135.

Yin, M. C., and Cheng, W. S. (1998). Antioxidant activity of several allium members. *Journal Agriculture Food Chemistry*, *46*, 4097-101.

Yoshioka, H., Tsuyumu, S., and Takayanagi, K. **(**1990). Radical formation during the processing of green tea. *Agricultural and Biological Chemistry*, *54*,203-204.

Yun, Z., Gao, H., Liu, P., Liu, S., Luo, T., Jin, S., Xu, Q. et al. (2013). Comparative proteomic and metabolomic profiling of citrus fruit with enhancement of disease resistance by postharvest heat treatment. *BMC Plant Biology*,13, 44.

Yusufu, M. I., and Obiegbuna, J. E. (2015). Effect of processing methods on the phytochemical content and consumer acceptability of two selected green leafy vegetables. *Agricultural Science Research Journal, 5*(7),105-110.

Zabidi, M. A., and Yunus, A. M. (2014). Effect on physicochemical and sensory attributes of bread substituted with different levels of matured soursop *(Anona muricata*) flour. *World Academy of Science, Engineering and Technology, 8*(7),740-744.

Zaenuri, L. A., Susilawati, T., Sumitro, S. B., and Wahyuningsih, S. (2014). Effects of additional crude extract of fig fruit (*Carissa spinarum*) into Tris egg yolk based extender on quality of buck semen. *Journal of Biology, Agriculture and Healthcare, 4*(9), 21-27.

Zaidel, D. N. A., Makhtar, N. A., Jusoh, Y. M. M., and Muhamad, I. I. (2015). Efficiency and thermal stability of encapsulated anthocyanins from red dragon fruit (*Hylocereus polyrhizus* (Weber) Britton and Rose) using microwave-assisted technique. *Chemical Engineering Transactions,43*,1-6.

Zavala, J. F. A., Wang, S. Y., Wang, C. Y., and Aquilar, G. A. (2004). Effect of storage temperature on antioxidant capacity and aroma compounds in strawberry fruit. *Lebensm-Wiss.U-Technology,37*,687-695.

Zilic, S., Dodig, D., Sermesic, M. M., Kandic, V., Kostandinovic, M. et al. (2011). Small grain cereals compared for dietary fibre and protein contents. *Genetika,43*(2),381-395.

Zivkovic, M., Rakic, S., Maletic, R., Povrenovic, D., Nikolic, M. et al. (2011). Effect of temperature on the physical changes and drying kinetics in plum (*Prunus domestica L.)* Pozegaca variety. *Chemical Industry and Chemical Engineering Quaterly,17*(3),283-289.

Zolfaghari, M., Sahari, M. A., Barzegar, M., and Samadloiy, H. (2010). Physicochemical and enzymatic properties of five kiwi fruit cultivars during cold storage. *Food Bioprocess Technology*, *3*, 239-246.

8. Appendix I

SENSORY EVALUATION OF THE PANELIST

Name of the panelist: **date:**

S.No.	Appearence	Colour	Texture	Flavour (Aroma/Taste)	Overall acceptability (If any)	Comments (If any)

Hedonic Scale

Expression	Points to be assigned
Liked very much	9
Liked moderately	8
Liked slightly	7
Neither liked nor disliked	6
Disliked slightly	5
Dislike moderately	4
Dislike very much	3
Dislike extremely	2
	1

Signature_____

8. Appendix I

SENSORY EVALUATION OF THE PANELIST

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Signature_____

7. BIBLIOGRAPHY

Abou ElHana, N. H. (2008). Microwave drying of apple. *Misr Journal of Agriculture Engineering, 25*, 980-1003.

Abou-Zaid, A. A., Ramadan, M. T., and Al-Asklany, S. A. (2011). Utilization of faba vegetables. *Biochemistry, 18*(2), 121–125. www.bioline.org.br/request

Abu-Goukh, A. A., Shattir, A. E., and Balla, M. M. E. (2003). Effect of harvesting method on quality and storability of dry dates in Sudan. *Tropical Science, 43*, 53-56.

Adubofuor, J., and Mensah, M. A. (2012). Sensory evaluation and proximate composition of rock buns and cakes prepared from partially- dried ripe pawpaw pulp incorporated into wheat flour. *Journal Agriculture Food Technology, 2*(11),172-177.

Agent (1994). *A survey of the market for fruits and vegetables in the hotel and restaurant industry*. Agent's business production, processing and marketing information centre,19,Colombo, 25.

Agoreyo, B. O., Akiroroh, O., Orukpe, O. A., Osaweren, O. R., and Owabor, C. N. (2011). The effects of various drying methods on the nutritional composition of *Musa paradisiacal, Dioscorea rotundata* and *Colocasia esculenta. Asian Journal of Biochemistry, 6*(6),458-464.

Ahmad, F., and Raj, A. (2012). Buckwheat: a legacy on the verge of extinction a Ladakh. *Current. Science,103*(1),13.

Ahmad, M. Z., Ali, M., and Mir, S. R. (2013). Anti- diabetic activity of *Carissa spinarum* L. stem barks and isolation of two new flavonol esters from the plant by using spectroscopic techniques. *Asian Journal of Biomedical and Pharmaceutical Sciences, 3*(18),22-28.

Ahuja, M. M. S. (1979). *Epidemiological studies on diabetes mellitus in India*. In :Ahuja MMS, Editor, Epidemiology of diabetes in developing countries. New Delhi: Imprint, 29-38.

Akhijahani, H. S., and Khodaei, J. (2011). Some physical properties of strawberry (Kurdistan Variety). *World Applied Science Journal,13*(2),206-212.

Akinhanmi, T. F., Atasie, V. N., and Akintokun, P. O. (2008). "Chemical composition and physicochemical properties of cashew nut (*Anacardium occidentale*) oil and cashew nut shell liquid." *Journal of Agricultural, Food and Environmental Sciences, 2*(1), 1–10.

Alam, M. J., Talukder, M. U., and Rahman, M. N. (2013). Evaluation of the nutritional and sensory quality of functional breads prepared from whole wheat and soyabean flour. *Annals. Food Science and Technology,14* (2),171-175.

Albers, S., Muchova, Z., and Fikselova, M. (2009). The effects of different treated brans additions on bread quality. *Scientia Agriculture Biochemica,40*(2),67-72.

Aleid, S. M., Elansari, A. M., Tang, Z. X., and Sallam, A. A. (2014). Effect of cold storage and packing type on Khalas and Sukkary dates quality. *Advance Journal of Food Science and Technology,6*(5),603-608.

Alfaro, S., Mutis, A., Quiroz, A., Seguel, I., and Scheuermann, E. (2014). Effects of drying on murtilla fruit polyphenols and antioxidant activity. *Journal of Food Research,3*(5),73-82.

Al-Farsi, M., Alsavar, C., Morris, A., Baron, M., and Shahidi, F. (2005). Comparison of antioxidant activity, anthocyanin, carotenoids and phenolics of three native fresh and sun dried date (*Phoenix dactylifera L.)* varieties grown in Oman. *Journal of Agriculture and Food Chemistry,53*, 7592-7599.

Alice, A. O., Oshundahunsi, O. F., Rahman, A., Kayode, A., Abiodun, A. et al. (2012). Proximate composition and sensory qualities of snacks produced from breadfruit flour. *Global Journal of Science Frontier Research Biological Sciences,12*(7),2249-4626.

Aljane, F., Toumi, I., and Ferchichi, A. (2007). HPLC determination of sugars and atomic absorption analysis of mineral salts in fresh figs of Tunisian cultivars. *African Journal of Biotechnology,6*(5),599-602.

Al-Ogaidi, H. K., and Mutlak, H. H. (1986). The phenolic compounds of four date cultivars during maturity stages. *Date Palm Journal,4*(4),191-196.

Al-Yahayai, R., and Al-kharusi, L. (2012). Physical and chemical quality attributes of freeze-stored dates. *International Journal Agriculture Biology, 14*, 97-100.

Amalina, N. I., Nordin, A., Ariffin, H., Andou, Y., Hassan, M. A., Shirai, Y. et al. (2013). Modification of oil palm mesocarp fiber characteristics using superheated steam treatment. *Molecules,18*, 9132-9146.

Amreen, F., Prem, P. S., Parul, A., Raghuveer, I., Shashi, A. *et al.* (2013). Treatment of various diseases by *Carissa spinarum* L. promising shrub. *International Journal Pharma Science Research,*4 (7), 2489-2495.

Anantawat, V. (2015). Effects of spray drying conditions on characteristics, nutritional value and antioxidant activity of gac fruit aril powder. *Integrated Business and Economic Resource,4,*1-11.

Ancos, B., Gonza, E. M., and Cano, M. P. (2000). Ellagic acid, vitamin C and total phenolic contents and radical scavenging capacity affected by freezing and frozen storage in raspberry fruit. *Journal Agriculture Food Chemistry, 48,* 4565-4570.

Andulla, B., and Varadacharyulu, N. C. H. (2003). Antioxidant role of mulberry leaves in streptozotocin – diabetic rats. *Clinica Chimica Acta, 338,*3-10.

Anon (2011). The general information about figs. www.erbeyliincir.gov.tr *(Accessed 4 June 2)(Turkish).*

Anonymous (1950). In the wealth of India : A Dictionary of Indian raw materials and industrial products, *CSIR NEW DELHI,3,*22.

Anonymous (1999). The wealth of India: *A dictionary of India raw materials and industrial products*. Council of Scientific and Industrial Research New Delhi, 4.

Anonymous (2001). The Wealth of India*: A dictionary of Indian raw materials and industrial products, first supplemented series.* National Institutes of Science Communicaton, *New* Delhi,2 CI-CY XXXV.

AOAC, Official method of analysis international. (2010). *Spectrophotometric method,7* (2), 161-4.

Ara, R., Jahan, S., Abdullah, A. T. M., Fakruddin, A. N. M., and Saha, B. K. (2014). Physico-chemical properties and mineral content of selected tropical fruits in Bangladesh. *Bangladesh Journal of Scientific and Industrial Research ,49*(3),131-136.

Aremu, M. O., Olaofe, O., and Akintayo, T. E. (2006). A comparative study on the chemical and amino acid composition of some Nigerian under-utilized legume flours. *Pakistan Journal of Nutrition, 5,* 34-38.

Ariffin, F., Baharom, M. A., Kaur, B., and Maurd, M. (2015). The physicochemical properties and sensory evaluation of bread made with a composite flour from wheat and Tempoyak (fermented Durian). *American Journal of Applied Sciences, 12* (11), 775.784.

Ariffin, H., Hassan, M. A., Kalsom, M. S. U., Abdullah, N., and Shirai, Y. (2000). Effect of physical, chemical and thermal pretreatments on the enzymatic hydrolysis of oil palm empty fruit bunch (OPEFB). *Journal of Tropical Agriculture and Food Science,36*(2), 000-000.

Arslan, D. (2015). Effects of degradation preventive agents on storage stability of anthocyanins in sour cherry concentrate. *Agronomy Research,13*(4), 892–899.

Asp, N. G., and Bjorck, I.(1992).Resistant starch. *Trends in Food Science and Technology, 3*,111-114.

Association of Official Analytical Chemists. (1975). *Official methods of analysis (12th editio*n). The Assocation: Washington, D.C.

Atlabachew, M., Chandravanshi, B. S., Abshiro, M. R., Torto, N., Chigome, S. et al .(2013). Evaluation of the effect of various drying techniques on the composition of the psychoactive phenylpropylamino alkaloids of Khat *(Catha Edulis for SK)* chewing leaves. *Bull. Chemical Society Ethiopa,27*(3), 347-358.

Avila, P. A., Namiesnik, J., Toledo,F., Werner, E., Ayala, A. L. M., Guzman, N. E. R., Infante, J. A. G. et al. (2012). The influence of different time durations of thermal processing on berries quality. *Food Control, 26* ,587-593.

Ayadi, A., Mechlouch, R. F., Bessaoud, C., Bennour, H., and Debouba, M. (2014). Effect of microwave and solar drying methods on the physicochemical properties of kiwifruit. *Journal of Agricultural Technology,10* (4),365-379.

Aydin, C. (2002). Physical properties of hazel nuts. *Biosystems Engineering, 82* (3), 297-303.

Aziz, N., Noor, M. A., and Ho, L. H. (2012). Physico-chemical and organoleptic properties of cookies incorporated with legume flour. *International Food Research Journal*,19(4),1539-1543.

Babiker, W. A. M., Abdel, M. E. S., Sirekhatim, B. E., and Elamin, A. K. (2013). Physicochemical properties of wheat bread supplemented with orange peel by-products. *International Journal of Nutrition and Food Sciences,2*(4),1-4.

Badola, H. K., and Aitken, S. (2010). Biological resources and poverty alleviation in the Indian Himalayas. *Biodiversity, 11*(3), 8-18.

Baker, A. A. and Gawish, R. A. (1997). Trials to reduce nitrate and oxalate content in some leafy vegetables. Interactive effects of the manipulating of the soil nutrient supply, different blanching media and preservation methods followed by cooking process. *Journal of Science, Food and Agriculture, 42*, 169-178.

Balasubramanian, D. (2001). Physical properties of raw cashew. *Nutrition Journal of Agricultural Engineering Research,78* (3),291-297.

Baliga, M., Bhat, H., Pai, R., Boloor, R., and Palatty, P. (2011). The chemistry and medicinal uses of the underutilized Indian fruit tree *Garcinia Indica Choisy* (kokum): A review. *Food Research International. In Press.*

Bernard, R., Issah, A. P., and Emmanuel, M. (2014). Effect of drying methods on phytochemical composition of orange fruit (*Citrus sinesis, L.)* peel flour in biscuit making. *Journal of Environmental Science, Toxicology and Food Technology,8*(10),72-75.

Bey, M. B., and Louaileche, H. (2015). A comparative study of phytochemical profile and *in vitro* antioxidant activities of dark and light dried fig (*Carissa spinarum* L.) varieties. *The Journal of Psychopharmacology, 4*(1), 41-48.

Bhogaonkar, P. Y., Chauhan, V. N., and Kanerkar, U. R. (2014). Nutritional potential of *Ficus racemosa L.* fruits. *Bioscience Discovery,5*(2),150-153.

Blois, M. S. (1958). Antioxidant determination by the use of stable free radicals. *Nature, 181*, 1199-2000.

Boca, S., Galoburda, R., Skrupskis, I., and Skrupska, D. (2014). The effect of freezing and hydrocolloids on the physical parameters of strawberry mass- based desserts. *Proc. Latvia University Agriculture, 31*(326), 12-24.

Boonsumrej, S., Chaiwanichsiri, S., and Tantratian, S. (2007). Effect of freezing and thawing on the quality changes of tiger shrimp (*Penaeus monodon*) frozen by air-blast and cryogenic freezing. *Journal of Food Engineering, 80,*292–299.

Borchani, C., Besbes, S., Masmoudi, M., Blecker,C., and Paquot, H. A. (2011). Effect of drying methods on physico-chemical and antioxidant properties of date fiber concentrates. *Food Chemistry, 125,*1194–1201.

Bouzari, A., Hilstege, D., and Barrett, D. M. (2015). Mineral, fiber and total phenolic retention in eight fruits and vegetables: A comparison of refrigerated and frozen storage. *Journal of Agriculture and Food Chemistry, 63*, 951-956.

Brackmann, A., Mazaro, S. M., and Saquet, A. A. (1997). Cold storage of persimmons *(Diospyros kaki L.)* cultivars Fuyu and Rama Forte. *Ciencia-Rural, 27,* 561 - 565.

Brito, B., Rodriguez, M., Samaniego, I., Jaramillo, M. I., and Valliant, F. (2006). Characterizing polysaccharides in cherimoya (*Annona cherimola Mill*) pure and their enzymatic liquefaction. *Europe Food Resource Technology, 115*(4),377-378.

Brooker, D. B., Bakker, A. F. W., and Hall, C. W. (1974). Drying cereal grains. *The AVI publishing company, Inc*, Westport,Co,USA,265.

Burke, J. L., Waghorn, G. C., Brookes, I. M., and Attwood, G. T. (2000). Formulating total mixed rations from forages- defining the digestion kinetics of contrasting species. *Proceedings of New Zealand Society of Animal Production 60*,9-14.

Butool, S., and Butool, M. (2013). Nutritional quality on value addition to jack fruit seed flour. *International Journal of Science and Research, 4* (4),2406-2411.

Candrawinata, V. I., Golding, J. B., Roach, P. D. and Stathopoulos, C. E. (2014). Total phenolic content and antioxidant activity of apple pomace aqueous extract: effect of time, temperature and water to pomace ratio. *International Food Research Journal, 21*(6), 2337-2344.

Caprez, A., Arrigoni, E., Amado, R., and Neucom, H. (1986). Influence of different types of thermal treatment on the chemical composition and physical properties of wheat bran. *Journal Cereal Science, 4*, 233–239.

Chaparzadeh, N., and Yavari, B. (2013). Antioxidant responses of Golden delicious apple under cold storage conditions. *Iranian Journal of Plant Physiology,4* (1), 907-915.

Chauhan, K., Sharma, S., Chawla, E., and Chauhan, B. (2010). Development of food products on corporating dry powdered figs to explore their hypercholestrolemic potential. *Food Science Research Journal, 2*(1), 196-201.

Chawla, A., Kaur, R., and Sharma, A. K. (2012). *Carissa spinarum* Linn. : A Review on its pharmacognostical, phytochemical and pharmacological aspects. *International Journal of Pharmaceutical and Phytopharmacological Research,1*(4),215-232.

Cheftel, J. C., Cheftel, H., and Besancon, P. (1989). Methods de conservation. In: Cheftel, J. C., Cheftel, H., Besancon, P., (Ed). Introduction a la bioquimica tecnologia de los alimentos. *Zaragoza: Acribia, cap,7,*173-299.

Chen, M. L., and Morris, W. C. (1990). Effect of heat treatments on the chemical analysis of dietary fiber. *Journal of Food Science, 55,* 1647-1650.

Cheng, M. (2011). Effects of drying temperature on the flavonoid, phenolic acid and antioxidative capacities of the methanol extract of citrus fruit (*Citrus sinensis* L.) peel. *International Journal of Food Science and Technology, 46*(6),1179-1185.

Chinma, C. E., Igbabul, B. D., and Omotayo, O. O. (2012). Quality characteristics of cookies prepared from unripe and defatted sesame flour blends. *American Journal of Food Technology,7*(7),398-408.

Chinyere, G.C. and Obasi, N. A. (2013). Vitamins and phytochemical contents in four leafy vegetable subjected to different processing methods. *African Journal of Biotechnology,12* (26),4168-4173.

Chism, G. W., and Haard, N. F. (1996). Characteristics of edible plant tissues. In: Food Chemistry. OR *Fennema New York*: *Dekker,* 943-1011.

Chobanian, A. V., Bakris, G. L., Black, H. R., Cushman, W. C., Green, 1. L. A., Izzo, J. L. J. et al. (2003). National Heart, Lung and Blood Institute Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure; National High Blood Pressure Education Program Coordinating Committee. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA, 289,* 2560-72.

Chomnawang, C., Nantachai, K., Yongsawatdigul, J., Thawornchinsombut, S., and Tungkwa-chara, S. (2007). Chemical and biochemical changes in hybrid catfish fillet stored at 4°C and its gel properties. *Food Chemistry, 103*,420–427.

Choo, C. L., and Aziz, N. A. (2010). Effects of banana flour and β- glucan on the nutritional and sensory evaluation of noodles. *Food Chemistry, 119*, 34–40.

Choudhary, S., Pathak, A. K., Khare, S., and Kushwah, S. (2011). Evaluation of antidiabetic activity of leaves and fruits of *Ficus religiosa* Linn. *International Journal of Pharmacy and Life Sciences,2* (12),1325-1327.

Chuen, Y. S., and Aziz, N., A. A. (2009). Chemical and physical properties of muffin prepared from different levels of mango (*Mangifera indica)* variety Chokanan pulp flour. Food Technology Division, School of Industrial Technology, University Sains Malaysia,11800 Minden, Penang, Malaysia.

Chumyam, A., Wangchai, K., Jungklang, J., and Faiyue, B. (2013). Effects of heat treatments on antioxidant capacity and total phenolic content of four cultivars of purple skin eggplants. *Science Asian*, *39*,246-251.

Clary, C. D., Meza, M. E., Wang, S., and Petrucci, V. E. (2007). Improving grape quality using microwave vacuum drying associated with temperature control. *Journal of food science,72*(1),23-28.

Crizel, T. M., Rios, A. O., Thys, R. C. S., and Flores, S. H. (2015). Effects of orange by-product incorporation on the functional and technological properties of pasta. *Food Science Technology, campinas, 35*(3), 546-551.

Dalal, R. P. S., Thakur, N. A. and Singh, A. (2010). Nutritional value of Karonda *(Carissa carandas* Linn*).* A non- conventional fruit under semi- arid condition of Punjab. *Indian Journal of Agroforestry,12*(2),102-104.

Damiani, C., Silva, F. A. D., Lage, M. E., Pereira, D. E. P., Becker, F. S. et al. (2013). Stability of frozen marolo pulp during storage. *Food Science Technology Campinas*, *33*(4),713-721.

Dangcham, S., Bowen, J., Ferguson, I. B., and Ketsa, S. (2008). Effect of temperature and low oxygen on pericarp hardening of mangosteen fruit stored at low temperature. *Postharvest Biology and Technology 50*,37–44.

Darjazi, B. B. (2011). Morphological and pomological characteristics of fig (*Carissa spinarum*) cultivars from varamin, Iran. *African Journal of Biotechnology, 10* (82), 19096-19105.

Davey, M. W. V., Montagu, M., Inzé, D., Sanmartin, M., Kanellis, A. et al. (2000). Plant L-ascorbic acid: Chemistry, function, metabolism, bioavailability and effects of processing. *Journal of the Science of Food and Agriculture*, *80*(7), 825–860.

De- Ancos, B., Gonzáles, E. M., and Cano, M. P. (2000a). Ellagic acid, vitamin C and total phenol contents and radical scavenging capacity affected by freezing and frozen storage in raspberry fruit. *Journal Agriculture Food Chemistry*, 48,4565-4570.

Diaz, P. O., Hernansezl, J. J. I., Avevedol, E. A., Ambrizl, S. L. R., Pardo, M. E. S. et al. (2014). Chemical, starch digestibility and sensory characteristics of durum wheat/ unripe whole banana flour blends for spaghetti formulation. *Food and Nutrition Sciences, 5*, 264-270.

Din, K. (2008). Physico-chemical properties fruit Karonda *(Carissa carandas)* Dans fat works Pastilnya, (QK495K452008 FRB).

Donovan, J. L., Meyer, A. S., and Waterhouse, A. L. (1998). Phenolic composition and antioxidant activity of prunes and prune juice (*Prunus domestica*). *Journal of Agriculture and Food Chemistry*,*46*(4),1247-1252.

Duen, M., Alonso, J. J., Buelga, C. S., and Bailo, T. E. (2008). Anthocyanin composition in (*Carissa spinarum*). *Journal of Food Composition and Analysis, 21*, 107–115.

Dunas, W., Jin, S., Zhao, G., and Sun, P. (2015). Microwave-assisted extraction of anthocyanin from Chinese bayberry and its effects on anthocyanin stability. *Food Science Technology, Campinas, 35*(3),524-530.

El- Sharnouby, G. A., Aleid, M. S., and Otaibi, M. M. (2012). Nutritional quality of biscuit supplemented with wheat bran and date palm fruits (*Phoenix dactylifera* L.). *Food and Nutrition Sciences, 3*, 322-328.

Elhana, N. H. A. (2008). Microwave drying of apple. Misr. *Journal of Agriculture, 25*(3),980-1003.

Elizabeth, K. G., and Poojara, R. H. (2014). Organoleptic attributes of garden cress seed incorporated snacks suitable for adolescents. *International Journal of Food and Nutritional Sciences,3*(6),126-129.

Embaby, H. E. S. (2011). Effect of heat treatment on certain antinutrient and *vivo* protein digestibility of peanut and sesame seeds. *Food Science Technology Research, 17*(1),31-38.

Ertekin, C., Gozlekci, S., Heybeli, N., Gencer, A., Adak, N., and Sengul, B. (2014). Drying of strawberry with infrared dryer. *International Conference of Agriculture Engineering,* C0689,1-7.

Eze, J., and Akubor, P. (2012). Effect of drying methods and storage on the physicochemical properties of Okra. *Journal of Food Processing and Technology*,3,8,177.

Famurewa, J. A. V. and Olumofin, K. M. (2015). Drying kinetics and influence on the chemical characteristics of dehydrated okra (*Abelmoschuesculentus*) using cabinet dryer. *European Journal of Engineering and Technology,3*(2),7-19.

FAO. (2003). State of food insecurity in the world: Monitoring progress towards the World Food Summit and Millenium Development Goals. FAO, Rome.

FAO. (2014). State of food insecurity in the world 2003: Monitoring progress towards the World Food Summit and Millenium Development Goals. FAO, Rome.

Farsi, M. A., Alasalvar, C., Morris, A., Baron, M., and Shahidi, F. (2005). Comparison of antioxidant activity, anthocyanins, carotenoids and phenolics of three native fresh and sun dried

date(*Phoenix dactylifera L.*) varieties grown in Oman. *Journal of Agriculture and Food Chemistry,1*-9.

Fatima, A., Singh, P. P., Irchhaiya, and R., Agarwal, P. (2013). Effect of leaves of *Carissa spinarum* linn. on blood glucose and lipid profile in alloxan induced diabetic rats. *American Journal of Phytomedicine and Clinical Therapeutics,* 4,385-394.

Fedha, M. S., Mwasaru, M. A., Njoroge, C. K., Ojijo, N. O., and Ouma, G. O. (2010). Effect of drying on selected proximate composition of fresh and processed fruits and seeds of two pumpkin species. *Agriculture and Biology Journal of North America,1*(6),1299-1302.

Fennema (1976). Principles of food science. Food chemistry. New York: Marcel Dekker Inc.

Gajanana, T. M., Gowda, I. N. D., and Reddy, B. M. C. (2010). Exploring market potential and developing linkages– A case of underutilized fruit products in India. *Agricultural Economics Research Review,* 23, 437- 443.

Galoburda, R., Boca, S., Skrupskis, I., and Seglina, D. (2014). Physical and chemical parameters of strawberry puree. *Foodbalt,* 172-177.

Garcia, J. M., Infante, J. A., Guzman, N. E. R., Baca, P. R., Cadillo, M. G. C., and Laredo, R. F. G. (2013). Drying parameters of half-cut and ground figs (*Carissa spinarum L.)* var. Mission and the effect on their functional properties. *Journal of Engineering,*10830,1-8.

Garmakhany, A. D., Kashaninejad, M., Amiri, S. S., and Nikoo, M. A. R. (2013). Effect of moisture content on biophysical properties of pomegranate seeds. *Minerva Biotechnologica, 25* (1), 9-16.

Geeta, K., and Sharda, K. (2013). Nutritional evaluation of Giloe (*Tinospora cordifolia*) extract incorporated energy dense food product. *Indian Journal of Research Paripex, 2*(9),41-43.

Gezer, I., H. H., and Demir, F. (2002). Some physical properties of Hacihaliloglu apricot pit and kernel. *Journal of Food Engineering, 56,* 49–57.

Gilani, A. H., Mehmood, M. H., Janbaz, K. H., and Khan, A. U. (2008). Ethnopharmacological studies on antispasmodic and antiplatelet activities of *Ficus carica*. *Journal of Ethnopharmacology, 119*, 1-5.

Girija, k., Lakshman, K., Udaya , C., Sachi, G. S., Divya, T.(2011). Anti- diabetic and anti-cholesterolemic activity of methanol extracts of three species of *Amaranthus*. *Asian Journal of Tropical Biomedicine;2* (1), 133-138.

Giusti, M. M., and Wrolstad, R. E. (2001). Characterization and measurement of anthocyanins by UV-visible spectroscopy. Unit F1.2. In Current Protocols in Food Analytical Chemistry. New York*:* John Wiley and Sons, Inc.

Gorecka, D., Pacholek, B., Dziedzic, K., and Gorecka, M. (2010). Raspberry pomace as a potential fiber source for cookies enrichment. *ACTA, Scientarium Polonorium Technologia Alimenariat, 9*(4),451-462.

Guesmi, F., Ferchichi, A., Fares, K., and Touil, L. (2006). Identification and differentiation of *Carissa spinarum L.* cultivars using inter simple sequence repeat markers. *African Journal Biotechnology, 5*(15), 1370-1374.

Gupta, P., Bhatnagar, I., Kim, K. S., Verma, A. K., and Sharma, A. (2014). *In-vitro* cancer cell cytotoxicity and alpha amylase inhibition effect of seven tropical fruit residues. *Asian Pacific of Tropical Biomedicine*,*4*(2),S665-S671.

Gupta, S., and Prakash, J. (2011). Nutritional and sensory quality of micronutrient-rich traditional products incorporated with green leafy vegetables. *International Food Research Journal, 18,* 667-675 .

Guvenc, M., Tuzcu, M., and Yilmaz, O. (2009). Analysis of fatty acid and some lipophilic vitamins found in fruits of the *Carissa spinarum* variety picked from the Adiyaman district. *Research Journal of Biological Sciences*,*4* (3),320-323.

Hakkinen, S. H., and Torronen, A. R. (2000). Content of flavonols and selected phenolic acids in strawberries and *Vaccinium* species: influence of cultivar, cultivation site and technique. *Food Research International Journal,33*, 517–24.

Hakkinen, S., Heinonen, M., Karewlampi, S., Mykkanen, H., and Torronen, A. R. (2000). Influence of domestic processing and storage on flavonols contents in berries. *Journal of Agriculture Food Chemistry, 48* (7), 2960-2965.

Hanwate, B. D., Kadam, R. M., and Yadav, D. N. (2005). Utilization of Karonda (*Carissa caranda*) juice in the manufacture of flavoured milk. *Department of Animal Husbandry and Dairy Science,*21-22.

Harborne, J. B. (1973). Phytochemical methods. *Chapman and Hall Ltd. London,* 11-113.

Hardi, Z. U., Zukic, M., Komlenic, D. K., Sabo, M., and Hardi, J. (2007). Quality parameters of noodles made with various supplements. *Czech Journal of Food Science,25*(3),151-157.

Hassan, S.W., Umar, R.A., Maihanu, H. M., Matazu, I. K., Faruk, U.Z., and Sani, A.A. (2007). The effect of drying methods on the nutrients and non- nutrients composition of leaves of *Gynandropsis gynandra* (*Capparaceae*). *Asian Journal of Biochemistry,*2, 349-353.

Hayat, K., Zhang, X., Farooq, U., Abbas, S., Xia, S., Jia, C. et al. (2016). Effect of microwave treatment on phenolic content and antioxidant activity of citrus mandarin pomace. *Food chemistry, 123,*423-429.

Hazbavi, E., Khoshtaghaza, M. H., Mostaan, A., and Banakar, A. (2014). Effect of storage duration on some physical properties of date palm (cv. Stamaran). *Journal of the Saudi Society of Agricultural Sciences, XXX,* XXX-XXX.

Hedge, J. E., and Hofreiter, B. T. (1962). In carbohydrate chemistry its stability in model systems. New York Academic Press. *Journal of Food Science and Technology, 30* (4), 246-8.

Heshe, G. G., Haki, G. D. and Woldegiorgis, A. Z. (2015). Effect of refined milling on the nutritional value and antioxidant capacity of wheat types common in Ethiopia and a recovery attempt with bran supplementation in bread. *Journal Food Process Technology,6*,11.

Ho, L. H., and Dahari, N. C. (2016). Effect of watermelon rind powder on physicochemical, texture and sensory properties of wet noodles. CyTA-*Journal of Food*, 14(3),465-472.

Ho, L. H., Latif, N. W. B. A. (2016). Nutritional composition, physical properties, and sensory evaluation of cookies prepared from wheat flour and pitaya (*Hylocereus undatus*) peel flour blends. *Cogent Food and Agriculture*, 2, 1-10.

Holland, N., Menezes, H. C., and Lafuente, M. T. (2002). Carbohydrate as related to the heating induced chilling tolerance and respiratory rate of 'Fortune' mandarin fruit harvested at different maturity stages. *Postharvest Biological Technology, 25*, 181–191.

Hosseinaei, O., Wang, S., Enayati, A. A., and Rials, T. G. (2012). Effects of hemicellulose extraction on properties of wood flour- plastic composites. *Composite Part A , 43*,686-694.

Hui, Y. H., Puil, C., Isabel, G. L., Miang, H. L., Murrell, K. D. et al. (2004). Hand book of frozen foods. *Marcel Dekker Incorporated*, 74 – 75.

Hultman, L., and Rustard, T. (2004). Iced storage of Atlantic salmon (*Salmo salar*) effects on endogenous enzymes and their impact on muscle proteins and texture. *Food Chemistry, 87*,31–34.

Hussain, I., Amjad, S. A. M., and Ahmeed, R. (2015).Effect of modified sun drying techniques on fruit quality characters of dates harvested at rutab stage. *Journal of Agriculture Research,52*(3),415-423.

Ibitoye, W. O., Afolabi, M. O., Otegbayo, B. O., and Akintola, A. C. (2013). Preliminary studies of the chemical composition and sensory properties of sweet potato starch- flour blend noodles. *Official Journal of Nigerian Institute of Food Science and Technology,31*(2),48-51.

Ibrahim, K. M., Shawi, N. A., and Juboury, A. A. (2014). A Study on the Hypoglycemic effect of *Carissa spinarum* L. leaves aqueous extract against alloxan-induced diabetes in rabbits. *Medical Journal of Babylon, 6*,1-3.

Incedayi, B., Tamer, C. E., Sinir, G. O., Suna, S., and Copur, O. U. (2016). Impact of different drying parameters on colour, beta carotene, antioxidant activity and minerals of apricot *(Prunus armeniaca L.).Food Science and Technology, 36*(1), 171-178.

Intankar, P. R., Lokhande, S. J., Verma, P. R., and Arora, S. K. (2011). Antidiabetic potential of unripe *Carissa carandas* linn. fruit extract. *Journal of Ethanopharmacology, 135*,430-433.

Ioannou, I., Hafsam, I., Hamdi, S., Charbonnel, C., and Ghoul, M. (2012). Review of the effects of food processing and formulation on flavonoid and anthocyanin behavior. *Journal of Food and Engineering,111*, 208-217.

Irondi, A. E., Anokam, K. K., and Ndidi, U. S. (2013). Effect of drying methods on the phytochemicals composition and antioxidant activities of *Carica papayas* seed. *International Journal of Biosciences,3*(11),154-163.

Islam, M. S. (2011). Effects of the aqueous extract of white tea (*Camellia sinensis*) in a streptozotocin- induced diabetic model rats. *Phytomedicine*, 19, 25- 31.

Itankar, P. R., Lokhande, S. J., Verma, P. R., Arora, S. K., and Patil, A. T. (2011). Antidiabetic potential of unripe *Carissa carandas* Linn. fruit extract. *Journal of Ethanopharmacology,17*, 135(2),430-433.

Jahromi, G., Shahdadi, A., and Nasabpour, R. (2014). Composition of phenolic- compounds antioxidant activity and microbial quality of two varieties of fresh and frozen date-palm fruit during eight months storage in freezer. *International Journal of Farming and Allied Sciences, 3* (9),1025-1030.

Jan, I., and Rab, A. (2012). Influence of storage duration on physico-chemical changes in fruit of apple cultivars. *The Journal of Animal and Plant Science,22*(3),708-714.

Jauharah, M. Z., Rosli, W. I., and Robert, D. S. (2014). Physicochemical and sensorial evaluation of biscuit and muffin incorporated with young corn powder. *Sains Malaysian, 43*(1), 45-52.

Jayakumar, S. P., Seni, M., Jagadeesan, M., and Sundararajan, R. (2014). Antidiabetic and antioxidant effects of ethanolic extract of Anjir leaves *(Ficus carica)* in alloxan induced diabetic rat. *Asian Journal of Phytomedicine and Clinical Research, 2*(1), 1 - 10.

Jeong, S. M., Kim, S. Y., Kim, D. R., Jo, S. C., Nam, K. C. et al. (2004). Effect of heat treatment on the antioxidant activity of extracts from citrus peels. *Journal of Agriculture and Food Chemistry,52*,11, 3389-3393.

Jha, S. N., Kingsly, A. R. P., and Chopra, S. (2006). Physical and mechanical properties of mango during growth and storage for determination of maturity. *Journal of Food Engineering, 72*,73-76.

Jin, P., Wang, S. Y., Wang, C. Y., and Zheng, Y. (2011). Effect of cultural system and storage temperature on antioxidant capacity and phenolic compounds in strawberries. *Food Chemistry, 124*,262-270.

Johnson, J. T., Iwang, E. U., Hemen, J. T., Odey, M. O., Efiong, E. E., and Eteng, O. E. (2012). Evaluation of anti-nutrient of watermelon *Citrullus lanatus*. *Annals of Biological Research,3*(11),5145-5150.

Joseph, B., and Raj, S. J. (2011). Pharmacognostic and phytochemical properties of *Carissa spinarum* Linn- An overview. *International Journal of Pharm Tech Research, 3* (1),8-12.

Juan, J. M. G., Alberto, G. I., Nuria, E. R. G., Patricia, R. B., Maria, G. C. C. et al. (2013). Drying parameters of half-cut and ground figs *(Ficus carica)* var. Mission and the effect on their functional properties. *Journal of Engineering*, 1-8,710830.

Juhaimi, F. A., Uslu, N., Bozkurt, D., Ghafoor, K., Babiker, E. E. et al. (2015). Effects of oven and microwave drying on phenolic contents and antioxidant activities in four apple cultivars. *Quality Assurance and Safety of Crops and Foods, Article in Press*, 1757-837X.

Jung, S. T., Park, S. Y., Zachwieja, M. F., Barton, H., Piotrowicz, E. K. et al. (2005). Some essential phytochemical and the antioxidant potential in fresh and dried persimmon. *International Journal of Food Science and Nutrition, 65*(2),105-113.

Kadam, M. L., Salve, R. V., Mehrajfatema, Z. M., and More, S. G. (2012). Development and evaluation of composite flour for missi roti /chapatti. *Journal Food Processing Technology, 3*,134,2-7.

Kamiloglu, S., and Capanoglu, E. (2015). Polyphenol content in Figs (*Carissa spinarum* L.). Effect of sun drying. *International Journal of Food Properties, 18*,521–535.

Kamiloglu, S. (2012). Effect of sun- drying on polyphenols and in vitro bioavailability of Sarilop and Bursa Siyahi figs *(Carissa spinarum L.).* Istanbul Technical University. *Graduate School of Science Engineering and Technology,* 1-140.

Kamiloglu, S., Serali, O., Unal, N., and Capanoglu, E. (2013). Antioxidant activity and polyphenol composition of black mulberry *(Morus nigra L.)* products. *Journal of Berry Research,3*,41-51.

Kanuur, C., and Khandelwal, K. (2014). Pharmacognostical investigation and evaluation of *Carissa spinarum* fruit extract for adaptogenic activity. *International Journal of Pharmaceutical Sciences and Research,* 5 (5), 2022-2032.

Kar, D. M., Maharana, L., Pattnaik, S., and Dash, G. K. (2006). Studies on hypoglycemic activity of *Solanum xanthocarpum* Schrad. And wendl. fruit extract in rats. *Journal of Ethnopharmacology ,108*, 251 - 56.

Kashaninejad, M., Mortazavi, A., Safekori, A., and Tabil, L. G. (2006). Some physical properties of pistachio *(Pistacia vera L.)* nut and its kernel. *Journal Food Engineering*,72,30-38.

Kaur, A., and Kochhar, A. (2014).Sensory and nutritional evaluation of value added products using potato flour for nutritional and health benefits. *International Journal of Medical Sciences, 7*(1),1-6.

Kawka, A., Gorecka, D., and Gasiorowski, H. (1999). The effects of commercial barley flakes on dough characteristic and bread composition. *Food Science and Technology,2*(2).

Khan, M. N., Sarwar, A., Adeel, M., and Wahab, M. F. (2011). Nutritional evaluation of *Carissa spinarum* indigenous to Pakistan. *African Journal of Food Agriculture, Nutrition and Development, 11*(5),1684-5374.

Khan, M. N., Sarwar, A., Adeel, M., and Wahab, M. F. (2011). Nutritional evaluation of *Carissa spinarum* on the contents of sugars,organic acid and phenolic compounds. *Journal of Agriculture and Food Chemistry, 59,*11696 -11702.

Khan, A., and Vincet, J. F. V. (1996). Mechanical damage induced by controlled freezing in apple and potato. *Journal Texture Studies*, 27,143-153.

Khanal, R. C., Howard, L. R., and Prior, R. L. (2010). Effect of heating on the stability of grape and blueberry pomace procyanidins and total anthocyanins. *Food Research International,43,*1464-1469.

Khapre, A. P., Satwadhar, P. N., and Deshpande, H. W. (2015). Studies on standardization of fig fruits (*Ficus carica*) powder enriched cookies and its composition. *Asian Journal of Dairy and Food Research,4*, 71-74.

Khapre, A. P., and Satwadhar, P. N. (2010). Physico-chemical characteristics of fig fruits (*Ficus carica)* cv Dinkar and its cabinet dried powder. *Food Science Resources Journal,2*(1),23-25.

Kojic, A. B., Planinic, M., Tomas, S., Jokic, S., Bilic, M., and Velic, D. (2011). Effect of extraction condition on the extractability of phenolic compounds from lypophilised fig fruits (*Ficus carica). Polish Journal of Nutritional Science,61*(3),195-199.

Komolka, P., Gorecka, D., and Dziedzic, K. (2012).The effect of thermal processing of cruciferous vegetables on their content of dietary fiber and its fractions. *Acta Scientarium Polonorum Technologia Alimentaria,11*(4),347-354.

Krishan, P. G., Chang, K. C., and Brown, G. (1987). Effect of commercial oat bran on the composition of bread. *Cereal Chemistry,64*(1),55-58.

Krishanprabha, V., and Kiruthiga, V.(2015). Development and analysis of nutrients, antioxidants in sweet potato and pumpkin powder incorporated value added products. *International Journal of Advanced Research in Biological Sciences, 2*(4),65-71.

Kshetrimayum, R., Shukla, R. N., and Mishra, A. (2015). Study on drying and quality characteristics of tray and microwave dried guava slices. *International Journal of Science, Engineering and Technology, 3*(4),965-969.

Kulkarni, A.S., and Joshi, D.C.(2013). Effect of replacement of wheat flour with pumpkin powder on textural and sensory qualities of biscuit. *International Food Research Journal, 20*(2), 587-591.

Kulkarni, S. S., Deasai, A. D., Ranveer, R. C., and Sahoo, A. K. (2012). Development of nutrient rich noodles by supplementation with malted ragi flour. *International Food Research Journal,19(1*),309-313.

Kumar, S., Kumar, V., Parkash, M. (2012). Antidiabetic and hypolipidemic activities of kigelia pinnata flowers extract in a streptozotocin induces diabetic rats. *Asian Journal of Tropical Biomedicine;2* (7), 543-546.

Kumari, V. P., and Sangeeta, N. (2014). Process development and evaluation of quality characteristics of multilegume pasta. *Asian Journal Dairy and Food Research*, 33 (3) ,190-196.

Kwok, B. H. L., Durance, H. C., and Kitts, D. D. (2004). Dehydration techniques affects phytochemical contents and free radical scavenging activities of Saskatoon berries *(Amelanachier alnifolia Nutt.). Journal of Food Science,69*(3),122-126.

Laleh, G. H., Frydoonfar, H., Heidary, R., Jameei, R., and Zare, S. (2006). The effect of light, temperature, pH and species on stability of anthocyanin pigments in four *Berberis* Species. *Pakistan Journal of Nutrition, 5*(1), 90-92.

Lee, S. C., Kim, J. H., Jeong, S. M., Kim, D. R., Ha, J. U. et al. (2003). Effect of far- infrared radiation on the antioxidant activity of rice hulls. *Journal Agriculture Food Chemistry, 51,* 4400-4403.

Legesse, M. B., and Emire, S. A. (2012). Functional and physicochemical properties of mango seed kernels and wheat flour and their blends for biscuit production. *African Journal of Food Science and Technology*,3(9),193-203.

Leong, S. Y., and Oey, I. (2012). Effect of processing on anthocyanins, carotenoids and vitamin C in summer fruits and vegetable. *Food Chemistry,133,*1577-1587.

Lisa, A., and Felicetti, L. (2002). Fiber digestibility and nitrogen requirements of Blue Duikers. *Journal of Zoology Biology, 21*,123-134.

Lisa, L. P. (1997). Wild plant food in agricultural environment: A study of occurrence, management and gathering rights in North East Thailand. *Human Organization, 56,* 209-221.

Liu, S. C., and Tsai, C. W. (2012). Effect of heating time on the antioxidative capacities of citrus fruit *(Citrus sinesis)* by products. *Food Science Technology Resources,18*(4),505-513.

Lohchoompol, V., Srzednicki, G., and Craske, J. (2004). The change of total anthocyanin in blueberries and their antioxidant effect after drying and freezing. *Journal of Biomedicine and Biotechnology,5,*248-252.

Lopez, J., Galvez, A. V., Torres, M. J., Mondaca, L. R., Quispe, I. F., and Scala, K. D. (2013).Effect of dehydration temperature on physico-chemical properties and antioxidant capacity of goldenberry (*Physalis peruviana* L.). *Chilean Journal of Agricultural Research,73*,1-3.

Lopez, M. R. R., Diaz, P. O., Perez, L. A. B., Tovar, J., and Nicanor, A. B. (2011). Fiber concentrates from orange (*Citrus sinesis* L.) Bagase: Characteristics and application as backery product ingredients. *International Journal of Molecular Science*, 12, 2174-2186.

Lutz, M., Hernandez, J., and Henriquez, C. (2015). Phenolic content and antioxidant capacity in fresh and dry fruits and vegetables grown in Chile. *CyTA Journal of Food*, *13*(4), 541-547.

Macias, M. A., Martinez, A, C., Mounir, S., Gaitan, G. M., and Allaf, K. (2013). Comparative study of the effects of drying methods on antioxidant activity of dried strawberry (*Fragaria* Var. *Camarosa*). *Journal of Food Research*, *2*(2),92-107.

Mahapatra, A. K., Mishra, S., Basak, U. C., and Panda, P. C. (2012). Nutrient analysis of some selected wild fruits deciduous forests of India: an explorative study towards non conventional bio-nutrition. *Advance Journal of Food Science and Technology 4*(1),15-21.

Mahmoud, M. H., Qura, A. Z. E., Badawy, I. H., Yehya, A., Hady, A. et al. (2013). Hypocholesterolemic effect of antioxidant containing fruits in rats fed on high cholesterol and fat diet. *Journal of Applied Sciences Research, 9* (7), 4233-4244.

Malomo, S. A., Eleyinmi, A. F., and Fashakin, J. B. (2011). Chemical composition, rheological properties and bread making potentials of composite flours from breadfruit, breadnut and wheat. *African Journal of Food Science, 5*(7), 400 – 410.

Manach, C., Scalbert, A., Moorand, C., Remesy, C., and Jimenez, L. (2004). Polyphenols: food sources and bioavailability. *American Journal Clinical Nutrition,79,*727-747.

Mansour, E. H., Dworschak, E., Pollhamer, Z., Gergely, A., Matazu, I. K. et al. (1999). The effect of drying method on the nutrients and non-nutrients composition of the front of *Hibiscus esculentus*(Okra). *Nigeria Journal Renewable Energy, 11,* 9-13.

Mansour, E. H., Dworschak, E., Pollhamer, Z., Gergely, A., and Hovari, J. (1999). Pumpkin and canola seed proteins and bread quality. *Acta Alimentaria*,28,59-70.

Matazu, I.K. and Haroun, A. A. (2004). The effect of drying method on the nutrients and non-nutrients composition of the fruits of *Hibiscus esculentus* (Okra). *Nigerian Journal Renewable Energy*, 11, 9-13.

Matsuo, T., and Itoo, S. (1978). The chemical structure of kaki - Tannin from immature fruit of the persimmon *(Diospyros kaki L.). Agricultural Biological Chemistry, 42,*1637 - 1643.

Mc Clement, D. J. (2003). Analysis of Food Products. Accessed July 26,2012. http:// people.u.mass.edu/-mcclemen/581Ash$Minerals.html.

Mc Donald, J. k., Caflin, N. A., Sommano. S., and Cocksedge, R. (2006). The Effect of post analysis of food Products. Accessed July26,2012.http://people.umass.edu/mcclemen/581Ash and minerals.html.

Mechlouch, R. F., Elaskesh, E. O., Elfalleh, H. H. W., and Thabet, A. A. G. (2015). Changes in the physico-chemical properties of palm date using different drying methods. *University, Bulletin,17*(1),59-78.

Meda, V., Gupta, M., and Opoku, A. (2008). Drying kinetics and quality characteristics of microwave–vacuum dried Saskatoon berries. *Journal of Microwave Power and Electromagnetic energy, 42*(4),42-44.

Mehraj, H., Sikder, R. K., Haider, M. N., Hussain, M.S., and Uddin, A. F. M. J. (2013). Fig (*Ficus carica*). A new crop in Bangladesh. *International Journal of Buisness, Social and Scientific Research, 1*(1),2309-7892.

Mehta, S. (1995). *Evaluation of different cultivars of Anola (Emblica officinalis Garten) for processing* . MSc. Thesis.CCS HAU, Hisar.

Mhalaskar, S. R., Lande, S. B., Satwadhar, P. N., Deshpande, H. W., and Babar, K. P. (2012). Development of technology for fortification of fig (*Ficus carica*) fruit into its value added product- fig toffee. *International Journal of Processing and Post Harvest Technology,3* (121),176-179.

Michael, O. A., Gernah, D. I., and Igbabul, D. (2013). Physico-chemical and sensory evaluation of wheat bread supplemented with stabilized undefatted rice bran. *Food and Nutrition Sciences*, 4, 43-48 .

Mihajer, S., Taha, R. M., and Mohajer, M. (2016). Effects of cryopreservation and relative humidity on viability and nutritional composition of sainfoin (*Onobrychis vicifolia scop*.). *Journal of Animal and Plant Science, 26* (2),116-122.

Miletic, N., Popovic, B., Mitrovic, O., Kandic, M., and Leposavic, A. (2014). Phenolic compounds and antioxidant capacity commonly consumed in Serbia. Czech. *Journal of Food Science,32* (4),360-368.

Ministry of Health and Family Welfare. (2008). Department of Ayurveda yoga and neuropathy, Unani siddha homoeopathy, *New Delhi, First edition (AYUSH),VI* (1),340.

Mishra, G., Mishra, A. A., and Shukla, R. N. (2014). Development of pulse, banana and pineapple pomace based weaning food and its quality evaluation during storage. *International Journal of Development Research,* 4 (6),1257-1262.

Mishra, D. K., Dolan, K. D., and Yang, L. (2008). Confidence intervals for modeling anthocyanin retention in grape pomace during non isothermal heating. *Journal of Food Science, 73,* E9–E15.

Mishra, R. M., and Gupta, P. (2005). Frugivory and seed dispersal of *Carissa spinarum (* L.*)* in a tropical deciduous forest of central India. *International Society for Tropical Ecology*,46(2),151-156.

Mithanka, D. M. T. (2012). Polyphenol content and antioxidant analysis of *Pseudolachinostylis Maprouneifolia Pax* Var Dikindtii used as livestock feed farmers from Eastern Botswana. *Journal of Pharmaceutical and Scientific Innovation,1*(5),51-57.

Mohammadian, M. A., Mobrami, Z., and Sajedi, R. H. (2011). Bioactive compounds and antioxidant capacities in the flavedo tissue of two citrus cultivars under low temperature. *Brazilian Society of plant physiology, 23*(3), 203-208.

Mohsenin, N. N. (1986). Physical Properties of Plant and Animal Materials, New York: Gordon and Breach Science Publishers.

Mohsenin, N. N. (1970). Physical Properties of Plant and Animal Materials. Gordon and Breach Science Publishers, New York, USA.

Moldovan, B., and David, L. (2014). Studied the temperature and preserving agents on the stability of cornelian cherries anthocyanins. *Molecules, 19*, 8177-8188.

Monica, A., Madeau, E., Piscopo, A. E., Sanguinetti, E., Caro, A. D., Poiana, M. E., Romeo, V. et al. (2009). *European Food Resources, 228*,441-448.

Mori, K., Yamamoto, N. G., Kitayama, M., and Hashizume, K. (2007). Loss of anthocyanins in red- wine grape under high temperature. *Journal of Experimental Botany, 58*(8),1935–1945.

Morris, A., Barnett, A., and Burrows, O. (2004). Effect of processing on nutrient content of foods. *Cajarticles, 37*,160-164.

Morton, J. (1987). Fruits of warm climates. (Book. Fl. Ig. Miami, 2005), 47-50.

Morton, J. F. (1987). Fruits of warm climates. Creative Resources Systems, *Inc. Winterville*, N.C.,USA,503.

Mrabet, A., Gutierrez, G. R., Bejarano, R. G., Arcos, R. R., Ferchichi, A., Sindic, M., and Araujo, A. J. (2015). Valorization of Tunisian secondary date varieties (*Phoenix dactylifera L*.) by hydrothermal treatments: New fiber concentrates with antioxidant properties. *LWT-Food Science and Technology, 60*,518-524.

Mule, P. R., Barbind, R. P., Korake, R. L., and Gavit, D. P. (2014). Proximate composition, sensory evaluation and production cost of fig milk shake prepared from buffalo milk. *Animal Science, 8*(2),43-47.

Mullen, W., Stewart, A. J., Michael, E., Jean, J., Gardner, P., Garry, G. D. et al. (2002). Effect of freezing and storage on the phenolic, ellagitannins, flavonoids and antioxidant capacity of red raspberries. *Journal of Agriculture and Food Chemistry, 50*,5197-5201.

Musa, A. (2013). Effect of freezing on some plant toxins and micronutrients in the leaves of *Amaranthus Cruenthus*. *Journal of Food Studies,2*(1),75-92.

Musa, K. H., Abdullah, A., Jusoh, K., and Subramaniam, V. (2011) Antioxidant activity of pink-flesh guava (*Psidium guajava* L.): effect of extraction techniques and solvents. *Food Analytical Method, 4*, 100–7.

Mutso, M., and Satrino, M. L. (2010). Fruit responses to postharvest heat treatment time: characterization of heat-treated strawberry (*Fragaria x ananassa*) cv. 'Candonga' fruits. *Agronomy Research 8*, (1), 815–826.

Nackilcioglu, E., and Hisil, Y. (2013). Research on the phenolic compounds in Sarilop (*Carissa spinarum* L.) fig variety. *GIDA, 38*(5), 267-274.

Nakamura (2008). Preliminary studies on the removal of astringency by freezing in Japnese persimmons. *Journal of the Japnese Society for Horticultural Science, 30*(1),73-76.

Nandan, U., and Bhardwaj, R. (2014). The role of underutilized fruits in nutritional and economic security of tribals: a review. *Critical Reviews in Food Science and Nutrition*,54 (7),880-890.

National Sample Survey Office. (2012). Ministry and Statistics and Programme Implementation, New Delhi Government of India.

Neal, M. C. (1965). In Gardens of Hawaii, University of Hawaii and Bishop Museum, Honolulu, Hawaii, USA, 40.

Nermin, B. (2008). Utilization of buckwheat flour in gluten-free noodles production. *Journal of Food, Agriculture environment, 62* (20),113-115.

Ngueguim, T. F., Dimo, T., Dzeufiet, D. P. D., Vouffo, B., Dongo, E., Renaud, B. et al. (2007). Antidiabetic activities of methanol-derived extract of *Dorstenia picta* twigs in normal and streptozotocin-induced diabetic rats. *Asian Journal of Traditional Medicines,2* (4), 140 - 148.

Nicoli, M. C., Anese, M., and Parpinel, M. (1999). Influence on processing on the antioxidant properties of fruits and vegetables. *Trends in Food Science and Technology,10*, 94-100.

Nieman, D. C., Butterworth, D. E., and Nieman, C. N. (1992) Nutrition. *WmC. Brown Publishers*, Dubugye, 237-312.

Nilsson, J. S., Stegmark, R., and Akesson, B. (2004). Total antioxidant capacity in different pea *(Pistum sativum)* varieties after blanching and freezing. *Food Chemistry,86,*501-507.

Nimkar, P. M., and Chattopadhyay, P. K. (2001). Some physical properties of green gram. *Journal of Agricultural Engineering Resources*, *80* (2), 183-189.

Nithiyanantham, S., Varadharajan, S., and Siddhuraju, P. (2012). Differential effects of processing methods on the total phenolic content, antioxidant and antimicrobial activities of three species of Solanum. *Journal of Food and Drug Analysis,20*(4),844-854.

Njiida, A. A. (2010). Chemical composition, fiber fraction and anti-nutritional substances of semi arid browse forages of North- Eastern Nigeria. *Nigerian Journal of Basic and Applied Science, 18* (2),181-188.

Noonan, S. C., and Savage, G. P. (1999).Oxalate content of foods and its effect on humans. *Asia Pacific Journal Clinical Nutrition,8,*64-74.

Nordin, N. I. A. A., Ariffin, H., Andou, Y., Hassan, M. A., Shirai, Y., Nishida, H. et al. (2013). Modification of oil palm mesocarp fiber characteristics using superheated steam treatment. *Molecules, 18*, 9132-9146.

Noutchogoue, V. K., Kapseu, C., Tchiegang, C., Piffaut, B., and Parmentier, M. (2005).Textural and Biochemical changes associated with the hardening phenomenon in aiele fruit (*Canarium Schweinfurthi Eng). Journal of Food Technology,3*(2),143-148.

Nwanekezi, E. C., and Agbugba, R. U. (2015). Effect of substitution of sucrose with date palm (*Phoenix dactylifera*) fruit on quality bread. *Food Processing and Technology,6*(9),484.

Nwaogwe, J. O., and Adejumo, B. A. (2015). Qualities of African breadfruit (*Treculia Africana*) seed flour influenced by thermal processing methods and duration. *International Journal of Technology Enhancement and Emerging Engineering Research, 3*(4),102-104.

Oancea, S., Moiseenco, F., and Traldi, O. P. (2014). Effects of freezing and oven drying of Romanian wild and cultivated red raspberries on total anthocyanins and total antioxidant capacity. *Romanian Biotechnological Letters, 19*(2), 9241-9247.

Obiegbuna, J. E., Akubor, P. I., Ishiwu, C. N., and Ndife, J. (2013). Effect of substituting sugar with date palm pulp meal on the physicochemical, organoleptic and storage properties of bread. *African Journal of Food Science*,7(6),113-119.

Oboh, G., Ademosun, A. O., Olasehinde, T. A., Oyeleye, S. I., and Ehiakhamen, E. O. (2015). Effect of processing methods on the antioxidant properties and inhibition of alpha amylase and alpha glucosidase by African pear (*Dacryodes edulis*) fruit. *Nutra foods*, *14*, 19-26.

Ogbadoyi, E. O., and Musa, A. (2013). Effect of freezing on some plant toxins and micronutrients in the leaves of *Amaranthus cruentus. Journal of Food Science,2* (1),75-92.

Ogunbanwo, S. T., Azinat, S., Olufunke, A., and Fadahunsi, I. F. (2013). Microbiological and nutritional evaluation of water melon juice (*Citrullus lanatus*). *Academia Arena,5*(3),36-41.

Ojinnaka, M. C., Anyanwu, F. A., and Ihemeje, A. (2013). Nutritional evaluation of cookies produced from African breadfruit (*Treculia africana)* starch and wheat flour. *International Journal of Agricultural and Food Science*, 3(3), 95-99.

Olajire, A. A., and Azeez, L. (2011). Total antioxidant activity, phenolic, flavonoid and ascorbic acid contents of Nigerian vegetables. *African Journal of Food Science and Technology, 2*(2), 022-029.

Omer, U. C., and Canan, E. T. (2014). Fruit processing. Strategies for quality assessment. *Food Engineering Series*, DOI 10.1007/978-1-4939-1378-7-2.

Oyaizu, M. (1986). Studies on products of browning reaction: antioxidative activities of products of browning reaction prepared from glucosamine. *Jap*nese *Journal ofNutrition,44*, 307-315.

Ozcan, M., Arslan, D., and Unver, A. (2004). Effect of drying methods on the mineral content of basil (*Ocimum basilicum L.*). *Journal of Food Engineering, 69,* 375-379.

Oztekin, S., Erdem, T., and Karaaslan, S. (2011). Effect of hot air and microwave drying on some physical properties of laurel berry. *African Journal of Agricultural Research*, 6(12), 2676-2679.

Pacco, H. C., and Menegalli, F. (2004). Drying of sliced figs of 'Gigante de Valinhos' variety (*Carissa spinarum*). In Silva, M. A. and Rocha, S.C.S. (eds.) *Drying. Proceeding of the 14 th International Drying Symposium*, Sao Paulo, Brazil, 1851- 1858.

Pacco, H. C., Vigneault, C., Castro, L. R., Menegalli, F. C., and Cortez, L. A. B. (2007). Temperature effect on drying kinetics of 'Gigante de Valinhos' figs. *Journal of Food and Environment, 5*(2),70-75.

Padulosi, S., Hoeschle- Zeledon, I., and Bordoni, P. (2008). Minor crops and underutilized species: lessons and prospects In: N. Maxted, B.V. Ford-Lloyd, S.P. Kell, J.M. Iriondo, M.E. Dulloo, J. Turok eds. *Crop wild relatives, conservation and use.* Wallingford, UK: CAB International.

Pandey, A. K., Ojhav, V., Yadav, S., and Sandhu, S. K. (2011). Phytochemical evaluation and radical scavenging activity of *Bauhinia variegate, Saraca asoka* and *Terminalia arjuna* barks. *Resource Journal Phytochemistry,2*,89-97.

Pandey, A. K., Dubey, A. K., Singh, R. K., and Vida, E. (2014). Addressing the problem of micronutrient malnutrition in Neh region- underutilized vegetables as a source of food. *International Journal of Food and Nutritional Science, 3*(3),75-83.

Papu, S., Singh, A., Javir, S., Sweta, S., Arya, A. M., and Singh, B. R. (2014). Effect of drying characteristics of garlic – a review. *Journal Food Process Technology,5*(4),1-6.

Pardeshi, I. L., Bhuskade, S. A., and Kalmegh, V. B. (2013). Development of cold extruded ready to cook (*Vigna radiate L.)* nuggets. *Journal of Food Research and Technology,1*(1),21-28.

Parmar, C., and Kaushal, M. K. (1982). *In: Wild Fruits.* Kalyani Publishers, New Delhi, India,15-18.

Patel, D. K., Kumar, R., Prasad, S. K., Sairam, K., and Hemalatha, S. (2011). Antidiabetic and *in vitro* antioxidant potential of *Hybanthus enneaspermus* (Linn) F. Muell in streptozotocin-induced diabetic rats. *Asian Pacific Journal of Tropical Biomedicine*,1,316-22.

Pathak, P. K., Preeti, D., and Kumar, S. (2009). Effect of post-harvest treatments on shelf-life of aonla (*Emblica officinalis*) fruits damaged during harvesting. *Journal of Food Science Technology, 46*, 283–285.

Patras, A., Brunton, N. P., Donnell, C. O., and Tiwari, B. K. (2010). Effects of thermal processing on anthocyanin stability in foods; mechanisms and kinetics of degradation. *Trends in Food Science and Technology 21*,3-11 .

Perez, C., Dominquez, E., Canal, J. R., Campillo, J. E., and Tarres, M. D. (2000). Hypoglycemic activity of aqueous extract from *Carissa spinarum* fig tree leaves in streptozotocin diabetic rats. *Pharm Biology*,38(3),181-186.

Pewlong, W., Sajjabut, S., Eamsiri, J., and Chookaew, S. (2014). Evaluation of antioxidant activities, anthocyanins, total phenolic content, vitamin C content and cytotoxicity of *Carissa carandas* Linn. *Food and Applied Biosciences,13*(1),509-517.

Piga, A., Del, C. A., and Corda, G. (2003). From plums to prunes: Influence of drying parameters on polyphenols and antioxidant activity. *Journal of Agriculture and Food Chemistry, 51*,3675-3681.

Pimia, R. P., Hakkinen, S. T., Aarni, M., Suortti, T., Lampi, A. M., Eurola, M. et al. (2003). Blanching and long term freezing affect various bioactive compounds of vegetables in different ways. *Journal Science Food Agriculture,83*,1389-1402.

Pinki and Awasthi, P. (2014). Sensory and nutritional evaluation of value added cakes formulated by incorporating beetroot powder. *International Journal of Food and Nutrition Science,3*(6),145-148.

Planinic, M., Aliakbarian, B., Perego, P., Greganic, K., Tomas, S., and Kojic, A. B. (2015). Influence of temperature and drying time on extraction yield of phenolic compounds from grape pomace variety "Portogizac". *Chemical and Biochemical Engineering Quarterly,29*(3),343-350.

Poiana, M. E., Moigradean, D., and Alexa, E. (2010). Influence of home- scale freezing and storage on antioxidant properties and colour quality of different garden fruits. *Bulgarian Journal of Agriculture Science, 16* (2),163-171.

Pradhan, R. C., Naik, S. N., Bhatnagar, N., and Vijay, V. K. (2009). Moisture dependent physical properties of jatropa fruit. *Industrial Crops and Products, 29,* 341-347.

Pragati, D., and Dhawan, S. S. (2003). Effect of drying methods on nutrition composition of dehydrated aonla fruit (*Emblica officinalis Garten*) during storage. *Plant Foods for Human Nutrition, 58,* 1–9.

Pragati, S., Dahiya, S., and Dhawan, S. S. (2003). Effect of drying methods on nutritional composition of dehydrated anola fruit (*Emblica officinalis Garten*) during storage. *Plant Foods for Human Nutrition, 58*,1-9.

Prakash, D., Upadhyay, G., and Pushpangadna, P. (2011). Antioxidant potential of some under-utilized fruits. *Indo-Global Journal of Pharmaceutical Sciences, 1*(1), 25-32.

Pratyush, K., Masih, D., and Sonkar, C. (2015). Development and quality evaluation of pumpkin powder fortified cookies. *International Journal of Science, Engineering and Technology, 3*(4),1034-1038.

Price, M. L., Socoyoc, S. V. and Butler, L. G. (1978). A Critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. *Journal Agriculture Food Chemistry,* 26, 1214-1218.

Price, K. R., and Rhodes, M. J. C. (1997). Analysis of the major flavonoid glycosides present in four varieties of onion and changing in composition resulting from autolysis. *Journal of Science, Food and agriculture,74*,331-335.

Rabeta, M. S. and Lin, S. P. (2015). Effect of different drying methods on the antioxidant activities of leaves and berries of *Cayratia trifolia*. *Sains Malaysian, 44*(2),275-280.

Raffo, A., Leonardi, C., Fogliano, V., Ambrosino, P., Salucci, M., Gennaro, L. et al. (2002). Nutritional value of cherry tomatoes (*Lycopersicon esculentum* cv. Naomi F1) harvested at different ripening stages. *Journal Agriculture Food Chemistry,50,* 6550–6.

Rahman, S., M., Islam, M., R., Rahman, S., Mosaiab, T., Ahmed, F. K., Nusratun, N., Ahsan, S. et al. (2011). Antihyperglycemic studies with methanol Extract of *Annona reticulata* L. (Annonaceae) and *Carissa carandas* L. (Apocynaceae) leaves in swiss albino mice. *Advances in Natural and Applied Sciences, 5*(2),218-222.

Rai, N., Asati, B. S., Patel, R. K., and Yadav, D. S. (2005). Underutilized horticultural crops in North Eastern region. *ENVIS Bulletin: Himalayan Ecology, 13*(1),1-11.

Raj, A., and Masih, D. (2014). Physico chemical and rheological properties of wheat flour muffin supplemented with orange peel powder. *International Journal of Science and Research,3*(8),2319-7064.

Raji, A. O., Akinoso, R., and Raji, M. O. (2016). Effect of freeze- thaw cycles on the nutritional quality of some selected Nigerian soups. *Food Science and Nutrition, 4*(2),163-180.

Ramaswamy, H. S., and Tung, M. A. (1981). Thermophysical properties of apples in relation to freezing. *Journal of Food Science, 46,*724-728.

Rani, B., and Kawatra, A. (1994). Fiber constituents of some foods. *Plant Foods for Human Nutrition,45,*343-347.

Rashidi, A. A., and Noureddini, M. (2011). Hypoglycemic effect of the aromatic water of leaves of *Carissa spinarum* in normal and streptozotocin induced diabetic rats. *International Journal of Current Pharmaceutical Research,1,*372-379.

Ratti, C. (1994). Shrinkage during drying of foodstuffs. *Journal of Food Engineering, 23*(1),91-105.

Raupp, D. S., Rodrigues, E., Rockenbach, I. I., Carbonar, P. F. C., and Borasto, R. F. (2011). Effect of processing on antioxidant potential and total phenolic in beet(*Beta vulgaris L.). Cien. Technology Aliment. Campinas*,*31*(30),688-693.

Razavi, S. M. A., Pourfarzad, A., Sourky, H., and Jahoromy, S. H. R. (2010).The physical properties of fig *(Ficus carica)* as a function of moisture content and variety. *The Philippine Agricultural Scientist,41*,896-904.

Redddy, D. K., Jangabelli, M., and Singh, J. K. (2014). Utilization of an underexploited fruit (*Ficus carica*) as a preserved product. *Journal of Agroecology and Natural Resource Management,1*(2),78-81.

Rehman, S., Nandeem, M., Ahmad, F., Mushtaq, Z. (2013). Biotechnological production of xylitol rom banana peel and its impact on physicochemical properties of rusks. *Journal Agriculture Science Technology,15*,747-756.

Reyes, Y. C., Alvarez, L. D., Baez, D. A., Esquivel, O. O., and Moreno, A. O. (2013). Polyphenol oxidase inactivation by microwave oven and its phenolic profile of loquat (*Eriobotrya Japonica)* fruit. *Food and Nutrition Science*,4 (9B),87-94.

Rickman, J. C., Barrett, D. M., and Bruhn, C. M. (2007). Nutritional comparison of fresh,frozen and canned fruits and vegetables. Part1. Vitamins C and B and phenolic compounds. *Journal of the Science of Food and Agriculture,87*, 930-944.

Rickman, J. C., Bruhn, C. M., and Barrett, D. M. (2007). Nutritional comparison of fresh, frozen and canned fruits and vegetables II. Vitamin A and carotenoids, vitamin E, minerals and fiber. *Journal of Science of Food and Agriculture*, 0022-5142.

Rithiruangdej, P., Parnbankled, S., Donchedee, S., Wongsagonsup, R. (2011). Physical, chemical, textural and sensory properties of dried wheat noodles supplemented with unripe banana flour. *Kasetstar Journal (Natural Science),45*(3),500-509.

Rodríguez, R., Jiménez, A., Fernández-Bolaños, J., Guillén, R., and Heredia, A. (2006). Dietary fiber from vegetable products as source of functional ingredients. *Trends Food Science Technology, 17*, 3-15.

Romjaun, Z. Z., and Prakash, J. (2013). Development and assessment of fiber- enriched muffins. *Advances in Food Science,* 35(4), 159165.

Rosell, C. M., Rojas, J. A., and Benedita, B. C. (2011). Influence of hydrocolloids on dough rheology and bread quality. *Food Hydro-colloid,15*,75-81.

Rossetti, L., Fronzo, R. A., and Gharezi, R. (1990). Effect of metformin treatment on insulin action in diabetic rats: *in vivo* and *in vitro* correlations. *Metabol*, 39, 425-435.

Rosy, K., Gupta, A., and Sarita, S. (2015). Development and sensory optimization of low cost micronutrient rich nutritious product by using locally available food resources. *International Journal of Food and Nutritional Science,5*(1).

Rout, S. P., Kar, D. M., Mohapatra, S. B., and Swain, S. P. (2013). Anti-hyperglycemic effect *Annona Reticulata* L. leaves on experimental diabetic rat model. *Asian Journal of Pharmaceutical and Clinical Research, 6*(1),56-60.

Rozier, A., Lean, M. E. J., McDonald, M. S., and Black, C. (1995). Quantitative analysis of the flavonoid content of commercial tomatoes, onion, lettuice and celery. *Journal of Agriculture Food Chemistry, 42*, 281-285.

Rukayah, A. (1992). Buahbuahan Nadir Semonanjung Malaysia, Dewan Bahasadan Pustaka, Kuala Lumpur, Malaysia.

Rupasinghe, H. P. V., Wang, L., Huber, G. M., and Pittis, N. L. (2008). Effect of baking on dietary fiber and phenolics of muffins incorporated with apple skin powder. *Food Chemistry, 107*,1217-1224.

Ryder, J. M., Fletcher, G. C., Stec, M. G. and Seelye, R. J. (1993). Sensory, microbiological and chemical changes in hake stored in ice. *International Journal of Food Science Technology,28,* 169-180.

Sachin, A., Shreesh, K. O., and Divya, V. (2009). Characterization of streptozotocin induced diabetes mellitus in swiss albino mice. *Global Journal of Pharmacology, 3* (2),81-84.

Sadiq, I. S., Izugaize, T., Shiaibu, M., Dogoyaro, A. L., Garba, A. et al. (2013). The nutritional evaluation and medicinal value of date palm (*Phoenix dactylifera*). *International Journal of Modern Chemistry,4*,147-154.

Sae-kang, V., and Suphantharika, M. (2006). Influence of P^H and xanthan gum addition on freeze thaw stability of tapioca starch pastes. *Carbohydrate polymer,* 65,371-380.

Safy, F. S. E. (2014). Drying characteristics of laquot slices using different dehydration methods by comparative evaluation. *World Journal of Dairy and Food Sciences, 9* (2), 272-284.

Sakhale, B. K., Chalwad, R. U., and Pawar, V. D. (2012). Standardization of process for preparation of fig- mango mixed toffee. *International Food Research Journal,19*(3), 889-891.

Salgado, S. M., Guerra, N. B., and Filho, A. B. (1999). Frozen fruit pulps: Effects of the processing on dietary fiber contents. *Revista de Nutrico,50*,281-285.

Salim, N., Quatmane, A., Latrache, H., Ennhali, S., Zinelabidine, L. H. et al . (2014). Bioactive components and antioxidant activity of Morrocan Paprika (*Capscium annuum L.)* under different storage time and conditions. *Turkish Journal of Agricultural and Natural Sciences*, 1734-742.

Salmanian, S., Mahoonak, S. A. R., Alami, M., and Ghorbani, M. (2014). Phenolic Content, antiradical, antioxidant and antibacterial properties of Hawthorn (*Crataegus elbursensis*) seed and pulp extract. *Journal of Agricultural Science and Technology, 16*(2), 343-354.

Sandhu, M. K. (1990).“Fig’’ in fruits tropical and subtropical, T.K. Bose and Mitra, S. K, Eds, *Naya Prokash, Calcutta, India,* 650-663.

Sangeeta, S., and Mahanta, C. L. (2013). Effect of steaming, boiling and microwave cooking on the total phenolics, flavonoids and antioxidant properties of different vegetables of Assam, India. *International Journal of Food and Nutritional Science,2*(3)47-52.

Sanwal, R., and Chaudhary, A. K. (2011). Wound healing and antimicrobial potential of *Carissa spinarum* Linn. in albino mice. *Journal Ethnopharmacology,*135(3),792-6.

Sarkis, J. R., Jaeschke, D. P., Tessaro, I. C., and Marczak, D. F. (2013). Effects of ohmic and conventional heating on anthocyanin degradation during the processing of blueberry pulp. *Food Science and Technology, 51,* 79-85.

Saunders, R. M. (1990). "The Properties of Rice Bran as a Food Stuff," *Cereal Foods World, 35,* (7), 632-639.

Scheirber, A., Keller, P., and Carle, R. (2001). Determination of phenolic acids and flavonoids of apple and pear by high- performance liquid chromatography. *Journal of Chromatography A, 910,* 265-273.

Schmidt, B. M., Erdman, J. W., and Lila, M. A. (2005). Effects of food processing on blueberry antiproliferation and antioxidant activity. *Journal of Food Science,70* (6), S389-S394.

Schutz, H. G., and Cardello, A. V. (2001). A labeled affective magnitude (LAM) scale for assessing food liking/disliking. *Journal of Sensory Studies, 16,* 117–159.

Scibisz, I., and Mitek, M. (2007).The changes of antioxidant properties in high bush blueberries (*Vaccinium corymbosum* L.). During freezing and long –term frozen storage. *Acta Scientarium Polonrum Technologia Alimentaria, 6* (4),75-82.

See, E. F., Nadiah, W. A., Aziah, N. A. A. (2007). Physico chemical and sensory evaluation of breads supplemented with pumpkin flour. *Asian Food Journal,14*(2),123-130.

Seeminska, M.D., Najda, A., Dyduch, J., Gantner, M., and Klimek, K. (2015). The content of secondary metabolites and antioxidant activity of wild strawberry fruit (*Freagaria vesca* L.). *Journal of Analytical Methods in Chemistry, 83,*1238,1-8.

Seleem, H. A. (2015). Effect of blending doum (*Hyphaene thebacia*) powder with wheat flour on the nutritional value and quality of cake. *Food and Nutrition Science,6*,622-632.

Shaheel, S. K., Swami, D. V., Prasanna, B. K., and Krishna, U. K. (2015). Effect of blending of karonda (*Carissa caranda*) juice with guava, papaya and pineapple juice on its quality and organoleptic evaluation. *Plant archives,15*,187-192.

Sharifian, F., Motlagh, A. M., and Nikbakht, A. M. (2012). Pulsed microwave drying kinetics of fig fruits(*Carissa spinarum L*). *Australian Journal of Crop Science,6*(10),1441-1447.

Sharma, A., and Gupta, A. P. (2013). Evaluation of antioxidant activity and validated method for analysis of polyphenols from non – edible parts of Indian tropical fruits by using microwave assisted extraction and LC-MS/MS. *International Journal of Bio Science and Pharma,4,*(1),227-241.

Sharma, S. and Chopra, R. (2015). Formulation, chemical and textural analysis of biscuits prepared with malted green gram (*Vigna radiata*). *International Journal of Agricultural and Food Science,* 5(3),98-103.

Sharma, V., and Chawla, P. (2011). Development and nutrient evaluation of oat supplementated products for old age people with constipation. *Ethno Medicine*,5(3),161-164.

Sharnouby, G. A., Aleid, M. S., and Otaibi, M. A. (2012). Nutritional quality of biscuit supplemented with wheat bran and date palm fruits (*Phoenix dactylifera* L.). *Food and Nutrition Science,3*,322-328.

Shen, Y., Fukushima, M., Ito, Y., Murak, E., Honsono, T., Seki, T., Ariga, T. (2010). Verification of the antidiabetic effects of cinnamon (*Cinnamomum zeylancium*) using insulin uncontrolled type 1 diabetic rats and cultured adipocytes. Biosciences Biotechnology Biochemistry,74, 2418- 2425.

Shivasharanappa, K., and Londonkar, R . (2014). Evaluation of total phenolic content and free radical scavenging activity of *Ficus glomerata Roxb. International Journal of Pharmaceutical and Clinical Research, 6*(2), 133-137.

Shobaki, F. A., Bahay, A. M., and Esmail, R. S. A. (2010). Effect of fig fruits (*Ficus carica)* and its leaves on hyperglycemia in alloxan diabetic rats. *World Journal of Diary and Food Sciences,5*(1),47-57.

Sikora, E., Bieniek, M. I., and Borczak, B. (2013). Composition and antioxidant properties of fresh and frozen stored blackthorn fruits (*Prunus Spinosa L.). Acta Scientarium Polonorum Technologia,12*(4),365-372.

Silva, E. P., Cardoso, A. F. L., and Fante, C. (2013). Effect of postharvest temperature on the shelf life of gabiroba fruit (*Campomanesia pubescens*). *Food Science and Technology,33*(4),632-637.

Simonyan, K. J., Yiljep, Y. D., Oyatoyan, O. B., and Bawa, G. S. (2009). "Effects of Moisture Content on Some Physical Properties of *Lablab purpureus* (L.) Sweet Seeds". *Agricultural Engineering International,* 1279,(XI).

Singh, A., Grover, K., and Sharma, N. (2014). Nutritional evaluation of value added products using dehydrated greens for security of haematinic nutrient. *Food Science Research Journal,5* (2),168-173.

Singh, L., Yadav, N., Kumar, A. R., Gupta, A. K., Chacko, J. et al. (2007). Preparation of value added products from dehydrated bathua leaves (*Chenopodium album Linn*.). *Natural Product Radiance,6*(1),6-10.

Singh, S., Bala, N., Verma, A., and Srivastava, S. (2015). Development of noodles using banana peels as a functional ingredient. *International Journal of Pure Applied and Bio Science, 3* (1),87-91.

Singh, P., and Sharma, H. R. (2003). Nutritional and organoleptic evaluation of *Colocasia* leaf rolls supplemented with different protein sources. *Journal of Human Ecology,*14(6),467-469.

Singh, S., Singh, A. K., Joshi, H. K., Bagle, B. G., and Dhandar. D. G. (2009). Evaluation of packages for transportation and storability of aonla (*Emblica officinalis*) under semi-arid environment of Western India. *Journal of Food Science Technology, 46,*127–131.

Singleton, V. L., Orthofer, R., and Raventos, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-ciocalteau reagent. *Methods in Enzymology*, *299*,152-178.

Siriwattananon, L., and Maneerate, J. (2016). Effect of drying methods on dietary fiber content in dried and vegetable from non-toxic agricultural field. *International Journal of Geomate,11*(28),2896-2900.

Skrede, G. (1996). Fruits. In *Freezing Effects on Food Quality*; Jeremiah, L. E., Ed.; Dekker: New York.

Skupien, K. (2006). Evaluation of chemical composition of fresh and frozen blueberry fruit (*Vaccinium corymbosum* L.*). Acta. Sci.Pol. Hortorum Cultus,5*(1),19-25.

Slatnar, A., Klancar, U., Stampar, F., and Veberic, R. (2011). Effect of drying of figs (*Carissa spinarum* L.*)*on the contents of sugars, organic acid and phenolic compounds. *Journal of Agriculture Food Chemistry,9* (59),21,11696-702.

Sobota, A., and Luczak, J. (2010). Badania skladu chemicnego makaronow instant, Bromat. *Chem. Toksykol., XLIII*(4),515-522.

Solomon, A., Golubowicz, S., Yablowicz, Z., Grossman, S., Bergman, M., Gottlieb, H. E., Altman, A., Kerem, Z. et al. (2006). Antioxidant activities and anthocyanin content of fresh fruits of common fig *(Carissa spinarum L.). Journal of Agricultural and Food Chemistry, 54*(20),7717-7723.

Sonasong, P., Srzednicki, G., and Lohachoompol, V. (2010). Effects of preconditioning on quality of dried blueberries, 10th International Working Conference on Stored Product Protection, Julius-Kühn-Archiv, 425, 264-269.

Soni, N., Mehta, G. S., and Gupta, R. K. (2014). Estimation of nutritional, phytochemical, antioxidant and anti-bacterial activity of dried *Ficus carica*. *Journal of Pharmacy and Phytochemistry*, *32* (2), 158-165.

Sozzi, G. O., Abrajan-Villasenor, M. A., Trinchero, G. D., and Fraschina, A. A. (2005). Post harvest response of 'Brown Turkey' figs *(Carissa spinarum* L.*)* to the inhibition of ethylene perception . *Journal of the Science of Food and Agriculture,85*,2503-2508.

Stanley, M., Prince, P., Kamalakkannan, N., Venugopal, P., and Menon,V. P. (2004). Antidiabetic and antihyperlipidemic effect of alcoholic *Syzigium cumini* seeds in alloxan induced diabetic albino rats. *Journal Ethanopharmacology,91*,209-213.

Statin, C., Dineshkumar, P., and Nithiyananthan, K. (2012). Evaluation of antidiabetic activity of methanolic leaf extract of *Carissa spinarum* in alloxan- induced diabetic rats. *Asian Journal of Pharmaceutical and Clinical Research, 5* (3),85-87.

Stumvoll, M., Nurjhan, N., and Perriello, G. (1995).Metabolic effects of metformin in non-insulin-dependent diabetes mellitus. *The New England Journal of Medicine*, 333,550-554.

Sudha, M. L., Baskaran, V., and Leelavathi, K. (2007). Apple pomace as a source of dietary fiber and polyphenols and its effect on the rheological characteristics and cake making. *Food* Chemistry, *104*(2), 686-692.

Sudha, N. L., Vertrimani, L., and Leelavathi, K. (2007). Influence of fiber from different cereals on the rheological characteristics of wheat flour dough and biscuit quality. *Food Chemistry,100*,1365-1370.

Sultana, B., Anwar, F., Ashraf, M., and Saari, N. (2012). Effect of drying techniques on the total phenolic contents and antioxidant activity of selected fruits. *Journal of Medicinal Plants Research, 6* (1),161-167.

Sultana, A., Rahman, T. R., Islam, M., Rahman, M., and Alim, M. A. (2014). Evaluation of quality of chapatti enriched with jackfruit seed flour and bengal gram flour. *Journal of Environmental Science, Toxicology and Food Technology, 8(*5),73-78.

Sunmola, A. I., David, M. G., Olanrewaju, and Chizea, O. T. V. (2011). Biochemical effect of some food processing methods on the health promoting properties of under-utilized *Carissa papaya* seed. *Journal of Natural Products, 4*,17-24.

Surekha, N., and Naik, R. S. (2014). Development of value added khakara from barn yard millet consumer acceptability, nutritional and shelf- life evaluation. *Asian Journal of Home Science*,9(1),60-65.

Swami, G., Nagpal, N., Rahar, S., and Singh, P. (2010). Effect of aqueous leaves extract of *Carissa* linn. on blood glucose levels of normoglycemic and alloxan- induced diabetic wister rats. *International Journal of Current Pharmaceutical Research*, *2*(3),65-67.

Swanston, F. S. K., Day, C., Bailey, C. J., and Flat, P. R. (1990). Traditional plant treatment for diabetes. Studies in normal and streptozotocin diabetic mice. *Diabetologia*, 33,462-4.

Szczesniak, A. S. (1998). *Effect on storage on texture*. In I. A. Taub and R.P. Singh. Food storage stability . Boca Raton: CRC Press.

Szkudlarz, S. M., Bajerska, J., Wojtasiak, R. Z., and Gorecka, D. (2013). White grape pomace as a source of dietary fiber and polyphenols and its effect on physical and nutraceutical characteristics of wheat biscuits. *Journal Science Food and Agriculture,93*,389-395.

Taneya, M. L. J., Biswas, M. M. H., and Din, S. U. (2014). The studies on the preparation of instant noodles from wheat flour supplementing with sweet potato flour. *Journal of Bangladesh Agriculture University,12*(1),135-142.

Tanwar, B., Andallu, B., and Modgil, B. (2014). Influence of processing on physicochemical, nutritional and phytochemical composition of *Carissa spinarum* products. *Asian Journal Dairy and Food Resources,33*(1),37-43.

Thakur, M. (2014). Underutilized food crops: treasure for the future India. *Food Science Resource Journal*, 5(2),174-183.

Thimmaiah, S. K. (1999). Standard Methods of Biochemical Analysis, Kalyani Publishers.

Thomas, L. R., William, E., Connor, D. S., and Warner, S. (2015). The interaction of dietary fibers and cholesterol upon the plasma lipids and lipoproteins, sterol balance and bowel function in human subjects. *The journal of clinical investigation,60*,1429-1437.

Thoravaldson, K., and Skjoldebrand, C. (1998).Water diffusion in bread during baking. *Lebensmittel Wissenchatt and Technologies,31*,658-663.

Tiwari, B. K., Brennan, C. S., Jaganmohan, R., Surbhi, A. and Alagusundaram, K. (2011). Utilization of pigeon pea (*Cajanus cajan L*) by product in biscuit manufacture. *LWT-Food Science and Technology,44,*153-159.

Turkmen, N., Sari, F., Sedat, Y., and Velioglu, S. (2005). The effect of cooking methods on total phenolics and antioxidant activity of selected green vegetables. *Food Chemistry, 93*,713-718.

Uchenna, O. A., Nkiruka, I. V., Eze, E. P., and Chinazaekpere, O. C. (2013). Nutrient, phytochemical composition and sensory evaluation of formulated diabetic snacks made from Nigeria foods, *Afzelia Africana* and *Detarium Microcapium* seed flour. *Pakistan Journal of Nutrition, 12*(2),108-113.

Uchenna, O.A., Nikiruka, I. V., Eze, E. P., and Chinazaekpere, O. C. (2013). Nutrient, phytochemical composition and sensory evaluation of formulated diabetic snacks made from Nigeria foods, *Afzelia Africans* seed flour and *Detarium Microcapium* seed flour. *International Journal of Basic and Applied Sciences,13*(2),40-44.

Udomkun, P., Argyropoulous, D., Nagle, M., and Mahayothee, B. (2015). Sorption behavoiur of papayas as affected by compositional and structural alterations from osmotic pretreatment and drying. *Journal of Food Engineering,157*,14-23.

Updegroff, D.M. (1969). *Anal. Biochemistry,* 32, 420.

Van der Piji, L. (1972). Principles of dispersal in higher plants . Springer- Verlag, New York.

Van, K. H. H., de Boer, B. C. J., and Tijuburg, L. B. M . (2000). Carotenoid bioavailability in humans from tomatoes processed in different ways determined from the carotenoids response in the triglyceride- rich lipoprotein fraction of plasma after a single consumption and in plasma after four days of consumption. *Journal Nutrition,130*,1189-1196.

Van, P. J., and Robertson, J. B. (1977).What is fiber and fiber in food? *Nutrition Review,35*, 12.

Vankatartanam, L. (1988). Packing of figs. A souvenir on packing of fruits and vegetables in India; Agriculture Horticultural Society Public Gardner: Hyderabad, India.

Vasisthala, H., and Srivastava, N. A. (2013). Effect of soaking and cooking on dietary fiber components of different type of chickpea genotypes. *Journal of Food Science Technology,50* (3),579-584.

Vazhacharickal, P. J., Mathew, J. J., Kumar, N. K., and Sebastin, M. (2015). A study on the vitamin C contents of various neglected and underutilized fruits from western ghat region in Kerala. *International Journal of Food, Agriculture and Veterinary Sciences, 5*(1),94-105.

Verma, A., and Singh, V. (2014). Nutritional value and organoleptic evaluation of mushroom powder fortified Indian recipe: Besan laddu. *Asian Journal of Home Science,* 9(1),78-81.

Verma, I., and Gupta, R. K. (2015). Estimation of phytochemical, nutritional, antioxidant and antibacterial activity of dried fruit of sacred figs (*Ficus religiosa*) and formulation of value added product(Hard candy). *Journal of Pharmacognosy and Phytochemistry,4*(3),257-267.

Vidal, V., and Frias, C. (1991). Legumes processing effects on dietary fiber components. *Journal Food Science, 56*,1350-1352.

Vinod, D., Nandkule, D. M., Chitra, S., and Devendrasing, D. P. (2015). Development and quality evaluation of Jackfruit seed and soy flour noodles. *International Journal of Science, Engineering and Technology, 3*(3),802-806.

Vinson, J. A. (1999). Functional food properties of figs. *Cereal Foods World, 44*(2),82-87.

Vinson, J. A., Zubik, L., Bose, P., Samman, N., and Proch, J. (2005). Dried fruits: excellent *in vitro and in vivo* antioxidants. *Journal of American College of Nutrition, 24* (1),44-50.

Waghray, K., Gulla, S., and Bhanuteja, K. (2011). Sensory attributes of wheat (*Triticum species*) flour based chapatti incorporated with soy flour (*Glycine max*) and dates (*Pheonix dactylifera*). *Journal of Dairying, Foods and Home Science, 30* (4), 262 – 266.

Wang, R., Ding, S., Zhao, D., Wang, Z., Wu, J., and Hu, X. (2016). Effect of dehydration methods on antioxidant activities, phenolic content, cyclic nucleotides and volatiles of jujube fruits. *Food Science and Biotechnology*, *25*(1),137-143.

Wang, C. Y., Chen, C., T., and Wang, S. Y. (2009). Changes of flavonoid content and antioxidant capacity in blueberries after illumination with UV-C. *Food Chemistry, 117*,426–431

Wang, G., Wang, H., Song, Y., Jia, C., Wang, Z. et al. (2004). Studies on anti-HSV effect of *Carissa spinarum* leaves. *Journal of Chinese Medicinal Materials*, 27,754-6.

Wang, S. Y., Zheng, W., and Galletta. G. J. (2002) Cultural system affects fruit quality and antioxidant capacity in strawberries. *Journal Agriculture Food Chemistry, 50,* 6534–42.

Wani, R. A., Prasad, V. M., Hakeem, S. A., Sheema, S., Anguchuk, S. *et al.* (2013). Shelf life of Karonda jams (*Carissa caranda*) under ambient temperature. *African Journal of Agriculture Research, 8* (21),2447-2449.

Wetwitayaklung, P., Sarunyakasitharin, K., and Phaechamud, T. (2008). Total phenolic content and antioxidant activity of fresh and preserved fruits of *Ellaeocarpus hygrophilus Kurz*. *Thai Pharmaceutical Health Science Journal,4* (1),21-28.

Whitton, P. D., and Hems, D. A. (1975). Glycogen synthesis in perfused liver of streptozotocin diabetic rats. *Biochemical Journal*,21,150-153.

Wich, A., and Prasad, M. (2012). Drying of Karonda (*Carissa spinarum*) pomace and its tablet product. *KKU Science Journal, 40* (3),887-889.

Williams, J. T., and Haq, N. (2002). Global research on underutilized crops - an assessment of current activities and proposals for enhanced cooperation.

Wilson, V., Shetye, S. S., Kaur, K., and Shetty, S. (2016). Study of synergistic effects on antioxidant activity and antimicrobial activity of polyherbal formulations containing *Ficus* species. *International Journal of Pharmacy and Pharmaceutical Sciences, 8*(4),51-53.

Wojdylo, A., Figiel, A., and Oszmianski, J. (2007). Influence of temperature and time of apple drying on phenolic compounds content and their antioxidant activity. *Polish Journal of Food and Nutrition Sciences,57*,(4), 601-605.

Wojdylo, A., Figiel, A., Lech, K., Nowicka, P., and Oszmianski, J. (2014). Effect of convective and vacuum- microwave drying on the bioactive compounds, colour and antioxidant capacity of sour cherries. *Food Bioprocess Technology,7*, 829-841.

Wojdylo, A., Figiel, A., and Oszmianski, J. (2009). Effect of drying methods with the application of vacuum microwaves on the bioactive compounds, colour and antioxidant activity of strawberry fruits. *Journal Agriculture Food Chemistry*,*57*(4),1337-1343.

World Health Organization. (2003). Diet, nutrition and prevention of chronic disease, World Health Organization, *Genevia,* 89.

Wrolstad, R. E. (2004). Interaction of natural colour with other ingredients: anthocyanin pigments-bioactivity and colouring properties. *Journal of Food Science,69,* C419-425.

Wu, X., Gu, L., Holden, J., Haytowitz, D. B., Gebhardt, S. E., Beecher, G. et al. (2004) Development of a database for total antioxidant capacity in foods: a preliminary study. *Journal Food Composition Anal., 17,* 407–22.

Xu, G., Ye, X., Chen, J., and Liu, D. (2007). Effect of heat treatment on the phenolic compounds and antioxidant capacity of citrus peel extract. *Journal of agriculture and Food Chemistry,55,*330-335.

Yadav, D.N., Gaikwad, R. P., Kadam, R. M., Bhambure, C. V., and Joshi, S. V. (2005). Incorporation of Karonda (*Carissa carandas*) pulp in ice-cream. *Department of Animal Husbandry and Dairy Science,*21-22.

Yamaguchi, T., Taeko, M., Rie, K., Hiroko, M. F., Junji, T., Hitoshi, T. et al. (2001). "Radical-scavenging activity of vegetables and the effect of cooking on their activity." *Food Science and Technology Research*, 7(3), 250-257.

Yan, L. Y., Teng, L. T., and Jhi, T. J. (2006). Antioxidant properties of guava fruit: comparison with some local fruits. *Sunway Academic Journal*, *3*, 9–20.

Yanardag, R., Ozsoy- Sacan, O., and Bolkent, S. (2005). Protective effects of metformin treatment on the liver injury of the streptozotocin-diabetic rats. *Human and Experimental Toxicology*, 24,129-135.

Yin, M. C., and Cheng, W. S. (1998). Antioxidant activity of several allium members. *Journal Agriculture Food Chemistry*, *46*, 4097-101.

Yoshioka, H., Tsuyumu, S., and Takayanagi, K. **(**1990). Radical formation during the processing of green tea. *Agricultural and Biological Chemistry*, *54*,203-204.

Yun, Z., Gao, H., Liu, P., Liu, S., Luo, T., Jin, S., Xu, Q. et al. (2013). Comparative proteomic and metabolomic profiling of citrus fruit with enhancement of disease resistance by postharvest heat treatment. *BMC Plant Biology*,13, 44.

Yusufu, M. I., and Obiegbuna, J. E. (2015). Effect of processing methods on the phytochemical content and consumer acceptability of two selected green leafy vegetables. *Agricultural Science Research Journal, 5*(7),105-110.

Zabidi, M. A., and Yunus, A. M. (2014). Effect on physicochemical and sensory attributes of bread substituted with different levels of matured soursop *(Anona muricata*) flour. *World Academy of Science, Engineering and Technology, 8*(7),740-744.

Zaenuri, L. A., Susilawati, T., Sumitro, S. B., and Wahyuningsih, S. (2014). Effects of additional crude extract of fig fruit (*Carissa spinarum*) into Tris egg yolk based extender on quality of buck semen. *Journal of Biology, Agriculture and Healthcare, 4*(9), 21-27.

Zaidel, D. N. A., Makhtar, N. A., Jusoh, Y. M. M., and Muhamad, I. I. (2015). Efficiency and thermal stability of encapsulated anthocyanins from red dragon fruit (*Hylocereus polyrhizus* (Weber) Britton and Rose) using microwave-assisted technique. *Chemical Engineering Transactions,43*,1-6.

Zavala, J. F. A., Wang, S. Y., Wang, C. Y., and Aquilar, G. A. (2004). Effect of storage temperature on antioxidant capacity and aroma compounds in strawberry fruit. *Lebensm-Wiss.U-Technology,37*,687-695.

Zilic, S., Dodig, D., Sermesic, M. M., Kandic, V., Kostandinovic, M. et al. (2011). Small grain cereals compared for dietary fibre and protein contents. *Genetika,43*(2),381-395.

Zivkovic, M., Rakic, S., Maletic, R., Povrenovic, D., Nikolic, M. et al. (2011). Effect of temperature on the physical changes and drying kinetics in plum (*Prunus domestica L.)* Pozegaca variety. *Chemical Industry and Chemical Engineering Quaterly,17*(3),283-289.

Zolfaghari, M., Sahari, M. A., Barzegar, M., and Samadloiy, H. (2010). Physicochemical and enzymatic properties of five kiwi fruit cultivars during cold storage. *Food Bioprocess Technology*, *3*, 239-246.

CERTIFICATE

I certify that Ambika Chauhan has prepared her thesis titled **" Influence of processing on nutritional and phytochemical composition of Fig (*Ficus carica*) and Karonda (*Carissa spinarum*) "** for the award of Ph.D degree of Lovely Professional University**,** under my guidance and supervision. This present work is mainly the result of her continuous efforts and original investigation under my sincere guidance and supervision.

The research work report is suitable for Ph.D degree award submission in Nutrition and Dietetics.

Beenu

Dr. Beenu Tanwar

Assistant Professor
Department of Dairy Technology
MIDFT, Dudhsagar Dairy
Mehsana, Gujarat

1. INTRODUCTION

World Health Organization (2003) reported that fruits are rich in fiber, antioxidants, organic acids, vitamins, phenolic contents (Salmanian *et al.,* 2014) and considered to be a protective foods (Nicoli *et al.,*1999). They are used as a source of traditional medicine (Jain *et al.,* 2013) to cure many health problems (Mahapatra *et al.,* 2012) and contributes as a main source of livelihood for the poor people (Gajanana *et al.,* 2010).

Underutilized fruits or neglected crops are not cultivated commercially, not grown and rarely found in the market (Agent, 1994). They are nutritionally beneficial for the people and play an important role in human health. These fruit species may be distributed globally, but still find some restriction in their consumption and production system (Williams *et al*., 2002). Several underutilized fruits are unfamiliar, unknown and less eaten. However, underutilized fruits have not yet received much awareness as antioxidant sources compared to commercial fruits. These fruits are neglected due to ignorance factor, lack of information, unavailability, deficient in these fruits promotional campaigns, difficulty in storage and harvesting (Badola and Aitken, 2010). Now, these fruits may be included in the health promotion campaigns (Rukayah, 1992). Different types of underutilized fruits are grown in India like aonla, tamarind, karonda, fig, citron, jackfruit etc. Some fruits, which are still underutilized and proves effective to satisfied nutrition demand. Recent research has been mentioned *Ficus carica* and *Carissa spinarum* are considered for the research purpose due to their higher nutritional value and medicinal uses (Baliga *et al.*, 2011).

Ficus carica is commonly known as "Fig" (Jander and Machado, 2008). *Ficus carica* called fig in English and anjir in Hindi (Wealth of India, 1999). It is riped from late of July to late of September (Anon, 2011). It is a deciduous and cultivated fruit tree from the family Moraceae. It is richest source of mineral elements, calcium and fiber content (Vinson, 1999). Dried fig can be stored for 6-8 months (Venkatartnam, 1988).

Carissa spinarum is an evergreen shrub and fruits got mature in late April. It is cultivated mainly in parts of dry foothills of the Punjab, also in Himalayan tract (India) and also on the coast of the Southern Andaman Islands (Parmar and Kaushal, 1982). Riped fruit has dark black colour. It is mostly cultivated in garden, as hedges for its edible berries (Van der Piji,1972). They

are highly nutritious and good source of protein. So, it is mainly offered for sale at certain places (Parmar and Kaushal, 1982).

Some of the locally available fruits which are very cheap as compared to unseasonable, imported fruits (Grabowski *et al.*,2003). Fruits are highly perishable in nature (Pathak *et al*., 2009), have short life span (7-10 days of post harvest life); (Sozzi *et al.,* 2005) and it affects the storage ability, physiological, nutritional and chemical properties of fruits (Orsat *et al.*,2006).

To minimize the effect of degradation, processing is considered to be a most effective tool. Several processing methods (freezing, sun drying and microwave drying) have been introduced with the aim to increase the shelf life of fruits. Sun drying and microwave drying method are proved to be a most important drying practice for the fruits (Matazu and Haroun, 2004). These methods are mainly used to produce heat to remove moisture content. Moisture content is removed by evaporation with heating process and played very important role to affect the nutrient content of fruits in different ways. It helps to increase or decrease the concentration of some nutrients (Hassan *et al*., 2007).

This study is mainly to carried out to observe the effects of these processing methods on the nutrients of fruits and to determine the most suitable method for nutrient retension rather than to increase their shelf life. So, the aim of this study is to focus on the influence of processing on nutritional and phytochemical composition of underutilized fruits i.e. fig and karonda.

These fruits, mainly in raw form are astringent in taste and accepted less. Nowadays, these fruits are commonly used to prepared value added products, which improves nutritional value and acceptance level of the products (Goyal *et al.*, 2008; Singh *et al*.,2009).

LIST OF FIGURES

5.20	B1(100% green gram nugget, B2= 15 % Karonda, B3= 30% Karonda, B4= 45 % Karonda)	185

LIST OF TABLES

3. OBJECTIVES OF THE STUDY

1. To evaluate proximate, nutritional, physical and phytochemical composition of fresh fig and Karonda fruits.
2. To assess the influence of processing methods viz. sun drying, microwave drying and freezing on physicochemical, nutritional and phytochemical composition of selected fruits.
3. To evaluate the effect of fruit extract of *Ficus carica* and *Carissa spinarum* on blood glucose level of normoglycemic and diabetic wistar rats
4. To develop various value added products from the selected fruits and analyze their nutritional composition during 6 months of storage.

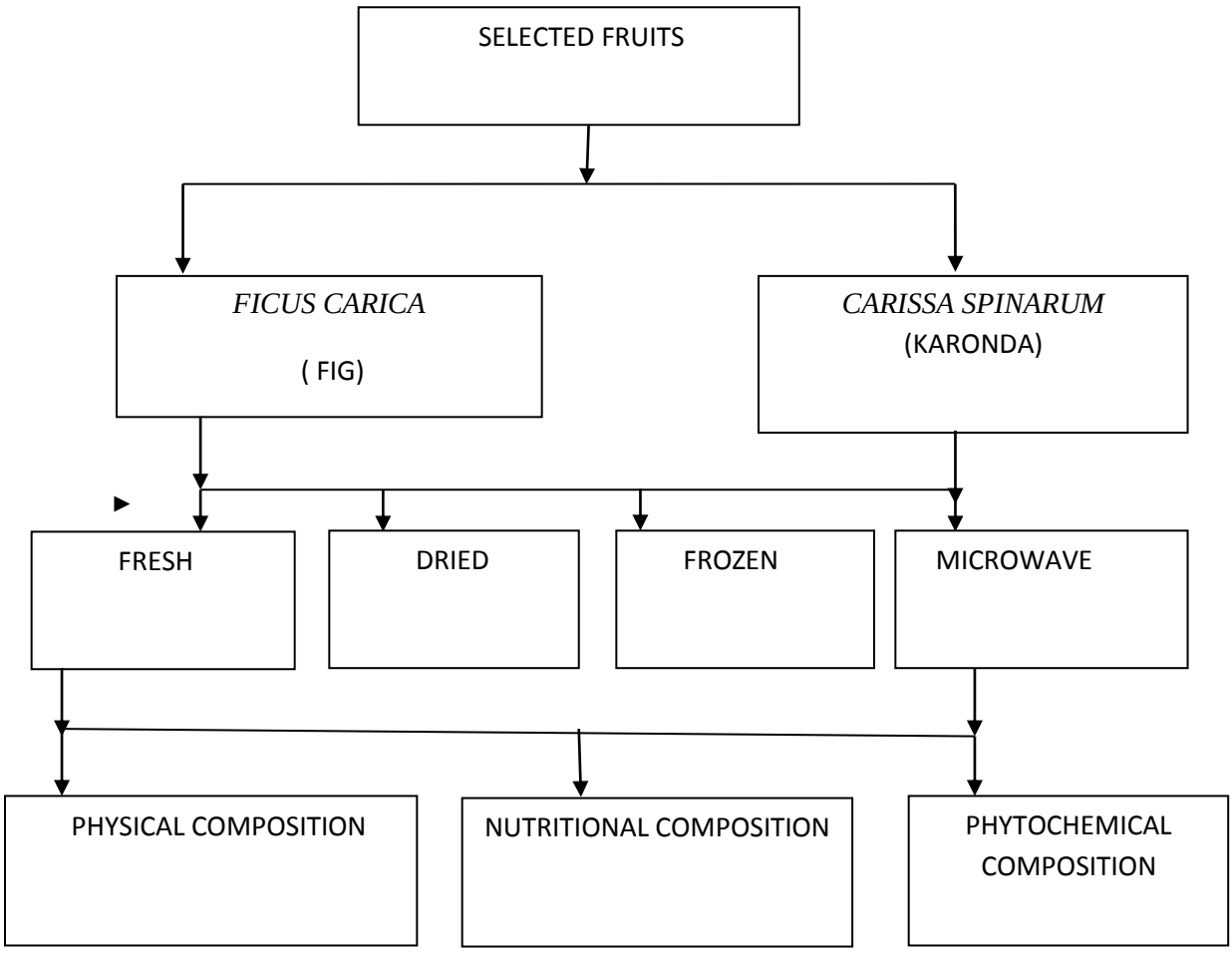

Fig. 4. 1 Flow chart for processing methods

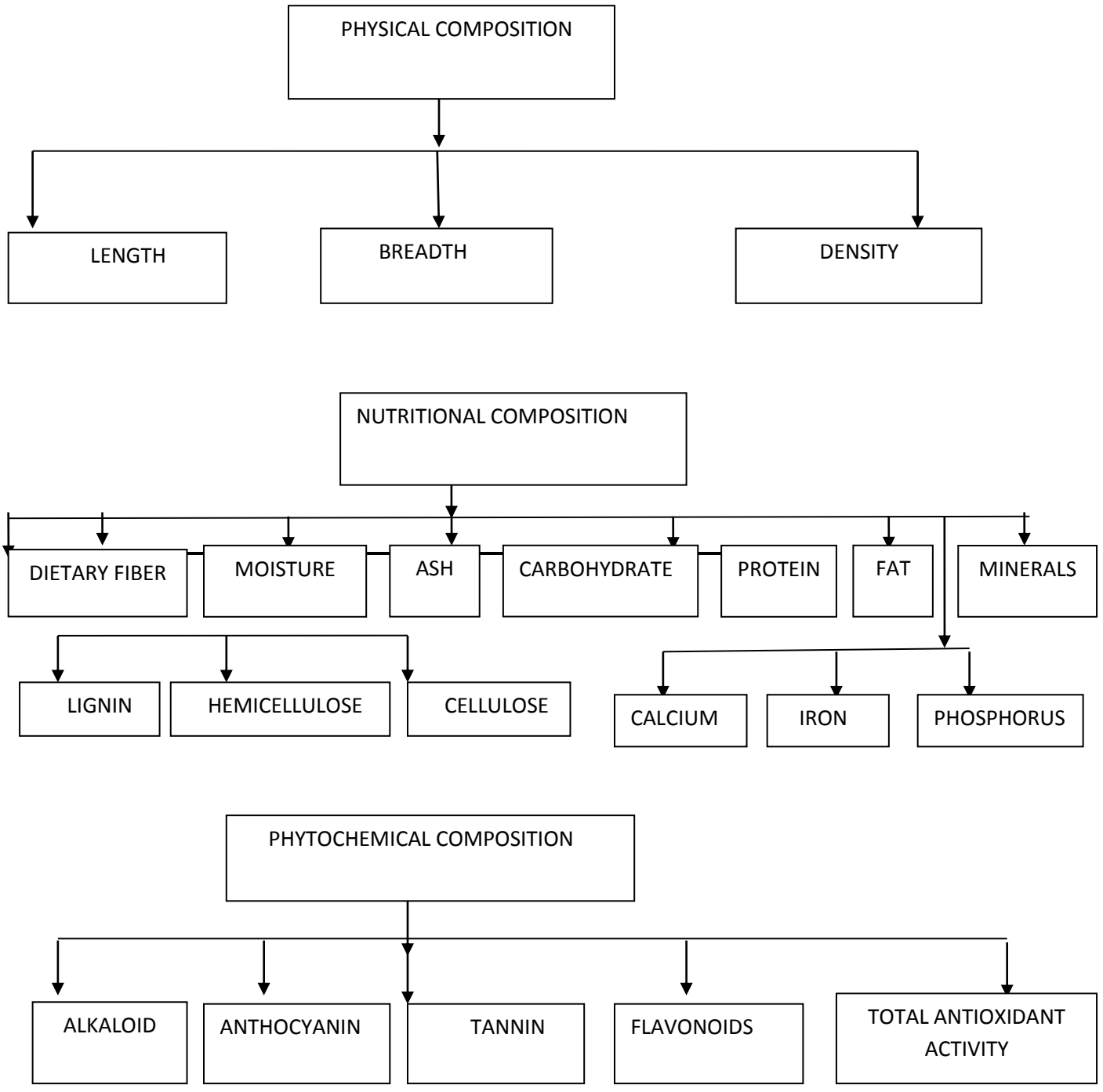

Fig. 4. 1 Flow chart for processing methods

4. RESEARCH METHODOLOGY

The present study was carried out in the Department of Food Technology and Nutrition, School of Agriculture and Food Technology, Lovely Professional University, Phagwara, Punjab. The research methodology and procedures to achieve the set objectives have been described under the following subheads:

4.1 Sample selection

4.2 Sample preparation

4.2 (a) Drying techniques

4.2 (b) Sorting

4.2 (c) Washing

4.2.(d) Sun drying

4.2 (e) Freezing

4.2 (f) Microwave drying

4.3 Physical composition

4.3 (a) Length and width

4.3 (b) Density

4.4 Nutritional composition

4.4 (a) Moisture content

4.4 (b) Ash content

4.4 (c) Carbohydrate content

4.4 (d) Fat content

4.4 (e) Protein content

4.4 (f) Dietary fiber

4.4 (g) Hemicellulose

4.4 (h) Neutral detergent fiber

4.4 (i) Acid detergent fiber

4.4 (j) Cellulose content

4.4 (k) Lignin content

4.5 Extraction preparation

4.5 (a) Total phenolic content

4.5 (b) Total flavonoid content

4.6 Antioxidant activity

4.6 (a) DPPH assay

4.6 (b) FRAP assay

4.7 Tannin content

4.8 Alkaloid content

4.9 Anthocyanin content

4.10 Mineral composition

4.11 Experimental design

4.11 (a) Experimental animals

4.11 (b) Preparation of extracts

4.11 (c) Method for acute toxicity test

4.11 (d) Preparation of interventions

4.11 (e) Animals and induction of diabetes mellitus

4.11 (f) Multiple dose of hypoglycemic study

4.11 (g) Experimental plan

4.12 Value added product development

4.12 (a) Procurement for raw materials

4.12 (b) Fruit powder preparation

4.12 (c) Experimental plan

4.12 (d) Organoleptic evaluation

4.13 Statistical analysis

4.1 Sample selection

Ripened whole fresh *Ficus carica* and *Carissa spinarum* were collected from orchard of a local cultivar from Bilaspur, Himachal Pradesh, (India) during 2014 - 2015.

4.2 Sample Preparation

4.2 (a) Sorting

Fresh, non insected fruits were selected for the study purpose. Discolored fruits were removed before washing.

4.2 (b) Washing

Selected fruits were washed by using distilled water and cleaned properly to remove dust particles. These fruits were dried properly and weighed accurately to and divide into four equal slots. First slot was for fresh (without any treatment), second slot (sun dried), third slot (freezing) and fourth slot was (microwave dried).

4.1 (c) Drying methods

Fruits were exposed to the methods given below:

4.2 (d) Sun drying

Fruits were distributed separately, on the stainless steel trays and dried under direct sunlight for 5 days between 15 July to 20 July, 2015 and stored in cellophane bag for further use.

4.2 (e) Frozen storage

In frozen, the selected whole fresh fruits were packed in polyethylene bags, sealed and safely collected in a freezer at -20°C for 20 days.

4.2 (f) Microwave drying

Selected fresh fruits were placed in a Pyrex petri dish in a single layer and heated for 3 minutes and 15 seconds by using microwave (Sharp R-248e; 800W). Dried fruits were cooled normal temperature. After that again weight was taken to measured the weight loss. After the treatment of different processing methods, selected fruits were used for further analysis.

4.3 Physical composition

4.3 (a) Length and Width

Ten fruits were randomly selected for the measurement of length by using a vernier calliper with 0.01 mm reading accuracy (Mohsenin,1970).

4.3 (b) Density

Randomly ten fruits were selected for mass and measured accurately by using an accurate (0.01) electrical balance (Balasubramanian, 2001). For the measurement of density fruit was weighed and toluene was used to dropped them. The density was calculated by using displacement method. Toluene was used to measure the density of fruits instead of water (Mohsenin, 1986; Gezer *et al.* 2002). Bulk density was calculated with a definite volume beaker. The fruits were poured from 15 cm height into a beaker and excess fruits were discarded. Weighed when it was filled. The bulk density explained as the ratio mass and total volume of the sample (Aydin, 2002).

4.4 Nutritional composition

4.4 (a) Moisture content (AOAC, 2010)

Procedure The moisture content was determined by using oven dried method. 3 gram fruit sample was weighed and taken in a pre heated petri dish. Dried petri dish was kept in oven at temperature 45°C for 3 hrs. It was taken out from pre heated oven then kept in a dessicator for 30 minutes to cool and attained constant weight. Samples were weighed again with petri dish after cooling. Weight loss was represented the moisture content.

Calculation

weight (g) of fruit sample before drying (W1)

weight (g) of fruit sample after drying (W2)

$$\text{Moisture}(\%) = \frac{(W1 - W2)}{W1} X\ 100$$

4.4 (b) Ash content (AOAC, 2010)

Total 3 gm fruit sample was weighed and put in previously pre dried silica crucible. Placed the crucible with lid in the furnance at heating temperature at 550 °C overnight to burn off all

impurities, which were presented on the surface of crucible. After that ashed sample were taken out from the muffle furnance and cooled in a dessicator for 2 hrs. Cooled samples were weighed again and calculated the per cent of ash content given below.

Calculation

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of fruit sample}} X\ 100$$

4.4 (c) Carbohydrate (Hedge and Hofreiter, 1962)

Reagents

5ml of 2 N HCL

Anthrone reagent: Dissolved 200 mg anthrone in 100 ml of ice-cold 95% H_2SO_4.

Standard glucose: Stock- Dissolved 100 mg in 100 ml water.

Working standard: 10 ml of stock diluted to 100 ml with distilled water. Added few drops of toluene and stored in a refrigerator.

Procedure

Take a boiling tube and weighed 100 mg fruit sample in it. Tubes were boiled for three hours in a boiling water bath with 5 ml of 2.5 N HCl. Wait for some time to cooled them at normal temperature. Neutralized it by using sodium carbonate powder until the froth ceases. Made up the volume to 100 ml and centrifuged these tubes. Supernatant was easily collected and taken 0.5, 1 ml aliquots and used it for further analysis. Prepared standards by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of standard solution '0' serves as blank. Made up the volume to 1 ml with distilled water. Anthrone reagent (4 ml) was added and heat them in a boiling water bath for eight minutes. Absorbance was taken at 630 nm. Drawn a standard graph on the X-axis versus absorbance on the Y-axis. From the graph calculated the total carbohydrate present in the sample tube.

Calculation $x = \frac{\text{mg of glucose}}{\text{vol.of fruit sample}}\ X\ 100$

4.4 (d) Fat (AOAC, 2010)

Reagent

Petroleum ether – 250 ml

Procedure

Soxhlet extraction method was used for the fat determination. Bottle was placed with the lid in the incubator at temperature 105 °C overnight. Weighed about 3gm of fruit sample into wraped paper filter. Fruit sample was wrapped in a extraction thimble and transferd into a soxhlet. Filled 250 ml of petroleum ether into the bolltle and fixed it with heating mantle. Connected the soxhlet apparatus and turned on the water to cool them and heated the sample for 14hrs by switched on the heating mantle. Evaporated solvent by using the vacum condenser. Bottle was dried completely at temperature 80°C - 90 °C to evaporate the solvent. Cooled it in a dessicator, after drying. Dried content was weighed with the bottle.

Calculation

$$\text{Fat (\%)} = \frac{\text{Weight of fat}}{\text{weight of fruit sample}} X\ 100$$

4.4 (e) Protein (AOAC, 2010)

Reagents

Kjedahl catalyst- Mixed 1 part of coppersulphate and 9 part of potassium sulphate

Conc.sulphuric acid – 200 ml

NaOH - 40%

HCl - 0.2 N

H_3BO_3 - 4%

Indicator solution- Mixed 200 ml of 0.2 % bromocresol green (in 95% ethanol) in 100 ml of 0.1% methyl red (in 95% ethanol)

Procedure

1gm weight sample was taken in a digestion flask. Then added 200ml of conc. sulphuric acid and 5gm Kjedhal catalyst in it. Prepared a tube which contained heated above mentioned chemical except sample as blank. Inclined position was used for the flask to heat it gently unit frothing ceases. Boiled contineously till solution was cleared. Then, 60 ml of distilled water was added in it and cooled it. Flask was connected immediately to the digestion bulb on condenser

and condenser tip was immersed in the standard acid. Mixed few indicator drops in a receiver. Flask was shaked to mix all contents properly untill, NH_3 was distilled. Removed receiver and washed the tip of condenser. Titratration was done by using the excess standard acid distilled with standard NaOH solution.

Calculation

$$\text{Protein (\%)} = \frac{(\text{A}-\text{B})XNX1.400\ 7X6.25}{\text{W}}$$

Where, A= Vol. (ml) of 0.2 N HCl used sample titration

B = Vol. (ml) of 0.2 N HCl used blank titration

N= Normality of HCl

W= Weight (g) of sample

14.007= Atomic weight of nitrogen

4.4 (f) Dietary fiber content (Van and Robertson, 1977)

4.4 (g) Hemicellulose = NDF-ADF

4.4 (h) Neutral detergent fiber (NDF)

Reagents

Neutral detergent solution
Sodium borate decahydrate -6.81g
Disodium ethylene diamine neutral -18.61 g
Sodium lauryl sulfate neutral – 30g
2- ethoxyethanol – 10 ml
Disodium phosphate anhydrous – 4.5g

Procedure

Dried sample was grinded well to pass through 1 mm screen. Weighed 1 gm of grinded sample in a crucible. Mixed solution of neutral detergent 100 ml into 0.5 gm of sodium sulfite in a crucible at normal temperature. Mixed few drops of n-octanol. After heat treatment refluxed it for 60 minutes from onset of boiling. Filtered properly, boiling water used to wash it three times. After that again wash it with cold acetone. Then, dried for 8 hours at heating

temperature 105 °C. Then kept in a dessicator to cool and weighed. Made ash in a muffle at temperature 550 °C for 2 hours. Cooled it in a dessicator and weighed.

Calculation

$$\text{NDF}\ (\%) = \frac{(\text{weight of crucible} + \text{weight of residue}) - \text{weight of crucible}}{\text{weight of sample}} \text{X}100$$

4.4 (i) Acid detergent fiber (ADF) (AOAC, 1975)

Reagents

Acid detergent solution- 75 ml

Buffer solution (P^H 1.5-2.0): 0.2M HCl -260 ml

0.2 M KCL - 1000ml

Hexadecyltrimethylammonium bromide-20gm dissolved in 1 liter of buffer solution.

Procedure

Dried sample was fine grinded and passed through 1mm screen. Weighed 1 gm of grinded sample. Added 75 ml of acid detergent solution into a Berzelius beaker and heated the sample on a hot plate for 5 minutes. Covered gently with the condenser and refluxed for 1 hour. Beaker was removed for refluxing apparatus and vacuum-filtered hot solution through tared gooch crucible by using 50-60ml hot water with 30 ml acetone. Vacuum has been used to dry fiber by sucking. Then crucible and fibre was dried overnight at temperature 110°C in oven. Percentage of fiber was calculated at dry basis.

Calculations

$$\text{ADF}\ \% = \frac{(\text{weight of crucible} + \text{weight of residue}) - \text{weight of crucible}}{\text{weight of sample}}\ \text{X}100$$

Cellulose= Neutral detergent fiber – Acid detergent fiber

4.4 (j) Cellulose content (Updegroff, 1969)

Reagents

Nitric reagent - Mixed 150 ml (80% acetic acid) and 15 ml (conc. nitric acid)

Anthrone reagent- Dissolved 200 mg anthrone in 100 ml conc. sulphuric acid.

Prepared fresh and chilled for 2 hours before use.

Sulphuric acid- 67%

Procedure

Taken a test tube with 1gm weighed sample. Added 3 ml of nitric acid and mixed in a vortex mixer. After that test tube was heated in a hot water-bath at temperature 100°C for half an hour. Cooled them and centrifuged for 20 minutes and supernatant was removed. Washed residue with distilled water. Mixed 10 ml (67% sulphuric acid) and allowed to stand for 1 hour. After that 1 ml of above solution was taken and diluted it to 100 ml. Then, 1 ml from that dilute solution was also taken and further added 10 ml of anthrone reagent in it. Boiling water bath was used to heat the tubes for ten minutes. Cooled and absorbance was taken at 630 nm. Anthrone reagent and distilled water was used as a blank. Weighed 100 mg cellulose and proceeded was taken in a test tube and all above mentioned steps for standard. Instead of just taken 1 ml of the diluted solution mentioned above taken a series of volumes and colour developed.

Calculation

Drawn the standard graph and cellulose sample was calculated.

4.4 (k) Lignin content (Burke *et al.* 2000)

Reagents

Acid detergent solution-75 ml

Buffer solution (P^H 1.5-2.0): 0.2M HCl -260 ml

0.2 M KCL - 1000ml

Hexadecyltrimethylammonium bromide-20gm dissolved in 1 liter of buffer solution.

Procedure

Dried sample was grinded fine to pass through 1mm screen. Weighed 1 gm of grinded sample . Berzelius beaker was used for the mixing of acid detergent solution and heated the sample on a hot plate for 5 minutes. Beaker was covered with the condenser and refluxed gently for 1 hours. Beaker was removed for refluxing apparatus and through tared gooch crucible was used to vacuum filter with 50-60ml hot water and with 30 ml acetone. Fiber has been sucked dried by using the vacuum. After that crucible and fiber was dried overnight at temperature 110°C in oven. Mixed 1.5 ml of 12 M H_2SO4 to all tubes contained residue fiber and digested at temperature 30°C for 30 minutes. After digestion the acid – insoluble residue was collected by using whatman filter paper with Buckner funnel (45mm) by filteration. Then, washed with water and two times with acetone and sample was dried at temperature 100 °C overnight. Weighed the filter and residue. Made ash at heating temperature 450°C for 6 hours. Weighed again after ashing . Lignin content was determined by the difference in the weight of the residue before and after ashing.

4.5 Extraction preparation

Methanol was used for the extraction of solvent. Taken a conical flask (covered it with aluminum foil) and filled it with 1 gm of weighed sample with 80 per cent methanol. After that agitated it in a orbital shaker at 50°C with 200rpm for two hours (Heidolph Unimax 1010, Schwabach, Germany). Mixture was filtered through a whatman filter paper No.4. Cleared solution was taken for the analysis (Emmy *et al.* 2009).

4.5 (a) Total phenolic content (Thimmaiah, 1999)

Reagents

Fruit powder juice (extract) -0.5 ml

Distilled water- 2.5 ml

Folin- Ciocalteu reagent- 0.5 ml

Sodium carbonate- 2ml

Conc. tannic acid -1000 µg/ml

Procedure

Folin –Ciocalteu (F- C) reagent was used to determine the phenolic content. Mixed 0.5 ml fruit extract in a beaker contained 2.5 ml of distilled water. Added 0.5 ml of Folin -Ciocalteau reagent (1:1) in it and incubated for 3 minutes. After that 2 ml (20% sodium carbonate) was mixed to each tube and kept for 1 minute in a hot boiling water bath. Wait to cool the tubes and taken absorbance at 650 nm. Tannic acid was used as standard. Graph was plotted by using different concentration of standard and absorbance therefore concentration of unknown was intercepted from graph.

4.5 (b) Total flavonoid content (Olajire and Azeez, 2011)

Reagents

Sample extracted - 1ml

Distilled water- 4 ml

Aluminum chloride – 0.3 ml of 10 %

Sodium nitrite- 0.3 ml of 5 %

Sodium hydroxide- 2ml of 1 M

Procedure

Total 1ml of extract solution was mixed in 4 ml (distilled water) and 0.3ml (5% sodium nitrite). Left it for 5 minutes and then mixed with 0.3ml 10% aluminum chloride in all mixture. Added 2ml of 1M NaOH in it after 6 minutes and volume make up to 10 ml with distilled water. After that absorbance was taken at 510 nm. Quercetin was used as a standard and graph was plotted against different concentration of standard and absorbance therefore concentration of unknown was intercepts from graph.

4.6 Antioxidant activity

4.6 (a) DPPH assay (Blois , 1958)

Reagents

DPPH solution- 50 µg/ml

Methanol- 50 µg/ml

Procedure

Antioxidant activity was determined by DPPH radical scavenging method. Extract was taken 50 μg/ml by pipette into DPPH solution conc. 50 μg/ml (1:1) for the initiation of reaction. Incubated it after 30 minutes and taken absorbance at 516 nm. DPPH solution 50 μg/ml was for standard and methanol was used for blank. The experiment was replicated with three independent assay.

Calculation

$$\text{Scavenging activity (\%)} = \frac{(Ac - As)}{Ac} X100$$

Where, Ac = Absorbance of the control

As=Absorbance of the sample

4.6 (b) Antioxidant activity

FRAP assay (Oyaizu,1986)

Reagents

Phosphate buffer- 1 ml

Potassium ferricyanide-1.0 ml

Trichloroacetic acid – 1.0 ml

Ferric chloride- 0.1 ml

Procedure

The antioxidant activity was determined by using (FRAP) ferric reducing assay. In this method 1 ml potassium ferricyanide (1.0 ml, 10 mg/ml) and phosphate buffer (1 ml, 0.2 M, pH 6.6) was mixed together and incubated for 20 minutes at temperature 50 °C. Mixed trichloroacetic acid (1.0 ml,100 mg/ml) with mixture and centrifuged for 5 minutes. Supernatant (1.0 ml) was mixed well by using distilled water (1.0 ml) and ferric chloride (0.1 ml, 1.0 mg/ml). Absorbance was taken at 700 nm.

Calculation

Scavenging activity (%) = $\frac{(A - B)}{A} X100$

4.7 Tannin content (Price *et al*. 1978).

Reagents

Concentrate HCL- 10 ml

Methanol- (1 %)

Vanillin reagent- (0.5% , 5 ml)

Catechin – 1 mg/ml

Procedure

Weighed 200 mg sample was taken in a test tubes. And extraction was done by using 10 ml (1% concentrated HCl) in methanol for 20 minutes. Mixed vanillin reagent (0.5%, 5 ml) to 1 ml extract and left it for 20 minutes at temperature 30°C. Then, taken absorbance at 500nm and result was expressed in catechin equivalents i.e. catechin (mg/100gm) which has been given a colour intensity equivalent to tannins after corrected the blank. Calculation of tannin content was done and results were expressed in mg/ 100 gm.

4.8 Alkaloid content (Herborne, 1973)

Reagents

Acetic acid – 100ml of 10 %

Ethanol – 100 ml

Conc. ammonium hydroxide- drop wise

Procedure

Weighed 5 gm of sample and kept into a 250 ml of beaker. Mixed 100 ml (10% acetic acid and ethanol). Beaker was covered tightly and left it for 4 hours. Filtered it properly and

concentrated it up to one-fourth of its original volume by using a boiling water bath. Concentrated ammonium hydroxide mixed dropwise in this extract till precipitation was completed. After settled down the whole solution, the precipitate was collected. Washed it with diluted ammonium hydroxide. Alkaloid was contained from the left residue after filteration. Dried it properly and weighed.

4.9 Anthocyanin content (Giusti and Wrolstad, 2001)

Reagents

Sample- 1ml

Potassium chloride-5ml

Sodium acetate-5 ml

Procedure

Anthocyanin quantification was done by using P^H- differential method. Taken extract was diluted in a solution of (1.0 M HCL,25 Mm KCL) P^H 1.0 and in a solution (0.4 M CH_3COONa) P^H 4.5. Absorbance was taken against distilled water at 510 nm and 700 nm.

Calculation

Diluted sample absorbance (A) as follows:

$A = (A_{510} – A_{700})$ pH 1.0 – $(A_{510} – A_{700})$ pH 4.5

Monomeric anthocyanin pigment (mg/L) = $x = \frac{(AXMWXDFX1000)}{\varepsilon X1}$

Where,

The molecular weight(MW)

The dilution factor (DF)

The molar absorptivity(ε)

Cyanidin-3-glucoside (pigment content) where MW = 449.2 and ε= 26,900

4.10 Mineral composition (AYUSH, 2008)

Calcium, Iron and Phosphorus

Reagents

Nitric acid- 10 ml

Procedure

Weighed 0.5 gm of coarse fruit sample in a casparian flask and mixed with 10 ml nitric acid. Covered it properly and left for overnight. After that, heated on a electric hot plate till the solution become cleared and transparent . Heat continuously till the solution became light yellow colour and white smoke dispersed. The solution was cooled and then transferred into 50 ml volumetric flask and diluted with the same solvent to the volume and mixed it properly. Prepared reagent blank solution with explained method. The mineral content was carried out from the cleared solution by Inductively coupled plasma- optical emission spectrometry (ICP-OES).

4.11 Experimental Design

4.11 (a) Experimental animals

Healthy male albino rats were 200gm -250gm body weight were mainly used for the study purpose. The rats were acclimatized in the animal house environment for seven days before starting the research work. The study was approved by Animals Ethics Committee in University (Regd. No. 954/PO/AC/06/CPCSEA).

4.11 (b) Preparation of extracts

Microwave dried fruits were selected for the study and converted into fine powder. Petroleum ether was used to remove fat from the powder material. Methanol and water mixture of 1:1 was used for the 72 hours extraction. Filtered extract was concentrated by rotary evaporator and vacuum dessicator was used to keep it. The calculated yield for the extract of *Ficus carica*

extract was 29 per cent and *Carissa spinarum* was 31.6 per cent and with respect to dried powder (Rout *et al.*2013).

4.11 (c) Method for acute toxicity test

Male rats (wistar albino) were fasted overnight and separated into two groups (n=3). Two groups were orally fed with the extract of *Ficus carica* and *Carissa spinarum* separately, in increasing dose of 1000 mg, 2500 mg and 5000 mg according to body weight of rats. And rats were observed continuously for 2 days for change noticed in their behaviour, neurologically, any toxicity sign and mortality. If any, so they were again observed for the next 7 days for any changes in their behavoiur and death. One- tenth and one fifth of the maximum safe dose of the extract were selected for the experiment which was used for acute toxicity (Rout *et al.*2013).

4.11 (d) Preparation of interventions

Selected fruit extract dosage according to body weight of rats i.e. 500 mg. Mixed it with distilled water by using Tween 20 at 25 per cent level. Tween 20 was used as suspending agent. The Metformin dose (50 mg/kg body weight) was also made by same method The sample used for test, solvent and Metformin drug were given orally to rats based on their level of dose according to their body weight (Rout *et al.*2013).

4.11 (e) Animals and induction of diabetes mellitus

Overnight fasted rats were administered (35mg/kg body weight) of single injection of Streptozotocin (STZ) interaperitoneally for the induction of diabetes (Gupta *et al*.2004). STZ solution was prepared by dissolving it into 0.9 per cent of ice cold saline instantly before use. Fasting blood sugar levels were observed (FBG>250 mg/dl)to be diabetic after a week of STZ administration and further used for the experiment (Sachin *et al*.2009).

4.11 (f) Multiple dose hypoglycemic study

Rats were divided into seven groups and each group contained six rats. Every group was either received solvent (2.5 ml), selected fruit extract doses and Metformin 50 mg/kg body weight of everyday 30 minutes before food throughout experimental period. All rats were continuously observed and blood sample was collected on 0,7 14 and 21 days. Blood sample was collected for the measurement of fasting blood sugar level (Ngueguim *et al.* 2007; Kar *et al.* 2006).

4.11 (g) Experimental plan

Seven groups of rats each group contained six rats and conducted a study for 21 days:

Group 1 Rats treated with basal diets (control group)

Group 2- Diabetic control group treated with drug streptozotocin, negative control group (Diabetic+ Streptozotocin)

Group 3- Diabetic rats treated with antidiabetic drugs i.e. metformin and supplemented with basal diet, positive control group (Diabetic + Metformin)

Group 4- Diabetic rats treated with 500 mg extract of *Ficus carica* according to body weight of rats supplemented with basal diet

Group 5- Diabetic rats treated with 500 mg extract of *Carissa spinarum* according to body weight of rats and supplemented with basal diet

Group 6- Normal rats treated with 500 mg extract of *Ficus carica* according to body weight of rats and supplemented with basal diet

Group 7- Normal rats treated with 500 mg extract of *Carissa spinarum* according to body weight of rats and supplemented with basal diet

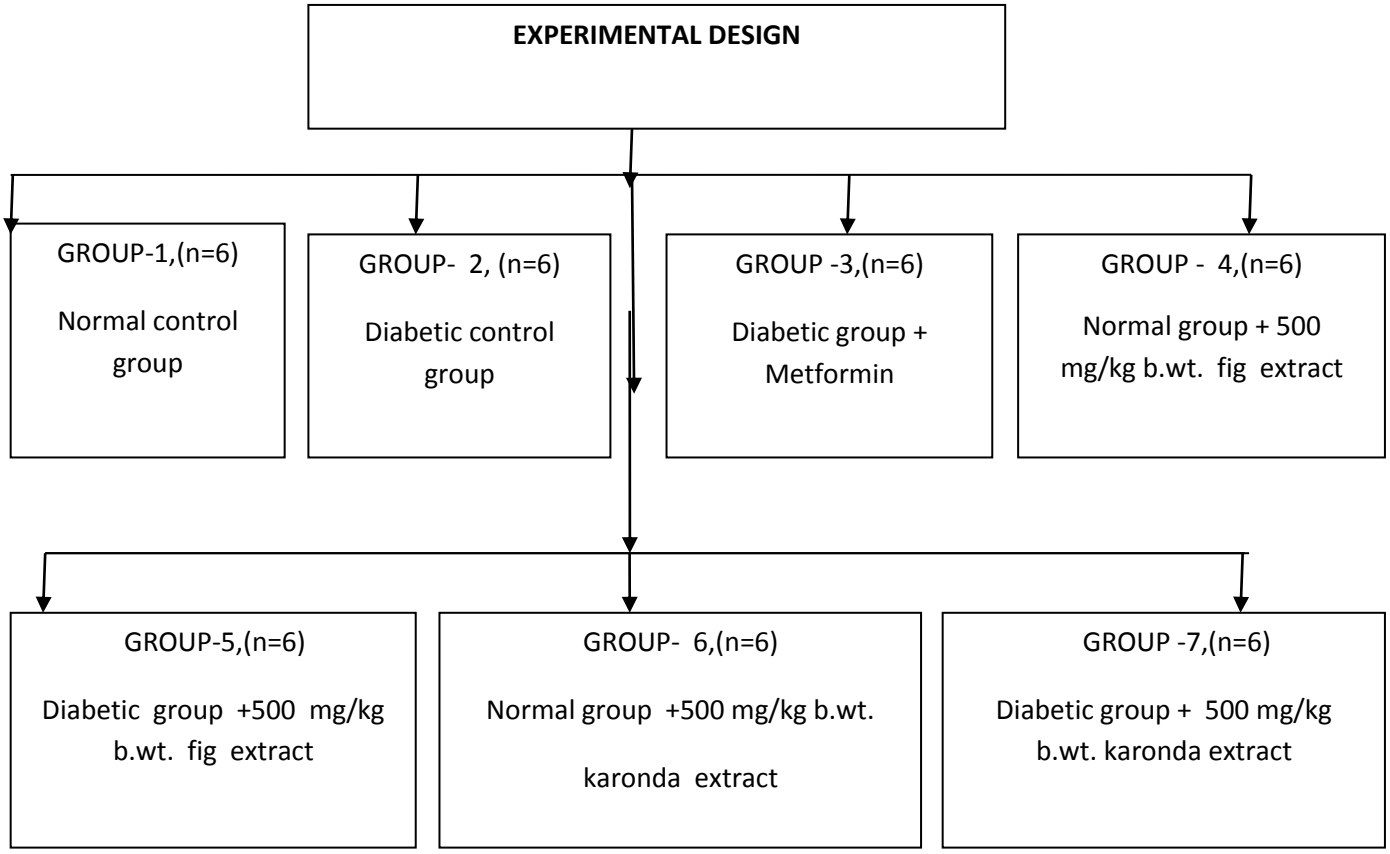

Fig. 4.2 Flow chart for value experimental design

4.12 Value added products development

4.12 (a) Procurement for raw materials

In order to develop (bun ,muffin, noodles and nuggets) value added products, the required materials were purchased from a local market in Jalandhar (wheat flour, R. oil, skimmed milk, honey, baking powder) etc.

4.12 (b) Fruit powder preparation

Fresh fruits were collected and spoiled fruits were removed before washing. Distilled water was used to wash these fruits three times to remove unwanted dirt particles then weighed and divided equally. Selected fruits were dried and distributed separately on the stainless steel trays and microwave dried for 3 minutes and 15 seconds (800W). Dried fruits were grounded fine in a grinding machine and sieved through 1mm sieve. All prepared mixture was stored in airtight container at room temperature and used for further analysis.

4.12 (c) Experiment design

The experimental design for the present research is depicted in **Table 4.1** and **Table 4.1.1** showed the different incorporation of fruits. In **Table 4.1.2** the different ingredients were used in making the buns were given in gm and **Fig 4.1** showed the flowchart for the preparation of buns.

Table 4.1 Experimental plan for bun

S. No.	Parameter	Level	Description
1.	Product	1	Bun
2.	Ingredient	5	Wheat flour, whole fresh fruit, R.oil, yeast powder and salt
3	Samples	8	B1, B2, B3, B4, T1, T2, T3 and T4 (Bun)
4.	Analysis	3	Nutritional analysis, Mineral analysis, sensory analysis

Table 4.2 Treatment description. Different combination of wheat flour, fresh fruit , R.oil, yeast powder and salt were used for the development of bun

Treatment	**Wheat Flour (WF), %**	***Ficus carica* (FC), %**	***Carissa spinarum* (CS), %**
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Where, B1 (Standard) =100% wheat flour bun, B2 = 15% *Carisssa spinarum*, B3= 30% *Carisssa spinarum*, B4= 45% *Carisssa spinarum*), T1= 100 % wheat flour bun , T2 = 15% *Ficus carica*, T3 = 30% *Ficus carica*, T4 = 45% *Ficus carica*

Table 4.3 Ingredients were used in the preparation of bun (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Wheat flour	100	85	70	55	100	85	70	55
2.	Fresh sample	0	15	30	45	0	15	30	45
3.	R.oil	1	1	1	1	1	1	1	1
4.	Yeast powder	2	2	2	2	2	2	2	2
5.	Salt	2	2	2	2	2	2	2	2

Bun Development (Alam *et al.* 2013)

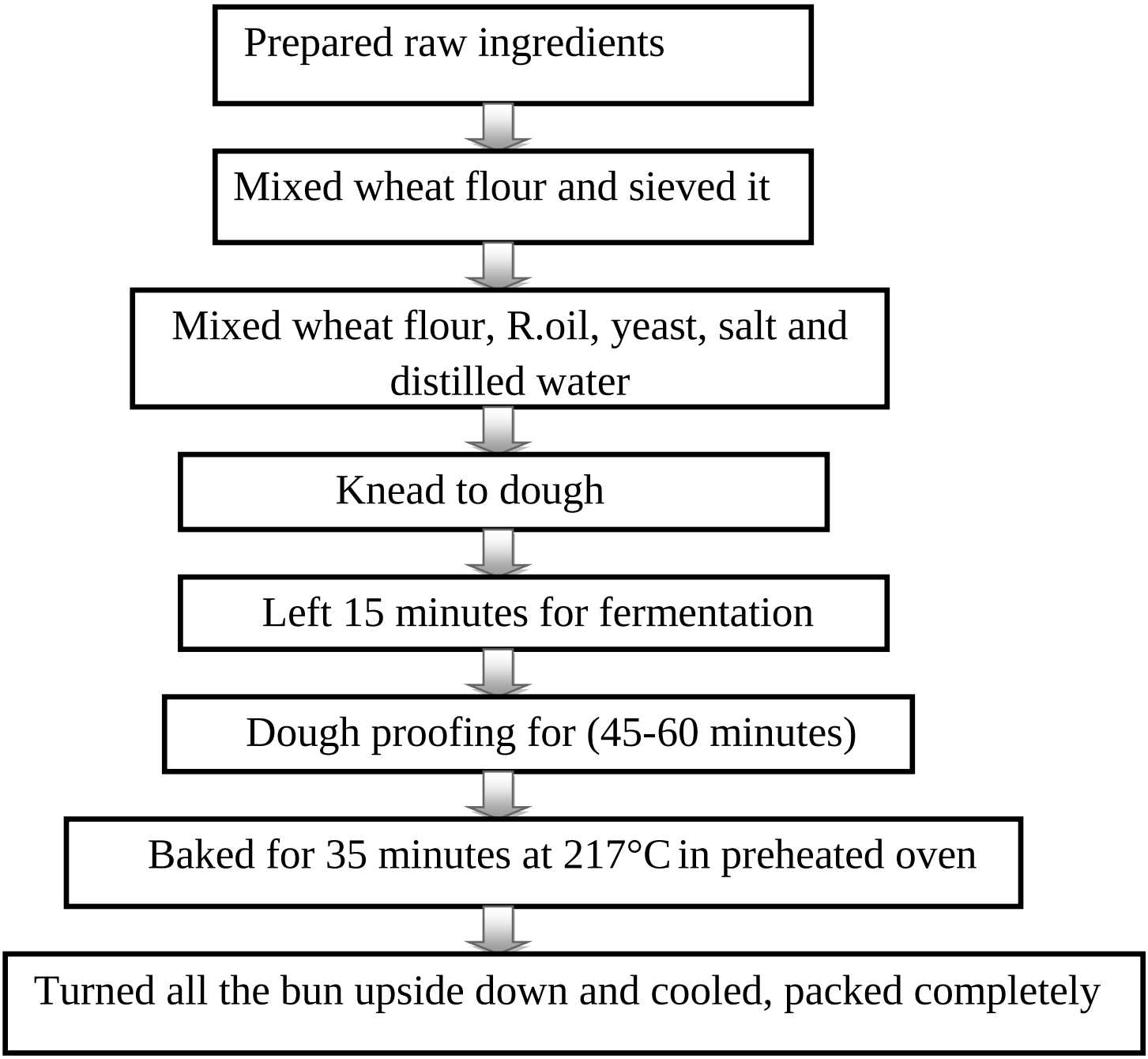

Fig. 4.3 Flow chart for the preparation of bun

Table 4.4 Experimental plan for muffin

S. No.	Parameter	Level	Description
1.	Product	2	Muffin
2.	Ingredient	6	Refined wheat flour, fresh fruit, R.oil, skimmed milk, honey, baking powder
3	Samples	8	B1, B2, B3, B4, T1, T2,T3and T4 (Muffin)
4.	Analysis	3	Nutritional analysis, Mineral analysis, sensory analysis

Table 4.5 Treatment description. Different combination of refined wheat flour, fresh fruit, R.oil, skimmed milk, honey, baking powder were used for the development of muffin

Treatment	**Wheat Flour (WF), %**	***Ficus carica* (FC), %**	***Carissa spinarum*(CS) %**
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Table 4.6 Ingredients were used in the preparation of muffin (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Refined wheat flour	100	85	70	55	100	85	70	55
2.	Sample/fruit powder	0	15	30	45	0	15	30	45
3.	R. oil	15	15	15	15	15	15	15	15
4.	Skimmed milk	25	25	25	25	25	25	25	25
5.	Honey	9	9	9	9	9	9	9	9
6.	Baking powder	1	1	1	1	1	1	1	1

Muffin Development (Uchenna *et al.* 2013)

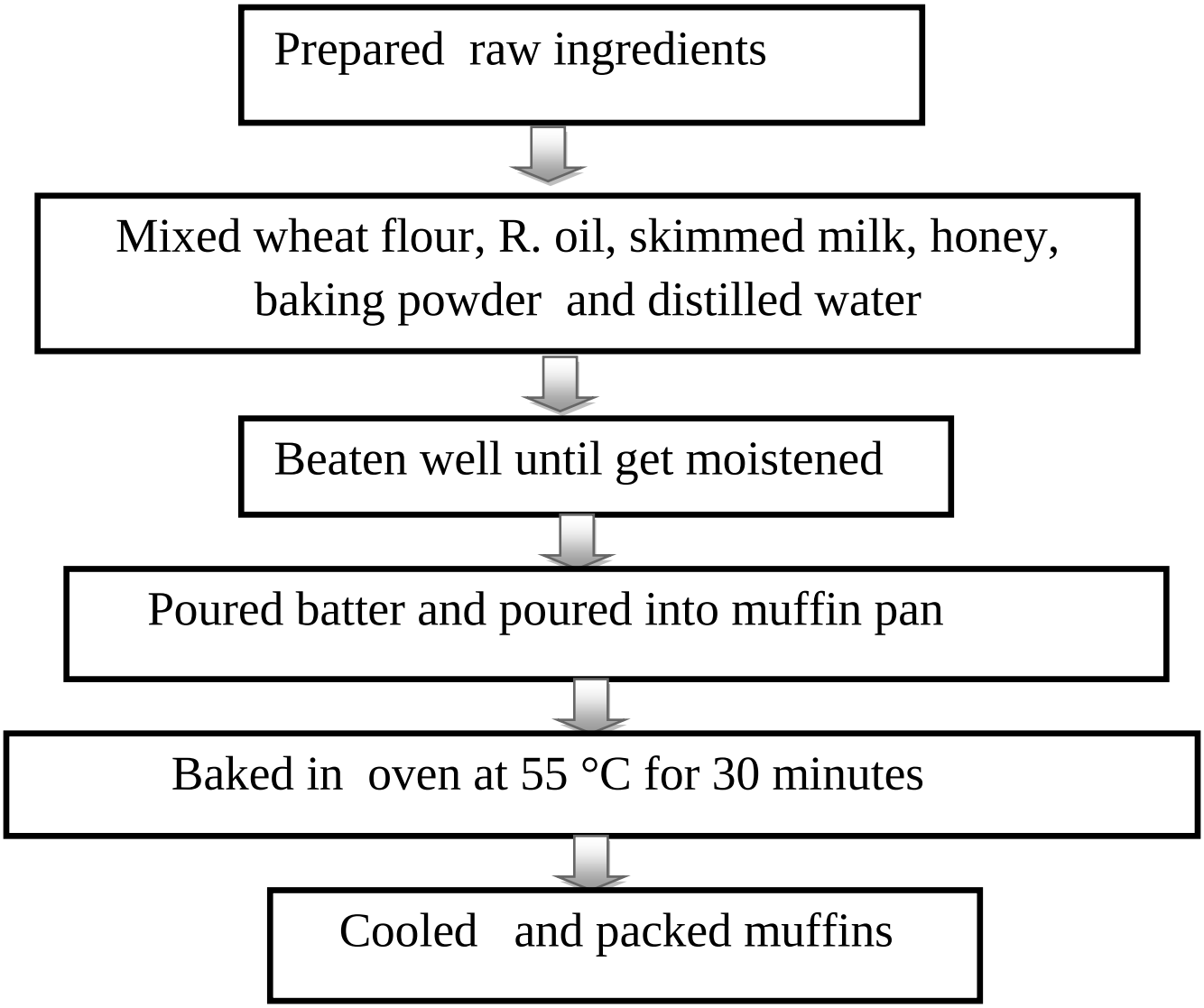

Fig. 4.4 Flow chart for the preparation of muffin

Table 4.7 Experimental plan for noodles

S. No.	Parameter	Level	Description
1.	Product	3	Noodles
2.	Ingredient	2	Wheatflour,fruit powder
3	Samples	8	B1, B2, B3, B4, T1, T2, T3 andT4 (Noodles)
4.	Analysis	2	Nutritional analysis, Mineral analysis

Table 4.8 Treatment description. Different combination of wheat flour, fruit powder was used for the development of noodles

Treatment	Wheat Flour (WF), %	*Ficus carica* (FC), %	*Carissa spinarum* (CS), %
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Table 4.9 Ingredients were used in the preparation of noodles (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Wheat flour	`100	85	70	55	`100	85	70	55
2.	Sample/fruit powder	0	15	30	45	0	15	30	45

Noodles Development (Ibitoye *et al.* 2013)

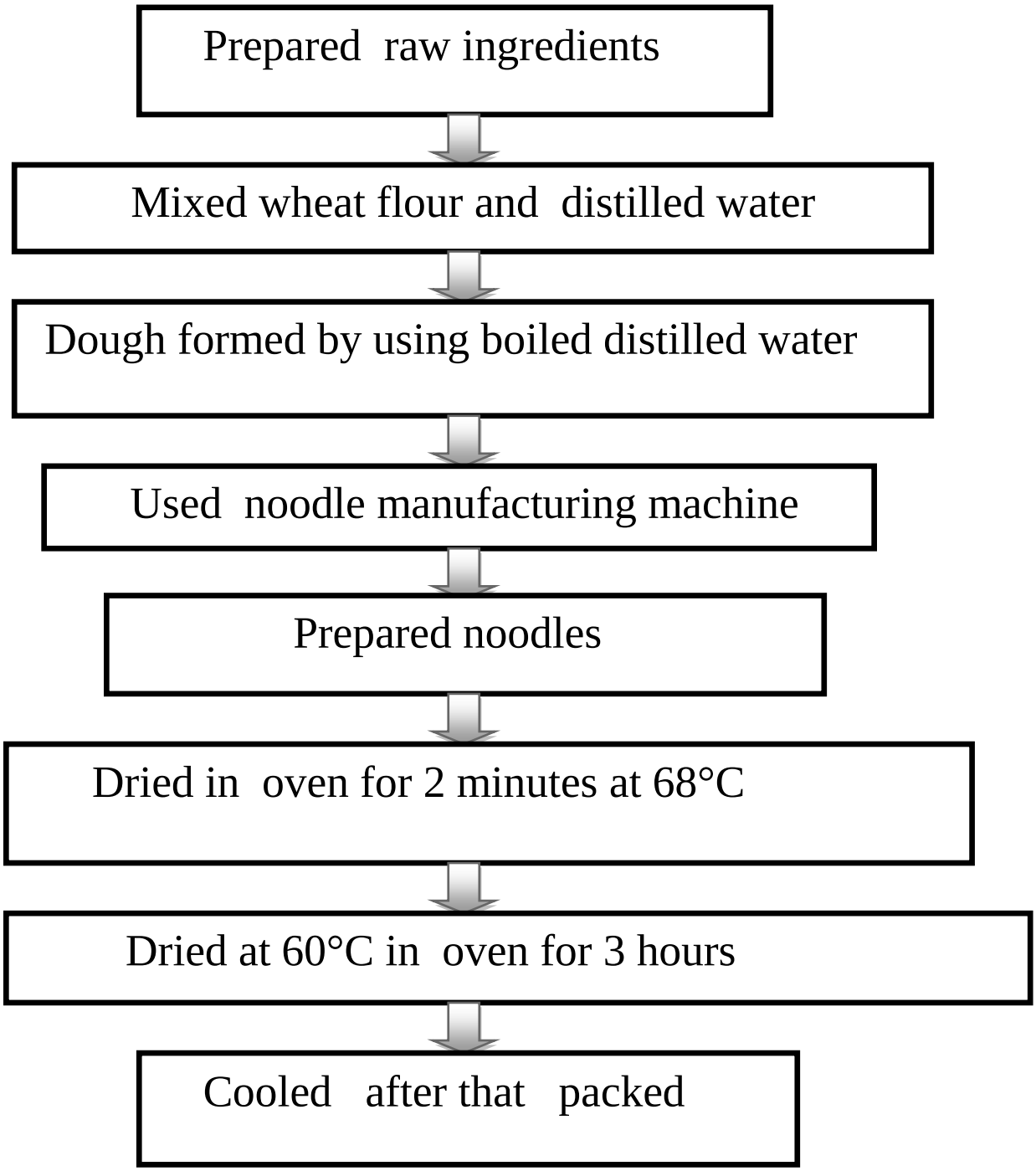

Fig. 4.5 Flow chart for the preparation of noodles

Table 4.10 Experimental plan for nuggets

S. No.	Parameter	Level	Description
1.	Product	4	Nuggets
2.	Ingredient	2	Moong flour, fruit powder
3	Samples	8	B1, B2, B3, B4, T1,T2,T3andT4 (Nuggets)
4.	Analysis	2	Nutritional analysis, Mineral analysis

Table 4.11 Treatment description. Different combination of moong flour, fruit powder was used for development of nuggets

Treatment	**Wheat Flour (WF), %**	***Ficus carica* (FC), %**	***Carissa spinarum* (CS), %**
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Table 4.12 Ingredients used in the preparation of nuggets (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Moong flour	100	85	70	55	100	85	70	55
2.	Sample/fruit powder	0	15	30	45	0	15	30	45

Nugget Development (Pandey *et al.* 2012)

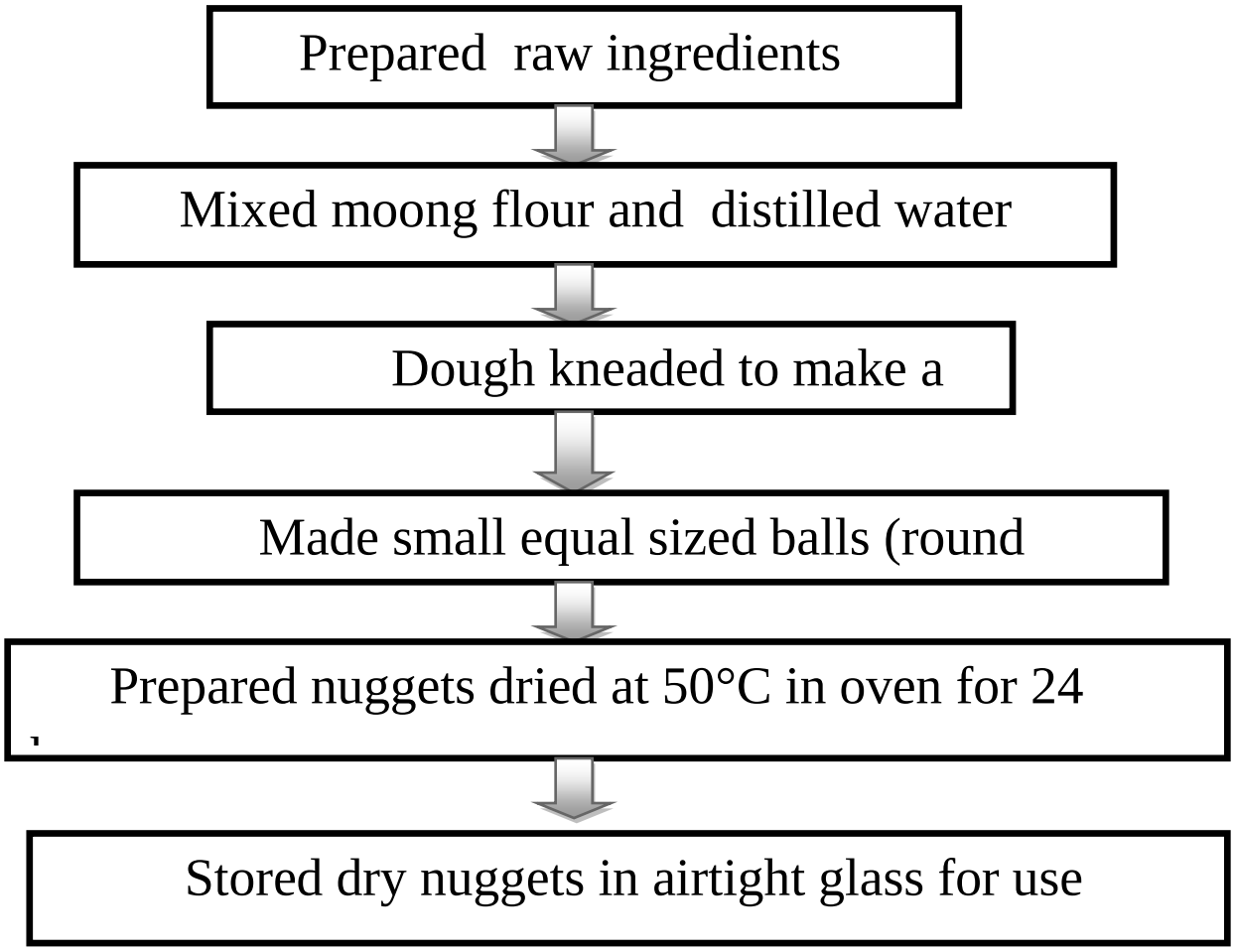

Fig. 4.6 Flow chart for the preparation of nuggets

4.12 (d) Organoleptic evaluation

Bun and muffin samples were evaluated for the appearance, colour, texture, flavor and overall acceptability by using 9 – point hedonic scale (Schutz and Cardello, 2001).

4.13 Statistical analysis

Experiments were performed in triplicates. These results were analyzed by using Graph pad prism 5 software for ANOVA (one-way analysis of variance) with Tukey's test for the determination of significant difference between the mean at 5 per cent level and statistically measured at significant level ($p < 0.05$).

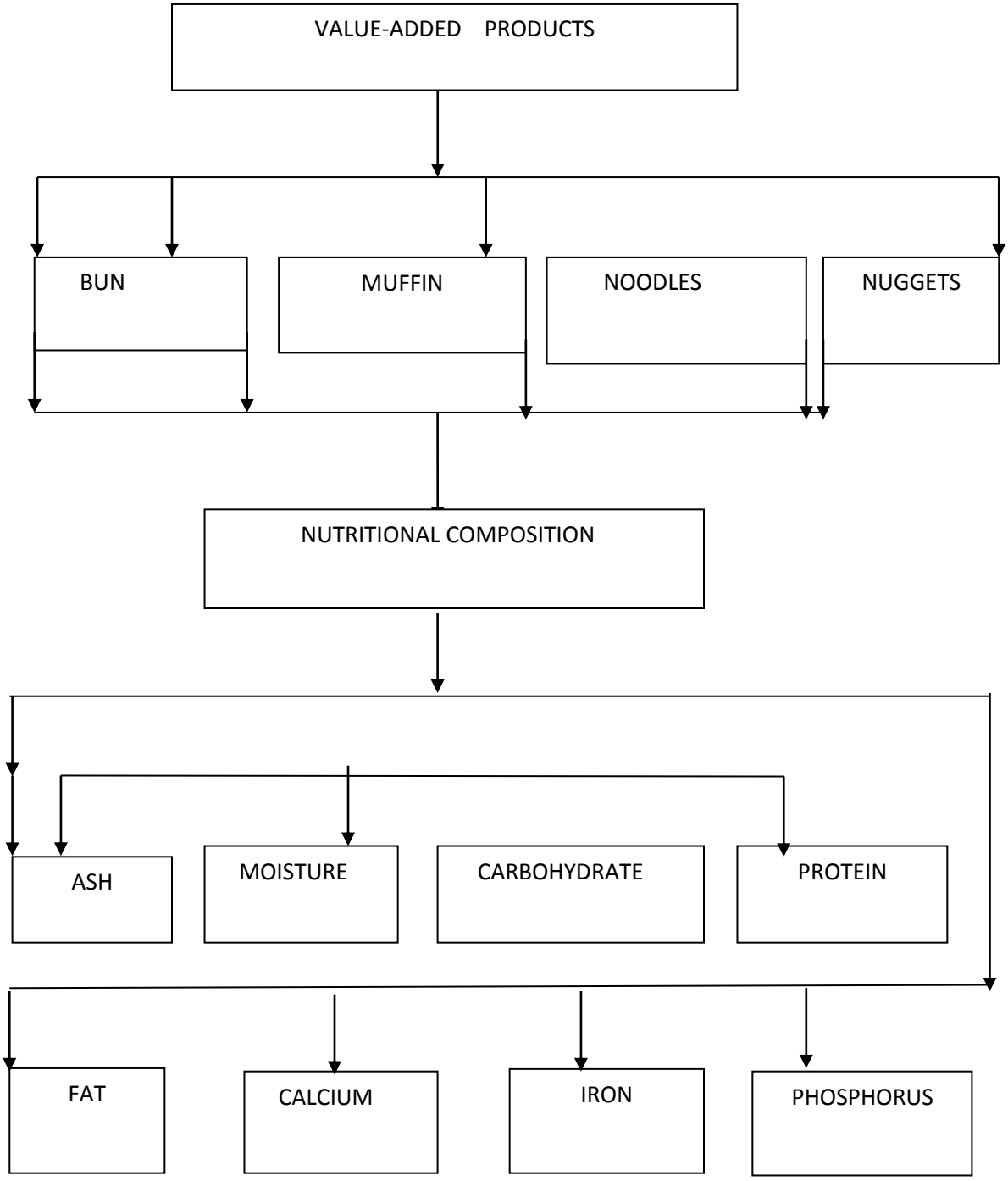

Fig. 4.7 Flow chart for value added products

5. RESULTS AND DISCUSSION

The present study was carried out in the Department of Food Technology and Nutrition, School of Agriculture and Food Technology, Lovely Professional University, Phagwara, Punjab during the year 2012- 2016. The results are discussed in the following subheads:

5.1 Analysis of *Ficus carica* (fig)

5.1 (a) Physical properties of fig

5.1 (b) Nutritional composition of fig

5.1 (c) Dietary composition of fig

5.1 (d) Phytochemical composition of *Ficus carica* (Total phenolic content)

5.1 (e) The total flavonoid content of fig

5.1 (f) Antioxidant activity (DPPH) of fig

5.1 (g) Antioxidant activity (FRAP) of fig

5.1 (h) Anti- nutritional content and anthocyanin content of fig

5.1 (i) Mineral composition of fig

5.2 Analysis of *Carissa spinarum* (Karonda)

5.2 (a) Physical properties of Karonda

5.2 (b) Nutritional composition of Karonda

5.2 (c) Dietary composition of Karonda

5.2 (d) Phytochemical composition of *Carissa spinarum* (Total phenolic content)

5.2 (e) The total flavonoid content of Karonda

5.2 (f) Antioxidant activity (DPPH) of Karonda

5.2 (g) Antioxidant activity (FRAP) of Karonda

5.2 (h) Anti- nutritional content and anthocyanin content of Karonda

5.2 (i) Mineral composition of Karonda

5.3 Experimental design

5.3 (a) Effect of fig (*Ficus carica*) methanolic extract on fasting blood glucose level in diabetic and non diabetic rats

5.3 (b) Effect of fig (*Ficus carica*) methanolic extract on body weight in diabetic and non diabetic rats

5.4 Experimental design

5.4 (a) Effect of Karonda (*Carissa spinarum*) methanolic extract on fasting blood glucose level in diabetic and non diabetic rats

5.4 (b) Effect of Karonda (*Carissa spinarum*) methanolic extract on body weight in diabetic and non diabetic rats

5.5 Formulation of value added product with substitution of fig

5.5 (a) Bun

5.5 (b) Nutritional composition

5.5 (c) Dietary fiber

5.5 (d) Mineral composition

5.5 (e) Organoleptic analysis

5.6 Muffin

5.6 (a) Nutritional composition

5.6 (b) Dietary fiber

5.6 (c) Mineral composition

5.6 (d) Organoleptic analysis

5.7 Noodles

5.7 (a) Nutritional composition

5.7 (b) Dietary fiber

5.7 (c) Mineral composition

5.7 (d) Organoleptic analysis

5.8 Noodles

5.8 (a) Nutritional composition

5.8 (b) Dietary fiber

5.8 (c) Mineral composition

5.8 (d) Organoleptic analysis

5.9 Formulation of value added product with substitution of Karonda

5.9 (a) Bun

5.9 (b) Nutritional composition

5.9 (c) Dietary fiber

5.9 (d) Mineral composition

5.9 (e) Organoleptic analysis

5.10 Muffin

5.10 (a) Nutritional composition

5.10 (b) Dietary fiber

5.10 (c) Mineral composition

5.10 (d) Organoleptic analysis

5.11 Noodles

5.11 (a) Nutritional composition

5.11 (b) Dietary fiber

5.11 (c) Mineral composition

5.11 (d) Organoleptic analysis

5.12 Noodles

5.12 (a) Nutritional composition

5.12 (b) Dietary fiber

5.12 (c) Mineral composition

5.12 (d) Organoleptic analysis

5.1 Analysis of *Ficus carica* (fig)

5.1 (a) Physical properties of fig

The effect of processing methods on the physical properties of fig is depicted in Table 6.1. The length of fresh fig was found to be 15.46 mm. Similar results, i.e. 20 mm to 36 mm were reported by Darjazi *et al*. (2011) in fresh fig fruit. A statistically significant increase ($p< 0.05$) in length was observed in fresh fig sample, the increasing order being MDS<SD <FRS<FS.

Table 5.1 Effect of processing methods on physical properties of fig

Drying methods	FS	SD	FRS	MDS
Length(mm)	15.46 ± 0.05^{a}	14.26 ± 0.05^{b}	14.46 ± 0.05^{c}	14.16 ± 0.05^{bd}
Width(mm)	18.14 ± 0.00^{a}	17.46 ± 0.05^{b}	17.86 ± 0.05^{c}	17.16 ± 0.05^{cd}
Density(gm/cc)	0.95 ± 0.00^{a}	0.93 ± 0.02^{a}	0.94 ± 0.01^{a}	0.91 ± 0.00^{ab}

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample

Length of sun dried fig was found to be 14.26 mm. Length decreased by 7.76 %, in sun dried fig as compared to fresh ones. Length of microwave dried fig was found to be 14.16 mm. Length decreased by 8.40 %, in microwave dried fig as compared to fresh ones. Similar results have been reported by Hazbavi *et al.* (2014), wherein they reported 3.06 % decrease in length in date palm fruit by thermal processing. Similar decrease in length has been reported by Zivcovic *et al*. (2011) in thermal dried plum. This may be attributed to the fact that thermal process leads to decrease in length of fruits as moisture content is reduced (Kashaninejad *et al*.2006) and also due to the shrinkage of fruits (Jha *et al*.2006).

Length of frozen fig was found to be 14.46mm. Length decreased by 6.46 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 4.80 % decrease in length in frozen dates. This decrease in length by frozen storage might be due to the period of cold storage (Al- Yahayai and Al- Kharusi,2012).

The width of fresh fig was found to be 18.14 mm. Similar results, i.e. 21mm to 48 mm was reported by Darjazi *et al*. (2011) in fresh fig fruit. A statistically significant increase ($p<0.05$) in width was observed in fresh fig sample, the increasing order being MDS<SD <FRS<FS.

Width of sun dried fig was found to be 17.46 mm. Width decreased by 3.74 % in sun dried fig as compared to fresh ones. Width of microwave dried fig was found to be 17.16 mm. Width decreased by 5.40 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Hazbavi *et al.*(2014), where they found 1.45 % decrease in width in thermal processed date palm fruit. Similar decrease in width has been reported by Zivcovic *et al*. (2011) in heat treated plum. This decrease in width by thermal process might be due to the reduction of moisture content (Kashaninejad *etal.*2006) and also due to the shrinkage of fruits (Jha *et al.*2006; Hazbavi *et al*, 2014). Width of frozen fig was found to be 17.86 mm. Width decreased by 1.54 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), wherein they reported 7.69 % decrease in width in frozen dates. This decrease in width by frozen storage might be due to the period of cold storage (Al- Yahayai and Al- Kharusi, 2012).

The density of fresh fig was found to be 0.95 gm/cc. Similar results, i.e. 1.46 gm/cc was reported by Razavi *et al*. (2010) in fresh fig fruit. A statistically significant increase ($p<0.05$) in density was observed in fresh sample, the increasing order being MDS<SD <FRS<FS. Density increased in fresh due to higher moisture content that leads to increase volume (Garmakhany *et al.* 2013). Density of sun dried fig was found to be 0.93 gm/cc. Density decreased by 2.10 % in sun dried fig as compared to fresh ones. Density of microwave dried fig was found to be 0.91 gm/cc. Density decreased by 4.21 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Pacco and Menegalli (2004), where they reported decrease in density in thermal dried fig fruit. This is may be attributed to the fact that thermal processing fig becomes more porous.

Density of frozen fig was found to be 0.94 gm/cc. Density decreased by 1.05 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Ramaswamy and Tung (1981), wherein they reported decrease in density by 6.74 % in frozen storage "Golden" apple.

5.1 (b) Nutritional composition of fig

The moisture content of fig fruit is depicted in Table 5.2. Moisture content of fresh fig was found to be 80.2 per cent. Similar results, i.e. 80.61 per cent was reported by Nakilcioglu and Hisil, (2013) in "Sarilop" fresh fig variety. The moisture content increased significantly ($p<0.05$) in frozen fig sample, the increasing order being MDS<SD<FS<FRS.

Table 5.2 Effect of processing methods on nutritional properties of fig

Drying methods	FS	SD	FRS	MDS
Moisture (%)	80.2 ± 0.00^{a}	25.86 ± 2.48^{b}	81.0 ± 1.97^{ac}	25.43 ± 3.23^{bc}
Ash (%)	4.00 ± 0.34^{a}	4.42 ± 0.19^{a}	4.20 ± 0.08^{a}	4.30 ± 0.23^{a}
Carbohydrate (%)	16.3 ± 0.18^{a}	65.15 ± 0.20^{b}	16.0 ± 0.03^{ac}	65.18 ± 0.08^{cd}
Fat (%)	0.53 ± 0.08^{a}	0.56 ± 0.00^{a}	0.51 ± 0.07^{a}	0.59 ± 0.03^{a}
Protein (%)	0.53 ± 0.15^{a}	3.01 ± 0.09^{a}	2.71 ± 0.32^{a}	3.18 ± 0.07^{a}

The moisture content of sun dried fig was found to be 25.85 per cent. Moisture content decreased by 67.75 % in sun dried fig as compared to fresh ones. Similar results have been reported by Siriwattananon and Maneerate (2016), in guava where they found 89.08% decrease in moisture content in sun dried fruit. Moisture content of microwave dried fig was found to be 25.43 per cent. Moisture content decreased by 68.29 % in microwave dried fig as compared to

fresh ones. Similar results have been reported by Nakilcioglu and Hisil (2013), wherein they reported 79.76% decrease in moisture content in fig fruit after thermal process. Similar decrease in moisture content (99.75%) has been reported by Lutz *et al.* (2015) in heat treated blackberry. Kshetrimayum *et al*. (2015), also reported 92.86 % reduction in moisture content in microwave dried guava slices. This reduction in moisture content by thermal process might be due to the rapid water loss (Mechlouch *et al.* 2015), heating temperature (Brooker, 1974) and higher absorption power (Meda *et al.* 2008).

Moisture content of frozen fig was found to be 81.0 per cent. Moisture content increased by 0.99 % in frozen fig as compared to fresh ones. Similar results have been reported by Aleid *et al*. (2014), where they reported 10.51% increase in moisture content in date during frozen storage and Damini *et al*.(2013), wherein they reported 2.45 % increase in the moisture content in frozen marolo pulp. Similar increase in moisture content (1.0 %) has been reported by Boca *et al.* (2014) in frozen strawberry puree. This may be attributed to the fact that frozen storage leads to increase in moisture content of fruits as destruction of cellular structure by syneresis (Sae-Kang and Suphantharika, 2006) that leads to release of intracellular water (Chefteh and Besancon, 1989) which is migrated out of the cell (Damiani *et al*.2013).

The ash content of fig fruit is depicted in Table 5.2. Ash content of fresh fig was found to be 4.00 per cent . Similar results, i.e. 5.74 per cent was reported by Chawla *et al*. (2012) in fresh fig fruit. Ash content increased non significantly ($p>0.05$) in all fig dried samples and the increasing order being FS<FRS<MDS<SD. The ash content of sun dried fig was found to be 4.42 per cent. Ash content increased by 10.5 % in sun dried fig as compared to fresh ones. Ash content of microwave dried fig was found to be 4.30 per cent. Ash content increased by 7.5 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Nordin *et al*. (2013), wherein they reported 12.53 % increase in ash content in palm during thermal process. This increase in ash content by thermal process might be due to the removal of moisture content (Lisa, 1997).

Ash content of frozen fig was found to be 4.20 per cent. Ash content increased by 5.0 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Zolfaghari *et al*. (2010), where they reported 8.3 % increase in ash content in kiwi fruit during frozen storage.

Similar increase in ash content 20 % has been reported by Ogunobanwo *et al*.(2013) in frozen water melon juice. This increase in ash content by frozen storage might be due to the presence of products which has chemical stability (Raji *et al.* 2016).

Fat content of fig fruit is depicted in Table 5.2. Fat content of fresh fig was found to be 0.53 per cent. Similar results, i.e. 0.34 per cent was reported by Mahmoud *et al*. (2013) in fresh fig fruit. A statistically non significant increase ($p<0.05$) in fat content in all dried fig samples and the increasing order being FRS<FS<SD<MDS.

The fat content of sun dried fig was found to be 0.56 per cent. Fat content increased by 5.66 % in sun dried fig as compared to fresh ones. Fat content of microwave dried fig was found to be 0.59 per cent. Fat content increased by 11.32 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Nwaigwe and Adejumo (2015), in African bread fruit where they found 2.10 % increase in fat content during thermal process. This may be attributed to the fact that thermal process leads to increase in fat content of fruits along with removal of moisture content (Morris *et al.* 2004). Fat content of frozen fig was found to be 0.51 per cent. Fat content decreased by 3.77 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 10.81 % decrease in fat content in frozen blackthorn fruit. This decrease in fat content by frozen storage might be due to oxidation (Ryder *et al*.1993) that leads to release oxidative enzymes from various rupture cellular organelles (Boonsumrej *et al.* 2007).

Carbohydrate content of fresh fig was found to be 16.3 per cent. Similar results, i.e. 17.1 per cent was reported by Guvenc *et al*. (2009) in fresh fig fruit. Significant difference ($p<0.05$) increased in carbohydrate content in all fig dried samples and the increasing order being FRS<FS<SD<MDS. The carbohydrate content of sun dried fig was found to be 65.15 per cent. Carbohydrate content increased by 299.69% in sun dried fig as compared to fresh ones. Carbohydrate content of microwave dried fig was found to be 65.18 per cent. Carbohydrate content increased by 299.87% in microwave dried fig as compared to fresh ones. Similar results have been reported by Guvenc *et al*. (2009) in fig fruit where they found 240.39 % increase in carbohydrate content during heat treatment and Clary *et al*. (2007), wherein they reported 265. 27% increase in carbohydrate content in microwave dried grapes. Similar increase in

carbohydrate content (13.15 %) has been reported by Nwaigwe and Adejumo (2015) in thermal treated African bread fruit. This increase in carbohydrate content by thermal process might be due to hydrolytic effect of carbohydrate stored in fruits (Akinhanmi *et al.* 2008).

Carbohydrate content of frozen fig was found to be 65.15 per cent. Carbohydrate content decreased by 1.84 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Galoburda *et al.* (2014), where they reported 55.2% decrease in the carbohydrate content in strawberry puree during frozen storage. Damiani *et al*. (2013), wherein they reported 16.11% decrease in carbohydrate content in frozen marolo pulp. Similar decrease in carbohydrate content (25.78%) has been reported by Zolfaghari *et al*. (2010), in frozen kiwi fruit. This may be attributed to the fact that frozen storage leads to decrease in carbohydrate content of fruits as increase in carbon consumption which is required for fruit respiration (Holland *et al*. 2002) and also due to the breakdown of cell structure during frozen storage (Cheftel and Besancon,1989).

The protein content of fig fruit is depicted in Table 5.2. Protein content of fresh fig was found to be 2.98 per cent. Similar results, i.e.1.30 per cent was reported by Guvenc *et al*. (2009) in fresh fig fruit. Protein content non significantly increased ($p>0.05$) in all fig dried samples and the increasing order being FRS<FS<SD<MDS. The protein content of sun dried fig was found to be 3.01 per cent. Protein content increased by 467.92 % in sun dried fig as compared to fresh ones. Protein content of microwave dried fig was found to be 3.18 per cent. Protein content increased by 500.00 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mahmoud *et al*.(2013) in fig fruit where they found 288.23 % increase in protein content during thermal process and Clary *et al*. (2007), wherein they reported 236.11 % increase in protein content in grapes during heat treatment. Similar increase in protein content (14.28 %) has been reported by Nwaigwe and Adejumo (2015) in African bread fruit during thermal process. This increase in protein content by thermal process might be due to the enhancement in dry matter contents by the concentration of soluble solids (Eze and Akubor, 2012).

Protein content of frozen fig was found to be 2.71 per cent. Protein content decreased by 411.32 % in frozen storage fig as compared to fresh ones. Similar results have been reported by

Sikora *et al.* (2013), where they reported 57.51% decrease in protein content in blackthorn fruit during frozen storage. Similar decrease in protein content (7.79 %) has been reported by Damiani *et al*. (2013) in frozen marolo pulp. This may be attributed to the fact that frozen storage decrease in protein content of fruits as reduction in proteins which are water and salt soluble (Chomnawang *etal.*2007), denaturation of proteins (Ryder *et al.* 1993) and destruction caused by enzymatic activity (Hultman and Rustard, 2004).

5.1 (c) Dietary composition of fig

The neutral detergent fiber (NDF) of fig fruit is depicted in Table 5.3. Neutral detergent fiber of fresh fig was found to be 12.73 per cent. Similar results, i.e. 12.49 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. A statistically significant ($p<0.05$) increase in NDF in all fig dried samples, the increasing order being FRS<FS<SD<MDS

Table 5.3 Effect of processing methods on dietary composition of fig

Drying methods	FS	SD	FRS	MDS
NDF (%)	12.73 ± 0.05^{a}	12.83 ± 0.05^{a}	12.53 ± 0.11^{b}	12.86 ± 0.05^{ac}
ADF (%)	0.40 ± 0.10^{a}	0.56 ± 0.11^{a}	0.38 ± 0.07^{a}	0.60 ± 0.05^{a}
Hemicellulose (%)	12.26 ± 0.05^{a}	12.30 ± 2.17^{a}	12.16 ± 0.05^{a}	12.33 ± 0.11^{a}
Cellulose (%)	15.91 ± 0.05^{a}	16.11 ± 0.07^{a}	15.90 ± 0.40^{a}	16.68 ± 0.05^{b}
Lignin (%)	1.72 ± 0.01^{a}	1.73 ± 0.01^{a}	1.70 ± 0.00^{a}	1.74 ± 0.01^{ab}

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The neutral detergent fiber of sun dried fig was found to be 12.83 per cent. NDF increased by 0.78 % in sun dried fig as compared to fresh ones. NDF in microwave dried fig was found to be 12.86 per cent. NDF increased by 1.02 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Clary *et al*. (2007), where they reported 58 % increase in dietary fiber content in microwave dried grapes. This increase in dietary fiber by thermal process might be due to the formation of Maillard reaction product (Chang and Morris, 1990; Vidal and Frias, 1991) and also due to the reduction in moisture content (Fennema, 1976), by leaching of soluble components to the solution that leads to form the heat resistant complexes between polysaccharides and other mechanism i.e. protein and phenolic content (Caprez *et al.* 1986; Rodriguez *et al.* 2006). Dietary fiber (hemicellulose, cellulose and lignin) also increased (Vasishtha *et al.* 2013) due to releasing of enzymatic fiber components from insoluble cell wall matrix (Hakkinen *et al.*2003).

Neutral detergent fiber of frozen fig was found to be 12.53 per cent. The NDF decreased by 1.57% in frozen storage fig as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 18.13 % decrease in dietary fiber in frozen blackthorn fruit and Salgado *et al.* (1999), wherein they reported reduction in dietary fiber in frozen tropical fruits. This decrease in NDF by frozen storage might be due to the reduction in of cell wall polysaccharides tissues that leads declined dietary fiber (Khan and Vincent, 1996).

Acid detergent fiber (ADF) of fig fruit is depicted in Table 5.3. Acid detergent fiber of fresh fig was found to be 0.40 per cent. Similar results, i.e. 0.74 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. The ADF increased non significantly ($p>0.05$) in dried fig samples, the increasing order being FRS<FS<SD<MDS. The acid detergent fiber of sun dried fig was found to be 0.56 per cent. ADF increased by 40 % in sun dried fig as compared to fresh ones. ADF in microwave dried fig was found to be 0.60 per cent. ADF increased by 50 % in microwave dried fig as compared to fresh ones. Acid detergent fiber in frozen fig was found to be 0.38 per cent. The ADF decreased by 5.0 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Mohajer *et al.* (2016), where they reported 32.66 % decrease in ADF in frozen sainfoin seed.

Hemicellulose content of fresh fig was found to be 12.26 per cent. Similar results, i.e. 12.09 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. A statistically non significant increase ($p>0.05$) in hemicellulose content in fresh fig samples, the increasing order being FRS<FR<SD<MDS. The hemicellulose content of sun dried fig was found to be 12.30 per cent. Hemicellulose content increased by 0.32 % in sun dried fig as compared to fresh ones. Hemicellulose content in microwave dried fig was found to be 12.33 per cent. Hemicellulose content increased by 0.57 % in microwave dried fig. Similar results have been reported by Komolka *et al*. (2012), where they reported 5 % increase in hemicellulose content in common cabbage by thermal processing. Hemicellulose content in frozen fig was found to be 12.16 per cent. The hemicellulose content decreased by 0.06 % in frozen storage fig.

Cellulose content of fig fruit is depicted in Table 5.3. Cellulose content of fresh fig was found to be 15.91 per cent. Similar results, i.e. 22.20 per cent was reported by Nzidda (2010) in " *Ficus polita*" a variety of fig fruit. The cellulose content increased significantly ($p<0.05$) in dried fig samples, the increasing order being FRS<FS<SD<MDS. The cellulose content of sun dried fig was found to be 16.11 per cent. Cellulose content increased by 1.25 % in sun dried fig as compared to fresh ones. Cellulose content in microwave dried fig was found to be 16.68 per cent. Cellulose content increased by 4.83 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015), where they reported 13.7% increase in cellulose content in date fruit during thermal process and Nordin *et al*. (2013), wherein they reported 3.31% increase in oil palm fruit during heat treatment. Cellulose content in frozen fig was found to be 15.90 per cent. The cellulose content decreased by 0.06 % in frozen storage fig as compared to fresh ones.

Lignin content of fresh fig was found to be 1.72 per cent. Similar results, i.e. 2.53 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. The lignin content increased significantly ($p<0.05$) in dried fig samples, the increasing order being FRS<FS<SD<MDS. The lignin content of sun dried fig was found to be 1.73 per cent. Lignin content increased by 0.58 % in sun dried fig as compared to fresh ones. Lignin content in microwave dried fig was found to be 1.74 per cent. Lignin content increased by 1.16 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015) in date fruit where they

found 20.68 % increase in lignin content during thermal process. Similar increase in lignin content (38.79 %) has been reported by Nordin *et al*. (2013) in thermal processed oil palm fruit. This increase in lignin content by thermal process might be due to increase the activity of lignin synthesis enzymes i.e. phenylalanine ammonia lyase (Yun *et al*.2013). Hosseinaei *et al.* (2012) also reported that due to heat, complex structure of lignin is formed which makes it difficult for degradation. Lignin content in frozen fig was found to be 1.70 per cent. The lignin content decreased by 1.16 % in frozen fig as compared to fresh ones. Similar results have been reported by Dangcham *et al*. (2008), where they reported 65.07 % decrease in lignin content in mangosteen fruit at low temperature storage.

5.1 (d) Phytochemical composition of fig (Total Phenolic content)

Processing methods caused remarkable changes in the total phenolic content of fig fruit is depicted in **Figure 5.1**. Total phenolic content (TPC) of fresh fig was found to be 4.58 mg TAE/100gm. Similar results, i.e. 1.15 mg GAE/100gm to 6.98 mg GAE/100gm were reported by Nakilcioglu and Hisil, (2013) in "Sarilop" fresh fig varieties.

A statistically significant increase ($p<0.05$) in TPC was observed in all dried fig samples, the increasing order being FRS<FS <SD<MDS. Total phenolic content of sun dried fig was found to be 4.92 mg TAE/100gm. TPC increased by 7.42 %, in sun dried fig as compared to fresh ones. Al-Farsi *et al.* (2005), reported 22.5 % increase in TPC in dates after sun drying. Total phenolic content of microwave dried fig was found to be 4.94 mg TAE/100gm. TPC increased by 7.86 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Reyes *et al.* (2013) in loquat where they found 10.52 % increase in TPC in microwave dried fruit as compared to fresh ones and Hayat *et al*. (2010), wherein they reported increase from 4.3% to 45.61% in microwave dried pomace. This increase in TPC by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (HMP) by Maillard reaction (Donovan *et al.* 1998) and also due to the breakdown of cellular structure of cells, which makes the phenolic content more extractable (Van *et al.* 2000). Singleton *et al.* (1999) mentioned enhancement in phenolic content may be due to the formation of aglycons by reacting with Folin-Ciocalteau reagent.

Total phenolic content of frozen fig was found to be 4.52 mg TAE/100gm. Frozen stored fig fruits exhibited 1.31 % decrease in total phenolic content as compared to fresh ones. Similar results have been reported by Mullen *et al.* (2002), where they reported 21 to 28 % decrease in the TPC in raspberries during frozen storage as compared to fresh ones. Similar decrease in TPC (0.81%) has been reported by Scibisz and Mitek (2007) in frozen blueberries. This may be attributed to the fact that frozen storage leads to decrease in total phenolic content of fruits as polyphenol oxidase enzymes (PPO) are released by breaking cells and that leads to oxidation of polyphenolics to quinines (De Ancos *et al*. 2000a).

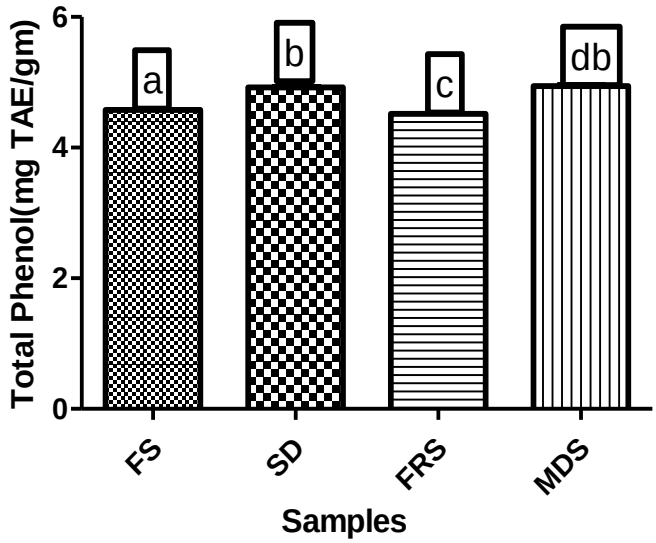

Fig. 5.1 Total Phenolic content of fig

Values are expressed in triplicates (mean ± SD)

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample

5.2 (e) Total Flavonoid content of fig

Flavonoid content of fig fruit is depicted in **Figure 5.2.** Total flavonoid content of fresh fig was found to be 0.21 mg QE/100gm. Similar results, i.e. 1.6 mg catechin equivalent/ 100gm

to 2.3 mg catechin equivalent /100gm were reported by Solomon *et al*. (2006) in "Brunswick " fresh fig varieties.

The total flavonoid content increased significantly ($p<0.05$) in fresh fig sample, the increasing order being SD<MDS<FS<FRS. The flavonoid content of sun dried fig was found to be 0.19 mg QE/100gm. Flavonoid content decreased by 9.52 % in sun dried fig as compared to fresh ones. Similar results have been reported by Wang *et al.* (2016) in jujube fruit where they found 26.75 % decrease in flavonoid content in sun dried fruit. Flavonoid content of microwave dried fig was found to be 0.20 mg QE/100gm. Flavonoid content decreased by 4.76 % in microwave dried fig as compared to fresh ones. Similarly reduction in total flavonoid content (33.3%) has been reported by Salim *et al.* (2014) in microwave dried pepper and Planinic *et al.* (2015), wherein they reported 15.3% reduction in flavonoid content in microwave dried grape fruit. Similar results have been reported by Macias *et al* .(2013), where they reported 23.13 % decrease in flavonoid content in strawberry fruit during thermal process. This decrease in flavonoid content by thermal process (Crozier *et al.* 1995; Price and Rhodes, 1997) might be due to the breakdown of some phytochemicals, which affects cell wall integrity and that leads to migration of some flavonoid components (Davey *et al.* 2000). Ioannou *et al.* (2012) also mentioned that heating process caused degradation might be due to parameters such as pH, oxygen, light, activity of polyphenoleoxidase enzymes and by hydrolysis of C- glycosides bonds, which are presented in flavonoids (Manach *et al.*2004). Flavonoid content of frozen fig was found to be 0.23 mg QE/100gm.

Flavonoid content increased by 9.52 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Mohammadian *et al*.(2011), where they reported 52.11% increase in flavonoid content in "*Citrus limon*" during frozen storage. This may be attributed to the fact that frozen storage leads to increase in flavonoid content of fruits as increase in quercetin derivatives during cold storage (Omer and Canan, 2014) that increases quercetin hydrolysis (Hakkinen *et al*.2000).

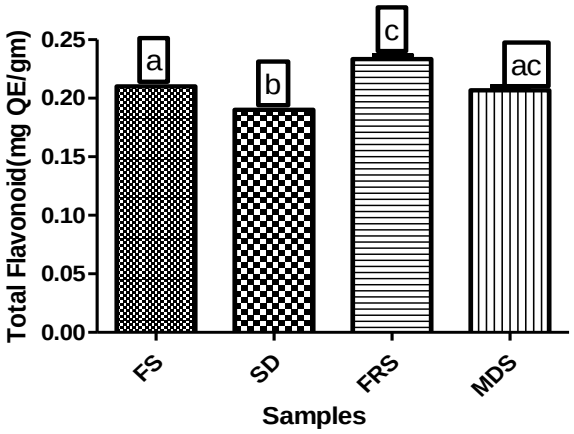

Fig. 5.2 Total Flavonoid content of fig

Values are expressed in triplicates (mean ± SD)

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.1 (f) Antioxidant activity of fig

Processing methods caused remarkable changes in antioxidant activity of fig fruit is depicted in **Figure 5.3.** Antioxidant activity of fresh fig was found to be 73.42 per cent. Similar results, i.e. 75.16 per cent was reported by Wilson *et al*. (2016) in " *Ficus religiosa*" a variety fig fruit.

Antioxidant activity significantly ($p<0.05$) increased in all dried fig sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity of sun dried fig was found to be 75.36 per cent. Antioxidant activity increased by 2.64 % in sun dried fig as compared to fresh ones. Antioxidant activity of microwave dried fig was found to be 75.84 per cent. Antioxidant activity increased by 3.29 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mechlouch *et al.* (2015), where they found 95.32 % increase in antioxidant activity (DPPH) in microwave dried palm date and Juhaimi *et al*.(2015), wherein they reported 280.33 % increase in DPPH antioxidant activity in microwave dried apple. Similar increase in antioxidant activity from 0.27 % to 0.96 % has been reported by Jeong et al.(2004) in heat treated citrus peel extract. This increase in antioxidant activity (DPPH) by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (Raupp *et al*.2011), presence of

naturally occurring compounds such as Maillard reaction products (Yin and Chang,1998; Piga *et al*. 2003;Lee *et al*.2003), released of a free phenolic fraction (Yamaguchi *et al*. 2001), due to oxidative and hydrolytic enzyme (Farsi *et al*.2005), disruption of cell wall that leads to release and enhances antioxidant activity (Chumyan *et al*.2013).

Antioxidant activity of frozen fig was found to be 71.66 per cent. Antioxidant activity (DPPH) decreased by 2.39 % in frozen storage fig as compared to fresh ones. Similar results have been reported by De Ancos *et al.* (2000), where they reported 12 % decrease in antioxidant activity (DPPH) in frozen raspberry fruit and Pimia *et al*.(2003), wherein they reported 20 % decrease in antioxidant activity in frozen peas. Similar decrease in antioxidant activity (1.64 %) has been reported by Mohammadian *et al.*(2011) in frozen "*Citrus limon*. This may be attributed to the fact that frozen storage leads to decrease in antioxidant activity of fruits as disruption of cell structure (Sikora *etal*.2013) and cell wall that leads to release of the oxidative and hydrolytic enzymes that can destroy antioxidant in fruits (Chism,1996).

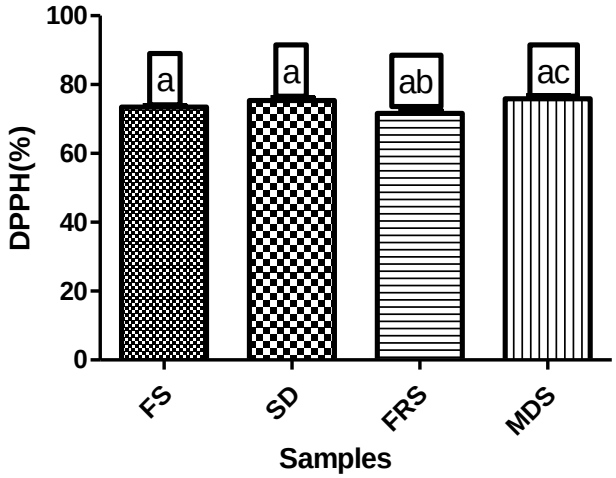

Fig. 5.3 Antioxidant activity (DPPH) of fig

Different superscripts in the same row are significantly different ($p<0.05$).

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.1 (g) Antioxidant activity of fig

Ferric reducing scavenging activity (FRAP) is depicted in **Figure 5.4.** Antioxidant activity of fresh fig was found to be 76.22 per cent. Shivasharanappa and Londonkar, (2014) reported lower antioxidant activity in"*Ficus glomerata*" variety of fig fruit, i.e. 29 per cent to 70 per cent as compared to our results. This difference might be due to many parameters such as fruit colour (Bey and Louaileche, 2015), extraction methods, solvent (Musa *et al.*2011), difference in cultivation (Wand *et al*. 2002; Hakkinen and Torronen, 2000), ripening period (Raffo *et al.* 2012), environmental factor (Wu *etal*.2014). Antioxidant activity non significantly ($p > 0.05$) increased in all dried fig sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity (FRAP) of sun dried fig was found to be 76.55 per cent. Antioxidant activity (FRAP) increased by 0.43 % in sun dried fig as compared to fresh ones. Antioxidant activity of microwave dried fig was found to be 78.54 per cent. Antioxidant activity increased by 3.04 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Piga *et al.* (2003), where they reported increase in antioxidant activity (FRAP) in plum fruit during thermal process. Higher antioxidant activity might be due to relative increase of FRAP value which determined the capacity of plant extract for the donation and acceptance of electrons (Yan *et al.* 2006). This increase in antioxidant activity by thermal process may be due to reduction in moisture content(Abou El-Hana, 2008), inhibition of oxidative enzymes and cell wall destruction which releases antioxidant compounds (Yamaguchi *et al.* 2001).

Antioxidant activity of frozen fig was found to be 75.76 per cent. Antioxidant activity (FRAP) decreased by 0.60 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Poiana *et al*.(2010), where they reported decrease from 6.5% to 12% in frozen strawberry fruit and Nilsson *et al.* (2004), wherein they reported decrease in antioxidant activity (FRAP) in frozen peas.

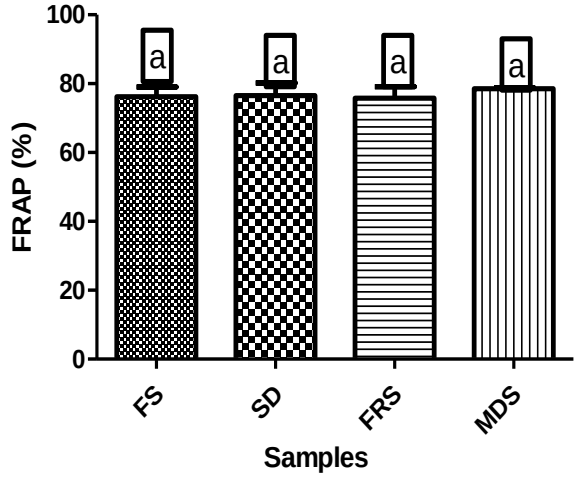

Fig. 5.4 Antioxidant activity (FRAP) of fig

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample

5.1 (h) Anti - nutritional content and anthocyanin content of fig

Tannin content of fresh fig was found to be 0.67 gm/100gm and depicted in Table 5.4. Similar results, i.e. 1.88 gm/100 gm was reported by Noonan and Savage (1999) in "*Ficus Benghalensis* " a variety of fig fruit. Tannin content increased significantly ($p<0.05$) in fresh fig samples, the increasing order being FRS<SD<MDS<FS.

Sun dried fig tannin content was found to be 0.61 gm /100gm. Tannin content decreased by 8.95 % in sun dried fig as compared to fresh ones. Tannin content of microwave dried fig was found to be 0.62 gm /100gm. Tannin content decreased by 7.46 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Pragati *et al.* (2003) in aonla fruit where they found 31.50% decrease in tannin content during thermal process and Nwaigwe and Adejumo (2015), wherein they reported 92.56 % decrease in tannin content in African bread fruit heat treatment. Similar decrease in tannin content (10.58 %) has been reported by Sunmola *et al.* (2011) in *Carica papaya* seed during thermal process. This decrease in tannin content by thermal process might be due to the oxidation of bioactive compounds (Yoshioka *etal.* 1990) and also due to the breakdown of cell structure which migrates the components that

are creating loss by leakage in the presence of oxygen and light (Scheieber *et al*.2001) and also due to various chemical reaction involving enzymes (polyphenoleoxidase) which are responsible to convert tannins into other products (Pragati *et al.* 2003; Mehta,1995).

Table 5.4 Effect of processing methods on anti - nutritional and anthocyanin content of fig

Drying methods	FS	SD	FRS	MDS
Tannin- (gm/100g)	0.67 ± 0.00^{a}	0.61 ± 0.00^{b}	0.60 ± 0.00^{bc}	0.62 ± 0.00^{bd}
Alkaloid- (gm/100g)	7.80 ± 0.04^{a}	7.76 ± 0.02^{a}	7.60 ± 0.1^{b}	7.79 ± 0.04^{ac}
Anthocyanin- (mg/100g)	4.78 ± 0.19^{a}	4.67 ± 0.00^{a}	4.89 ± 0.19^{a}	4.56 ± 0.50^{a}

Tannin content of frozen fig was found to be 0.60 gm /100gm. Tannin content decreased by 10.44 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 33.33 % reduction in tannin content in frozen dates. Similar decrease in tannin content in persimmons fruit has been reported by Nakamura (1961) during frozen storage. This decrease in tannin content by frozen storage might be due to the non-enzymatic activity in fruits (Al-Ogadi and Mutlak, 1986; Abu-Goukh *et al*. 2003), change occurs in chemical properties of tannin (Nakamura ,1961) that leads to coagulate soluble tannin into insoluble (Brackmann *et al.*1997; Matsu and Itoo,1978).

Alkaloid content of fig fruit is depicted in Table 5.4. Total alkaloid content of fresh fig was found to be 7.80 gm /100gm. Similar results, i.e. 9.6 gm/100gm was reported by Soni *et al*. (2014) in fig fruit. A statistically significant increase ($p<0.05$) in alkaloid content was observed in fresh fig samples, the increasing order being FRS<SD<MDS<FS. The alkaloid content of sun dried fig was found to be 7.76 gm /100gm. Alkaloid content decreased by 0.51 % in sun dried fig as compared to fresh ones. Alkaloid content of microwave dried fig was found to be 7.79 gm /100gm. Alkaloid content decreased by 0.12 % in microwave dried fig as compared

to fresh ones. Similar results have been reported by Nwaigwe and Adejumo (2015) in African bread fruit they found 20.75 % decrease in alkaloid content during heat treatment and Irondi *et al*. (2010), wherein they reported decrease in alkaloid content in *Carica papaya* by thermal process. This decrease in alkaloid content by thermal process might be due to the breakdown of cell structure which results migration of components, that leads to loss by various chemical reactions i.e. involving enzymes, light and heat (Atlabachew *et al*. 2013). Alkaloid content of frozen fig was found to be 7.60 gm /100gm. Alkaloid content decreased by 2.56 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Atlabachew *et al*. (2013), where they reported 56 % decrease in alkaloid content (cathinone) in frozen (*Catha Edulis* Forsk) leaves.

The anthocyanin content of fig fruit is depicted in Table 5.4. Total anthocyanin content of fresh fig was found to be 4.78 mg cyanidin-3-glucoside equivalents/100gm. Similar results, i.e. 0.1 mg cynide-3-glucose/100gm to 27.3 mg cynidin-3-glucoside equivalent /100gm were reported by Solomon *et al*. (2006) in "Mission" fresh fig varieties. Anthocyanin content increased non significantly ($p > 0.05$) in frozen fig samples, the increasing order being MDS<SD<FS<FRS.

The anthocyanin content of sun dried fig was found to be 4.67 mg cyanidin-3-glucoside equivalents/100gm. Anthocyanin content decreased by 2.30 % in sun dried fig as compared to fresh ones. Anthocyanin content of microwave dried fig was found to be 4.5 mg /100gm. Anthocyanin content decreased by 2.30 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Wojdylo *et al.* (2009) in strawberry where they found 12.9 % decrease in anthocyanin content in microwave dried fruit. Similar decrease in anthocyanin content (35.69 %) has been reported by Wojdylo *et al*. (2014) in microwave dried sour cherries. This decrease in anthocyanin content by thermal process (Juan *et al*.2013) might be due to different factors i.e. heat, oxygen, metal ion, co-pigmentation and pH (Mishra and Yang, 2008), polyphenol oxidase enzymes activity (Kwok *et al.*2004) and browning reaction (Wrolstad *et al.* 2004).

Total anthocyanin content of frozen fig was found to be 4.89 mg cyanidin-3-glucoside equivalents/100gm. Anthocyanin content increased by 4.60 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Scibisz and Mitek (2007), where they

reported 1.30 % increase in anthocyanin content in frozen blueberries. Similar increase in anthocyanin content (2.16 %) has been reported by Mullen *et al.* (2002) in frozen red raspberries. This increase in anthocyanin content might be due to ice crystal formation that favours to reallocation of water molecules in cell structure, that leads to enhance the release of membrane bound anthocyanin (Szczesniak, 1998; Leong and Oey, 2012) and also due to the cellular disruption in fruits (Skrede, 1996) which contributes to increase the cyanidin -3-galactoside content in fruits (Scibisz and Mitek, 2007).

5.1 (i) Mineral composition of fig

The mineral composition of fig fruit as depicted in Table 5.5. Calcium content of fresh fig was found to be 80.76 mg /100gm. Similar results, i.e.78 mg/100gm was reported by Khan *et al*. (2011) in fresh fig fruit.

Table 5.5 Effect of processing methods on mineral composition of fig

Drying methods	FS	SD	FRS	MDS
Calcium- (mg/100g)	80.6± 0.01 ^{a}	285.23±0.01 ^{b}	80.76± 0.01 ^{c}	302.86± 0.01^{cd}
Iron- (mg/100g)	12.01±0.01^{a}	12.66± 0.01 ^{b}	11.51 ±0.01^{c}	13.20 ±0.01^{dc}
Phosphorus- (mg/100g)	17.66± 0.01^{a}	106.16 ± 0.01^{cd}	17.41± 0.01^{c}	123.13± 0.01 ^{cd}

Calcium content increased significantly ($p<0.05$) in microwave dried fig sample, the increasing order being FS<FRS<SD<MDS. Mineral composition might be increased or decreased by different processing methods (Rickman *et al.* 2007). The calcium content of sun dried fig was found to be 285.23 mg /100gm. Calcium content increased by 253.18% in sun dried fig as compared to fresh ones. Calcium content of microwave dried fig was found to be 302.86 mg /100gm . Calcium content increased by 275.01 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Clary *et al.* (2007) in grapes where they found

157.81 % increase in mineral content in microwave dried fruit and Incedayi *et al.* (2016), wherein they reported 70.93 % increase in calcium content in microwave dried apricot fruit. This increase in calcium content by thermal process might be due to increasing of dry matter content. Ozcan *etal.* (2004) also reported that changes in the concentration of minerals are also depending on the method and the drying temperature used (Ozcan *et al.* 2004).

Calcium content of frozen fig was found to be 80.76 mg /100gm. Calcium content increased by 0.198 % in frozen storage fig as compared to fresh ones. Similar results were reported by Zolfaghari *et al*.(2010), where they reported 13.42 % increase in calcium content in frozen kiwi fruit of "Abbot" cultivar. Similar increase in calcium content (6.25%) has been reported by Bouzari *et al*.(2015) in frozen carrot.

Iron content of fresh fig was found to be 12.01 mg /100gm. Similar results, i.e. 10.09 mg/100gm was reported by Khan *et al*. (2011) in fresh fig. Iron content increased significantly ($p<0.05$)in microwave dried fig sample, the increasing order being FRS<FS<SD<MDS. The iron content of sun dried fig was found to be 12.66 mg /100gm . Iron content increased by 5.41% in sun dried fig as compared to fresh ones. Iron content of microwave dried fig was found to be 13.20 mg /100gm. Iron content increased by 9.90 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Clary *et al*. (2007) in grapes where they found 35.29 % increase in iron content during thermal process. Similar increase in iron content (395.06%) has been reported by Jung *et al*. (2005) in microwave dried persimmon fruit. Iron content of frozen fig was found to be 11.51 mg /100gm. Iron content decreased by 4.16 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Zolfaghari *et al*.(2010) in kiwi fruit where they found 13.80 % decrease in iron content in frozen storage.

Phosphorus content of fresh fig was found to be 17.66 mg /100gm. Guvenc *et al*. (2009) was reported higher phosphorus content in fresh fig fruit i.e. 22 mg/100gm as compared to our results. This differences might be due variation in cultivars, storage period and genetic factor (Zolfaghari *et al.* 2010). Phosphorus content increased significantly ($p<0.05$) in microwave dried fig sample, the increasing order being FRS<FS<SD<MDS. The phosphorus content of sun dried fig was found to be 106.16 mg /100gm. Phosphorus content increased by 501.13 % in sun dried fig as compared to fresh ones. Phosphorus content of microwave dried fig was found

to be 123.13 mg /100gm. Phosphorus content increased by 597.22 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Ozcan and Arslan, (2011) in tomato where they found 250% increase in phosphorus content during heat treatment . Phosphorus content of frozen fig was found to be 17.41 mg /100gm. Phosphorus content decreased by 1.42 % in frozen storage fig as compared to fresh ones. Similar decrease in phosphorus content 14.53 % has been reported by Zolfaghari *et al*.(2010) in frozen kiwi fruit and Ogbadoyi and Musa (2013), wherein they reported reduction in mineral content in frozen storage "*Amaranthus cruentus".* This may be attributed to the fact that frozen storage leads to decrease in iron content of fruits as high moisture content that leads to form ice crystals and causes leakage from the cell membranes (Baker and Gawish, 1997) that leads to reduction in mineral elements (Hui *et al*., 2004; McDonald *et al.,* 2006).

5.2 Analysis of *Carissa spinarum* (Karonda)

5.2 (a) Physical properties of karonda

The length of fresh karonda was found to be 7.46 mm. Similar results, i.e. 6 mm length was reported by Amreen *et al.* (2013) in fresh *Carissa spinarum* fruit. A statistically significant increase ($p<0.05$) in length was observed in fresh karonda sample, the increasing order being MDS<SD <FRS<FS.

Table 5.6 Effect of processing methods on physical properties of karonda

Drying methods	FS	SD	FRS	MDS
Length(mm)	7.46 ± 0.05^{a}	6.06 ± 0.05^{b}	6.36 ± 0.05^{c}	5.96 ± 0.05^{db}
Width(mm)	4.54±0.00a	3.76 ± 0.05^{b}	3.86 ± 0.05^{c}	3.26 ± 0.05^{cd}
Density(gm/cc)	0.64 ± 0.01^{a}	0.61 ± 0.00^{a}	0.62 ± 0.00^{ab}	0.60 ± 0.00^{a}

Where, Fresh- FS, Sun drying-SD, Freezed -FRS, Microwave drying-MDS

Length of sun dried karonda was found to be 6.06 mm. Length was decreased by 20.10 %, in sun dried karonda as compared to fresh ones. Length of microwave dried karonda was found to be 5.96 mm. Length decreased by 20.10 %, in microwave dried karonda as compared to fresh ones. Similar results have been reported by Oztekin *et al.* (2011), wherein they reported 0.70 % decrease in length in berry fruit by thermal processing. Similar decrease in length has been reported by Zivcovic *et al*. (2011) in thermal dried plum.

This may be attributed to the fact that thermal process leads to decrease in length due to the shrinkage of fruits (Hazbavi *etal*. 2014). Length of frozen karonda was found to be 6.36 mm. Length decreased by 14.74 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 4.80 % decrease in length in frozen dates. This decrease in length by frozen storage might be due to the period of cold

storage (Al- Yahayai and Al- Kharusi,2012). The width of fresh karonda was found to be 4.54 mm. Similar results, i.e. 6 mm width was reported by Amreen *et al.(*2013) in fresh *Carissa spinarum* fruit. A statistically significant increase ($p<0.05$) in width was observed in fresh karonda sample, the increasing order being MDS<SD <FRS<FS.

Width of sun dried karonda was found to be 3.76 mm. Width decreased by 17.18 % in sun dried karonda as compared to fresh ones. Width of microwave dried karonda was found to be 3.26 mm. Width decreased by 28.19 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Oztekin *et al.* (2011), wherein they reported 6.79 % decrease in width in berry fruit by thermal processing. Similar decrease in width has been reported by Zivcovic *et al*. (2011) in heat treated plum. This decrease in width by thermal process might be due to the reduction of moisture content (Kashaninejad *et al.*2006) and also due to the shrinkage of fruits (Jha *et al.*2006; Hazbavi *et al*, 2014). Width of frozen karonda was found to be 3.86 mm. Width decreased by 14.97 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), wherein they reported 7.69 % decrease in width in frozen dates. This decrease in width by frozen storage might be due to the period of cold storage (Al- Yahayai and Al- Kharusi, 2012).

The density of fresh karonda was found to be 0.64 gm/cc. Similar results, i.e. 0.82 gm/cc was reported by Din (2008) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically significant increase ($p<0.05$) in density was observed in all dried karonda samples, the increasing order being MDS<SD<FRS<FS. Density increased in fresh fruits due to higher moisture content that leads to increase volume (Garmakhany *et al.* 2013). Density of sun dried karonda was found to be 0.61 gm/cc. Density decreased by 4.68 % in sun dried karonda as compared to fresh ones. Density of microwave dried karonda was found to be 0.60 gm/cc. Density decreased by 6.25 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Pacco and Menegalli (2004), where they reported decreased density in thermal dried fruit. This may be attributed to the fact that fruit becomes more porous due to heating process.

Density of frozen karonda was found to be 0.62 gm/cc. Density decreased by 3.12 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Ramaswamy

and Tung (1981), wherein they reported decrease in density by 6.74 % in frozen storage "Golden" apple.

5.2 (b) Nutritional composition of karonda

The moisture content of karonda fruit is depicted in Table 5.7. Moisture content of fresh karonda was found to be 81.05 per cent. Similar results, i.e. 83.17 per cent was reported by (Morton, 1987) in "*Carissa carandas"* a variety of karonda. The moisture content increased significantly ($p<0.05$) in frozen karonda sample, the increasing order being MDS<SD<FS<FRS.

Table 5.7 Effect of processing methods on nutritional composition of karonda

Drying methods	FS	SD	FRS	MDS
Moisture(%)	81.05 ± 1.97^{a}	16.86 ± 0.75^{b}	82.06 ± 2.19^{ac}	16.83 ± 0.40^{bc}
Ash (%)	2.46 ± 0.06^{a}	2.51 ± 0.05^{a}	2.48 ± 0.07^{a}	2.50 ± 0.06^{a}
Carbohydrate (%)	18.66 ± 0.25^{a}	60.51 ± 0.00^{b}	18.16 ± 0.59^{ac}	61.81 ± 0.01^{cd}
Fat (%)	1.30 ± 0.01^{a}	1.50 ± 0.03^{b}	1.29 ± 0.02^{ac}	1.51 ± 0.01^{bc}
Protein (%)	2.07 ± 0.04^{a}	2.41 ± 0.33^{a}	2.04 ± 0.04^{a}	2.51 ± 0.33^{a}

The moisture content of sun dried karonda was found to be 16.86 per cent. Moisture content decreased by 79.19 % in sun dried karonda as compared to fresh ones. Similar results have been reported by Kamiloglu and Capanoglu (2015), in fig where they found 76% decrease in moisture content in sun dried fruit. Moisture content of microwave dried karonda was found to be 16.83 per cent. Moisture content decreased by 79.23 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015), wherein they reported 88.88% decrease in moisture content in okra after thermal process.

Similar decrease in moisture content (70.32 %) has been reported by Guvenc *et al.* (2009) in heat treated fig. Udomkun *et al*.(2015), also reported 98.06 % reduction in moisture content in thermal dried papaya. This reduction in moisture content by thermal process might be due to the rapid water loss (Mechlouch *et al.* 2015), heating temperature (Brooker, 1974) and higher absorption power (Meda *et al.* 2008).

Moisture content of frozen karonda was found to be 82.06 per cent. Moisture content increased by 1.24 % in frozen karonda as compared to fresh ones. Similar results have been reported by Aleid *et al*. (2014), where they reported 10.51% increase in moisture content in date during frozen storage and Damini *et al*.(2013), wherein they reported 2.45 % increase in the moisture content in frozen marolo pulp. Similar increase in moisture content (1.0 %) has been reported by Boca *et al.* (2014) in frozen strawberry puree. This may be attributed to the fact that frozen storage leads to increase in moisture content of fruits as destruction of cellular structure by syneresis (Sae-Kang and Suphantharika, 2006) that leads to release of intracellular water (Chefteh and Besancon, 1989) which is migrated out of the cell (Damiani *et al*.2013).

The ash content of karonda fruit is depicted in Table 5.7. Ash content of fresh karonda was found to be 2.46 per cent. Similar results, i.e. 2.53 per cent was reported by Mishra and Gupta (2005), in fresh *Carissa spinarum*. The result of ash content non significantly ($p>0.05$) increased in all karonda dried samples and the increasing order being FS<FRS<MDS<SD. The ash content of sun dried karonda was found to be 2.51 per cent. Ash content increased by 2.03 % in sun dried karonda as compared to fresh ones. Ash content of microwave dried karonda was found to be 2.50 per cent. Ash content increased by 1.62 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Guvenc *et al*. (2009), wherein they reported 379.16 % increase in ash content in fig during thermal process. Similar increase 1.48 % ash content in fig fruit during heat treatment has been reported by Mahmoud *et al.* (2013). This increase in ash content by thermal process might be due to the removal of moisture content (Morris *et al.* 2004).

Ash content of frozen karonda was found to be 2.48 per cent. Ash content increased by 0.81 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Zolfaghari *et al*. (2010), where they reported 8.3 % increase in ash content in kiwi fruit during

frozen storage. Similar increase in ash content (20 %) has been reported by Ogunobanwo *et al*.(2013) in frozen water melon juice. This increase in ash content by frozen storage might be due to the presence of products which has chemical stability (Raji *et al.* 2016).

Fat content of karonda fruit is depicted in Table 5.7. Fat content of fresh karonda was found to be 1.30 per cent. Similar results, i.e. 2.57 per cent was reported by Morton (1987) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically significant increase ($p<0.05$) in fat content in all dried karonda samples and the increasing order being FRS<FS<SD<MDS.

The fat content of sun dried karonda was found to be 1.50 per cent. Fat content increased by 15.38 % in sun dried karonda as compared to fresh ones. Fat content of microwave dried karonda was found to be 1.51 per cent. Fat content increased by 16.15% in microwave dried karonda as compared to fresh ones. Similar results have been reported by Mrabet *et al.* (2015), in date where they found 7.64 % increase in fat content during thermal process. This may be attributed to the fact that thermal process leads to increase in fat content of fruits along with removal of moisture content (Morris *et al.* 2004). Fat content of frozen karonda was found to be 1.29 per cent. Fat content decreased by 0.76 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Ogunbanwo *et al.* (2013), where they reported 50 % decrease in fat content in water melon juice and Raji *et al*. (2016) reported decrease 0.95% fat content in *Ewedu* soups during frozen storage. This decrease in fat content by frozen storage might be due to oxidation (Ryder *et al*.1993) that leads to release oxidative enzymes from various rupture cellular organelles (Boonsumrej *et al.* 2007).

Carbohydrate content of fresh karonda was found to be 18.66 per cent. Similar results, i.e. 15.16 per cent was reported by Ara *et al*. (2014) in fresh "*Carissa carandas"* a variety of karonda fruit. The carbohydrate content was significantly ($p<0.05$) increased in all karonda dried samples and the increasing order being FRS<FS<SD<MDS. The carbohydrate content of sun dried karonda was found to be 60.51 per cent. Carbohydrate content increased by 224.27% in sun dried karonda as compared to fresh ones.

Carbohydrate content of microwave dried karonda was found to be 61.81 per cent. Carbohydrate content increased by 231.24 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Guvenc *et al*. (2009) in fig fruit where they

found 240.39 % increase in carbohydrate content during heat treatment and Famurewa and Olumofin,(2015),wherein they reported 141.30 % increase in carbohydrate content in microwave dried okra. Similar increase in carbohydrate content (325.47 %) has been reported by Mahmoud *et al.* (2013) in thermal treated sycamore fruit. This increase in carbohydrate content by thermal process might be due to hydrolytic effect of carbohydrate stored in fruits (Akinhanmi *et al.* 2008).

Carbohydrate content of frozen karonda was found to be 18.16 per cent. Carbohydrate content decreased by 2.67 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Galoburda *et al.* (2014), where they reported 55.2% decrease in the carbohydrate content in strawberry puree during frozen storage. Damiani *et al*. (2013) also reported 16.11 % decrease in carbohydrate content in frozen marolo pulp. Similar decrease in carbohydrate content (25.78%) has been reported by Zolfaghari *et al*.(2010), in frozen kiwi fruit. This may be attributed to the fact that frozen storage leads to decrease in carbohydrate content of fruits due to the breakdown of cell structure during frozen storage (Cheftel and Besancon, 1989).

The protein content of karonda fruit is depicted in Table 5.7. Protein content of fresh karonda was found to be 2.07 per cent. Similar results, i.e. 3.64 per cent was reported by Mahapatra *et al*. (2012) in fresh " *Carissa spinarum"* fruit. The protein content increased non significantly ($p>0.05$) in all karonda dried samples and the increasing order being FRS<FS<SD<MDS. The protein content of sun dried karonda was found to be 2.41 per cent. Protein content increased by 16.42 % in sun dried karonda as compared to fresh ones. Protein content of microwave dried karonda was found to be 2.51 per cent. Protein content increased by 21.25 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Fedha *et al*.(2010) in pumpkin where they found 2.5 % increase in protein content during thermal process and Clary *et al*. (2007), wherein they reported 236.11 % increase in protein content in grapes during heat treatment.

Similar increase in protein content (258.55%) has been reported by Guvenc *et al*. (2009) in fig fruit during thermal process. This increase in protein content by thermal process might be due to

the enhancement in dry matter contents by the concentration of soluble solids (Eze and Akubor, 2012).

Protein content of frozen karonda was found to be 2.04 per cent. Protein content decreased by 1.44% in frozen storage karonda as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 57.51% decrease in protein content in blackthorn fruit during frozen storage. Similar decrease in protein content (4.22 %) has been reported by Ogunbanwo *et al*. (2013) in frozen water melon juice and Raji *et al*. (2016) reported decrease 3.83% protein content in *Ewedu* soups during frozen storage. This may be attributed to the fact that frozen storage decrease in protein content of fruits as reduction in proteins which are water and salt soluble (Chomnawang *et al.*2007), denaturation of proteins (Ryder *et al.* 1993) and destruction caused by enzymatic activity (Hultman and Rustard, 2004).

5.2 (c) Dietary composition of karonda

The neutral detergent fiber (NDF) of karonda fruit is depicted in Table 5.8. Neutral detergent fiber of fresh karonda was found to be 25.43 per cent. Similar results, i.e. 27.27 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit.

NDF was significantly ($p<0.05$) higher in all karonda dried samples, the increasing order being FRS<FS<SD<MDS. The neutral detergent fiber of sun dried karonda was found to be 25.56 per cent. NDF increased by 0.51 % in sun dried karonda as compared to fresh ones. NDF in microwave dried karonda was found to be 26.23 per cent. NDF increased by 3.14 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015), where they reported 6.54 % increase in dietary fiber content in microwave dried okra. Similar increase 102.2 % dietary fiber in *Musa paradisaca* during oven drying has been mentioned by Agoreyo *et al.* (2011) and Mahmoud *et al.* (2013) reported increase 1.48 % ash content in fig fruit during heat treatment. This increase in dietary fiber by thermal process might be due to the formation of Maillard reaction product (Chang and Morris, 1990; Vidal and Frias, 1991) and also due to the reduction in moisture content (Fennema, 1976), by leaching of soluble components to the solution that leads to form the heat resistant complexes between polysaccharides and other mechanism i.e. protein and phenolic content components (Caprez *et al.* 1986; Rodriguez *et al.* 2006). Dietary fiber (hemicellulose,

cellulose and lignin) also increased (Vasishtha *et al.* 2013) due to releasing of enzymatic fiber components from insoluble cell wall matrix (Hakkinen *et al.*2003).

Table 5.8 Effect of processing methods on dietary composition of karonda

Drying methods	FS	SD	FRS	MDS
NDF(%)	25.43± 0.05^{a}	25.56± 0.66^{a}	25.26±0.05^{b}	26.23± 0.05^{ac}
ADF(%)	16.03± 0.11^{a}	16.13± 0.66^{a}	15.96±0.49^{a}	16.50± 0.00^{a}
Hemicellulose (%)	9.40± 0.51^{a}	9.43±0.98^{a}	9.20±0.10^{a}	9.66±0.15^{a}
Cellulose(%)	14.05±0.13^{a}	14.67±0.54^{a}	12.97±0.00^{a}	14.89 ± 0.09^{b}
Lignin (%)	3.10± 0.05^{a}	3.20± 0.05^{a}	3.00± 0.10^{a}	3.33±0.05^{ab}

Neutral detergent fiber of frozen karonda was found to be 25.26 per cent. The NDF decreased by 0.66 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 18.13 % decrease in dietary fiber in frozen blackthorn fruit and Salgado *et al.* (1999), wherein they reported reduction in dietary fiber in frozen tropical fruits and Raji *et al*. (2016) reported decrease 0.92% dietary fiber in *Ewedu* soups during frozen storage. This decrease in NDF by frozen storage might be due to the reduction in of cell wall polysaccharides tissues that leads declined dietary fiber (Khan and Vincent, 1996).

The acid detergent fiber (ADF) of karonda fruit is depicted in Table 5.8. Acid detergent fiber of fresh karonda was found to be 16.03 per cent. Similar results, i.e. 18.03 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. The ADF was non significantly ($p>0.05$) increased in dried karonda samples, the increasing order being

FRS<FS<SD<MDS. The acid detergent fiber of sun dried karonda was found to be 16.13 per cent. ADF increased by 0.62 % in sun dried karonda as compared to fresh ones. ADF in microwave dried karonda was found to be 16.50 per cent. ADF increased by 1.24% in microwave dried karonda as compared to fresh ones. Acid detergent fiber in frozen karonda was found to be 15.96 per cent. The ADF decreased by 4.80 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Mohajer *et al.* (2016), where they reported 32.66 % decrease in ADF in frozen sainfoin seed.

Hemicellulose content of fresh karonda was found to be 9.40 per cent. Similar results, i.e. 9.24 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically non significant increase ($p>0.05$) in hemicellulose content in fresh karonda samples, the increasing order being FRS<FS<SD<MDS. The hemicellulose content of sun dried karonda was found to be 9.43 per cent. Hemicellulose content increased by 0.31 % in sun dried karonda as compared to fresh ones. Hemicellulose content in microwave dried karonda was found to be 9.66 per cent. Hemicellulose content increased by 2.76 % in microwave dried karonda as compared to fresh ones. This increase in hemicellulose content by thermal process. Similar results have been reported by Komolka *et al*. (2012), where they reported 5 % increase in hemicellulose content in common cabbage by thermal processing. Hemicellulose content in frozen karonda was found to be 9.20 per cent. The hemicellulose content decreased by 2.12 % in frozen storage karonda.

Cellulose content of karonda fruit is depicted in Table 5.8. Cellulose content of fresh karonda was found to be 14.05 per cent. Similar results, i.e. 11.64 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. The cellulose content increased significantly ($p<0.05$) in dried karonda samples, the increasing order being FRS<FS<SD<MDS. The cellulose content of sun dried karonda was found to be 14.67 per cent. Cellulose content increased by 4.41% in sun dried karonda as compared to fresh ones. Cellulose content in microwave dried karonda was found to be 14.89 per cent . Cellulose content increased by 5.97 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015), where they reported 13.7% increase in cellulose content in date fruit during thermal process and Nordin *et al*. (2013), wherein they

reported 3.31% increase in oil palm fruit during heat treatment. Cellulose content in frozen karonda was found to be 7.68 per cent. The cellulose content decreased by 7.68 % in frozen storage karonda as compared to fresh ones.

Lignin content of fresh karonda was found to be 3.10 per cent. Similar results i.e. 6.39 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. The lignin content increased significantly($p<0.05$) in dried karonda samples, the increasing order being FRS<FS<SD<MDS. The lignin content of sun dried karonda was found to be 3.20 per cent. Lignin content increased by 3.22 % in sun dried karonda as compared to fresh ones. Lignin content in microwave dried karonda was found to be 3.33 per cent. Lignin content increased by 7.41 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015) in date fruit where they found 20.68 % increase in lignin content during thermal process. Similar increase in lignin content (38.79 %) has been reported by Nordin *et al*. (2013) in thermal processed oil palm fruit. This increase in lignin content by thermal process might be due to increase the activity of lignin synthesis enzymes i.e. phenylalanine ammonia lyase (Yun *et al*. 2013). Hosseinaei *et al.* (2012) also reported that due to heat, complex structure of lignin is formed which makes it difficult for degradation. Lignin content in frozen karonda was found to be 3.00 per cent. The lignin content decreased by 3.23 % in frozen karonda as compared to fresh ones. Similar results have been reported by Dangcham *et al*. (2008), where they reported 65.07 % decrease in lignin content in mangosteen fruit at low temperature storage.

5.2 (d) Phytochemical composition of *Carissa spinarum* (Total phenolic content)

Processing methods caused remarkable changes in the total phenolic content of karonda fruit is depicted in Figure 5.5. Total phenolic content (TPC) of fresh karonda was found to be 5.31 mg TAE/100gm. Similar results i.e. 4.67 mg GAE/100gm was reported by Pewlong *et al.* (2014) in "*Carissa carandas"* a variety of karonda fruit .

A statistically significant increase ($p<0.05$) in TPC was observed in all dried karonda samples, the increasing order being FRS<FS <SD<MDS. Total phenolic content of sun dried karonda was found to be 5.50 mg TAE/100gm. TPC increased by 3.57 %, in sun dried karonda as compared to fresh ones. Sangeeta and Mahanta (2013), reported 30.18 % increase in TPC in tomato after

microwave drying. Total phenolic content of microwave dried karonda was found to be 5.74 mg TAE/100gm. TPC increased by 8.09 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Chumyam *et al.* (2013) in purple skin eggplants where they found 155.42 % increase in TPC in microwave dried fruit as compared to fresh ones and Turkmen *et al.*(2005), wherein they reported 126 % increase TPC in microwave dried pepper. Similar increase 85.12% TPC in pear by thermal treatment has been reported by Oboh *et al.*(2015). This increase in TPC by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (HMP) by Maillard reaction (Donovan *et al.* 1998) and also due to the breakdown of cellular structure of cells, which makes the phenolic content more extractable (Van *et al.* 2000). Singleton *et al.* (1999) mentioned enhancement in phenolic content may be due to the formation of aglycons by reacting with Folin-Ciocalteau reagent.

Phenolic content of frozen karonda was found to be 5.11 mg TAE/100gm. Frozen stored karonda fruits exhibited 3.76 % decrease in total phenolic content as compared to fresh ones. Similar results have been reported by Mullen *et al.* (2002), where they reported 21 to 28 % decrease in the TPC in raspberries during frozen storage as compared to fresh ones. Similar decrease in TPC (0.81%) has been reported by Scibisz and Mitek (2007) in frozen blueberries. This may be attributed to the fact that frozen storage leads to decrease in total phenolic content of fruits as polyphenol oxidase enzymes (PPO) are released by breaking cells and that leads to oxidation of polyphenolics to quinines (De Ancos *et al*. 2000a).

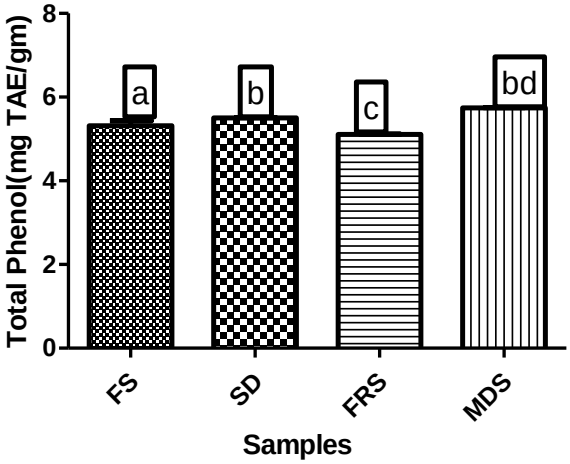

Fig. 5.5 Total Phenolic content of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS= Freezed sample, MDS=Microwave dried sample.

5.2 (e) Total flavonoid content of karonda

Flavonoid content of karonda fruit is depicted in Figure 5.6. Total flavonoid content of fresh karonda was found to be 0.44 mg QE/100gm. Similar results, i.e. 1.53 mg (rutin equivalent /100gm) was reported by Itankar *et al*.(2011) in "*Carissa carandas"* a variety of karonda. The total flavonoid content increased significantly ($p<0.05$) in fresh karonda sample, the increasing order being SD<MDS<FS<FRS. The flavonoid content of sun dried karonda was found to be 0.31 mg QE/100gm. Flavonoid content decreased by 29.54 % in sun dried karonda as compared to fresh ones. Similar results have been reported by Wang *et al.* (2016) in jujube fruit where they found 26.75% decrease in flavonoid content in sun dried fruit. Flavonoid content of microwave dried karonda was found to be 0.32 mg QE/100gm. Flavonoid content decreased by 27.27 % in microwave dried karonda as compared to fresh ones. Similar reduction in total flavonoid content (23.74%) has been reported by Sangeeta and Mahanta (2013) in microwave banana blossom and Planinic *et al.* (2015), wherein they reported 15.3% reduction in flavonoid content in microwave dried grape fruit. Similar results have been reported by Macias *et al* .(2013), where they reported 23.13 % decrease in flavonoid content in strawberry fruit during thermal process. This decrease in flavonoid content by thermal process (Crozier *et al.* 1995;

Price and Rhodes, 1997) might be due to the breakdown of some phytochemicals, which affects cell wall integrity and that leads to migration of some flavonoid components (Davey *et al.* 2000). Ioannou *et al.* (2012) also mentioned that heating process caused degradation might be due to parameters such as pH, oxygen, light, activity of polyphenoleoxidase enzymes and by hydrolysis of C- glycosides bonds, which are presented in flavonoids (Manach *et al.*2004).

Flavonoid content of frozen karonda was found to be 0.52 mg QE/100gm. Flavonoid content increased by 18.18 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Mullen *et al*. (2002), where they reported 21.07 % increase in flavonoid content in red raspberries during frozen storage. This may be attributed to the fact that frozen storage leads to increase in flavonoid content of fruits as increase in quercetin derivatives during cold storage (Omer and Canan, 2014) that increases quercetin hydrolysis (Hakkinen *et al*.2000).

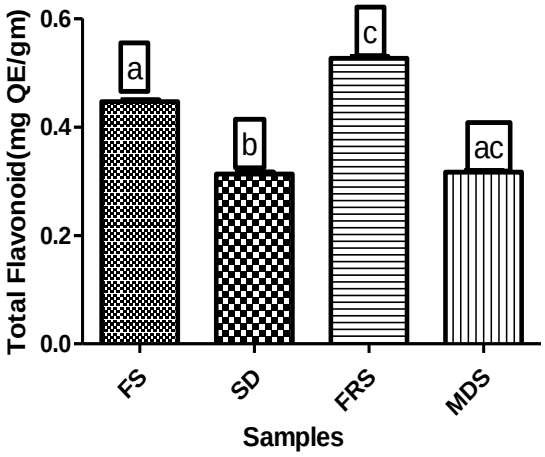

Fig. 5.6 Total Flavonoid content of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.2 (f) Antioxidant activity of karonda

Processing methods caused remarkable changes in antioxidant activity of karonda fruit is depicted in **Figure 5.7.** Antioxidant activity of fresh karonda was found to be 34.45 per cent. Similar results, i.e. 39.1 per cent was reported by Prakash *et al*. (2011) in "*Carissa carandas"* a variety of karonda fruit.

Antioxidant activity significantly ($p<0.05$) increased in all dried karonda sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity of sun dried karonda was found to be 34.47 per cent. Antioxidant activity increased by 0.05 % in sun dried karonda as compared to fresh ones. Antioxidant activity of microwave dried karonda was found to be 34.48 per cent. Antioxidant activity increased by 0.08 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Wojdylo *et al.* (2007), where they found 4.68 % increase in antioxidant activity (DPPH) in thermal dried apple and Chumyan *et al*. (2013), wherein they reported 266.12 % increase in DPPH antioxidant activity in microwave dried eggplants. Similar increase in antioxidant activity 138 % has been reported by Turkmen *et al*. (2005) in microwave heat treated pepper. Similar increase antioxidant activity 112.31% in berries has been reported by Rabeta and Lin (2015) and Sultana *et al.* (2012) also reported increase 3.57 % DPPH antioxidant activity in oven dried apricot. This increase in antioxidant activity (DPPH) by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (Raupp *et al*.2011), presence of naturally occurring compounds such as Maillard reaction products (Yin and Chang,1998; Piga *et al*. 2003; Lee *et al*.2003), released of a free phenolic fraction (Yamaguchi *et al*. 2001), due to oxidative and hydrolytic enzyme (Farsi *et al*.2005), disruption of cell wall that leads to release and enhances antioxidant activity (Chumyan *et al*.2013).

Antioxidant activity of frozen karonda was found to be 30.83 per cent. Antioxidant activity (DPPH) decreased by 10.50 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by De Ancos *et al.* (2000), where they reported 12 % decrease in antioxidant activity (DPPH) in frozen raspberry fruit and Pimia *et al*. (2003), wherein they reported 20 % decrease in antioxidant activity in frozen peas. Similar decrease in antioxidant activity (1.64 %) has been reported by Mohammadian *et al.* (2011) in frozen "*Citrus limon*" .

This may be attributed to the fact that frozen storage leads to decrease in antioxidant activity of fruits as disruption of cell structure (Sikora *etal*.2013).

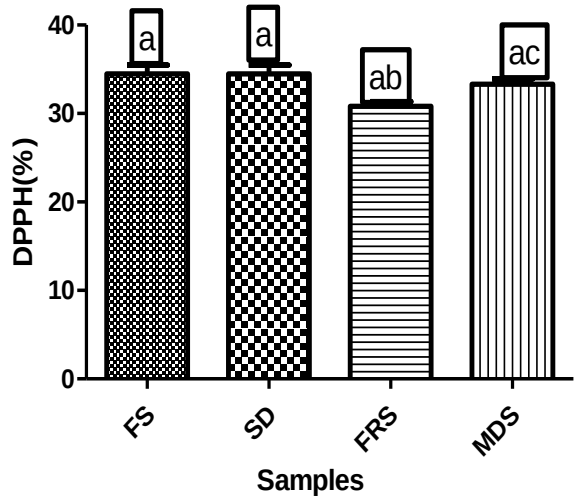

Fig. 5.7 Antioxidant activity (DPPH) of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.2 (g) Antioxidant activity of karonda

Antioxidant activity of karonda fruit is depicted in **Figure 5.8.** Antioxidant activity of fresh karonda was found to be 58.63 per cent. Prakash *et al.* (2011) reported lower antioxidant activity (48.2 %) in "*Carissa carandas*" a variety of karonda fruit as compared to our results. This difference might be due to many parameters such as fruit colour (Bey and Louaileche, 2015), extraction methods, solvent (Musa *et al.* 2011), cultivation location (Wand *et al.* 2002; Hakkinen and Torronen, 2000), ripening stage (Raffo *et al.* 2012), harvested condition and season (Wu *et al* .2014). Antioxidant activity increased non significantly ($p > 0.05$) in all dried karonda sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity (FRAP) of sun dried karonda was found to be 58.68 per cent. Antioxidant activity (FRAP) increased by 0.08 % in sun dried karonda as compared to fresh ones. Antioxidant activity of microwave dried karonda was found to be 58.79 per cent. Antioxidant activity increased by 0.27 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by

Rabeta and Lin (2015), where they reported increase 1040.12% antioxidant activity (FRAP) in berries during thermal process. Higher antioxidant activity might be due to relative increase of FRAP value which determined the capacity of plant extract for the donation and acceptance of electrons (Yan *et al.* 2006). This increase in antioxidant activity by thermal process may be due to reduction in moisture content(Abou El-Hana, 2008), inhibition of oxidative enzymes and cell wall destruction which releases antioxidant compounds (Yamaguchi *et al.* 2001).

Antioxidant activity of frozen karonda was found to be 55.36 per cent. Antioxidant activity (FRAP) decreased by 5.57 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Poiana *et al.*(2010), where they reported decrease from 6.5% to 12% in frozen strawberry fruit and Nilsson *et al.* (2004), wherein they reported decrease in antioxidant activity (FRAP) in frozen peas.

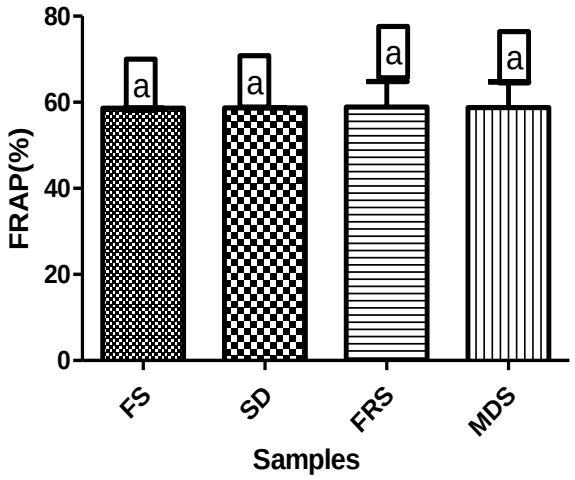

Fig. 5.8 Antioxidant activity (FRAP) of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.2 (h) Anti-nutritional content and anthocyanin content of karonda

Tannin content of fresh karonda was found to be 0.98 gm/100gm. Similar results, i.e. 1.02 gm/100gm was reported by Gupta *et al*. (2014) in "*Carissa carandas"* a variety of karonda fruit. Tannin content increased non significantly ($p>0.05$) increased in fresh karonda samples, the increasing order being FRS<SD<MDS<FS.

Table 5.9 Effect of processing methods on anti-nutritional and anthocyanin content of karonda

Drying methods	FS	SD	FRS	MDS
Tannin- (g/100g)	0.98± 0.01[a]	0.96± 0.01[a]	0.95±0.02 [a]	0.97± 0.00 [a]
Alkaloid- (g/100g)	1.94± 0.00 [a]	1.92±0 .01[a]	1.90±0.00[b]	1.92 ±0 .00[ac]
Anthocyanin- (mg/100g)	54.03± 0.00 [a]	53.43± 0.00[a]	55.20± 2.48 [a]	53.39± 5.02[a]

The tannin content of sun dried karonda was found to be 0.96 gm /100gm. Tannin content decreased by 2.04% in sun dried karonda as compared to fresh ones. Tannin content of microwave dried karonda was found to be 0.97 gm /100gm. Tannin content decreased by 1.02 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Chinyere and Obasi (2013) in leafy vegetable where they found 8.82 % decrease in tannin content during thermal process and Embaby (2011), wherein they reported 15.7 % decrease in tannin content in peanut seed during heat treatment. Similar decrease in tannin content (5.88 %) has been reported by Yusuf and Obiegbuna (2011) in *Vernonia amygdalina* leaf during thermal process. This decrease in tannin content by thermal process might be due to the oxidation of bioactive compounds (Yoshioka *et al.* 1990) and also due to the breakdown of cell structure which migrates the components that are creating loss by leakage in the presence of oxygen and light (Scheieber *et al*. 2001) and also due to various chemical reaction involving

enzymes (polyphenoleoxidase) which are responsible to convert tannins into other products (Pragati *et al.* 2003; Mehta,1995).

Tannin content of frozen karonda was found to be 0.95 gm /100gm. Tannin content decreased by 3.06 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 33.33 % reduction in tannin content in frozen dates. Similar decrease in tannin content in persimmons fruit has been reported by Nakamura (1961) during frozen storage. This decrease in tannin content by frozen storage might be due to the non-enzymatic activity in fruits (Al-Ogadi and Mutlak, 1986; Abu-Goukh *et al*. 2003), change occurs in chemical properties of tannin (Nakamura ,1961) that leads to coagulate soluble tannin into insoluble (Brackmann *et al.*1997; Matsu and Itoo,1978).

Alkaloid content of karonda fruit is depicted in Table 5.9. Total alkaloid content of fresh karonda was found to be 1.94 gm /100gm. Similar results, i.e. 1.96 gm/100gm was reported by Gupta *et al*. (2014) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically significant increase ($p<0.05$) in alkaloid content was observed in fresh karonda samples, the increasing order being FRS<SD<MDS<FS. The alkaloid content of sun dried karonda was found to be 1.92 gm /100gm. Alkaloid content decreased by 1.03 % in sun dried karonda as compared to fresh ones. Alkaloid content of microwave dried karonda was found to be 1.92 gm /100gm. Alkaloid content decreased by 1.03 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Chinyere and Obasi (2013) in leafy vegetable they found 22.83 % decrease in alkaloid content during heat treatment and Yusuf and Obiegbuna (2011), wherein they reported decrease 68.12% alkaloid content in *Vernonia amygdalina* by thermal process. This decrease in alkaloid content by thermal process might be due to the breakdown of cell structure which results migration of components that leads to loss by various chemical reactions i.e. involving enzymes, light and heat (Atlabachew *et al*. 2013). Alkaloid content of frozen karonda was found to be 1.90 gm /100gm. Alkaloid content decreased by 2.06 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Atlabachew *et al*. (2007), where they reported 56 % decrease in alkaloid content (cathinone) in frozen (*Catha Edulis* Forsk) leaves.

The anthocyanin content of karonda fruit is depicted in Table 5.9. Total anthocyanin content of fresh karonda was found to be 54.03 mg cyanidin-3-glucoside equivalents/100gm. Similar results, i.e. 54 mg/100gm was reported by Pewlong *et al*. (2014) in "*Carissa carandas"* a variety of karonda fruit.

Anthocyanin content increased non significantly ($p>0.05$) in frozen karonda samples, the increasing order being MDS<SD<FS<FRS. The anthocyanin content of sun dried karonda was found to be 53.43 mg /100gm. Anthocyanin content decreased by 1.11 % in sun dried karonda as compared to fresh ones. Anthocyanin content of microwave dried karonda was found to be 53.39 mg /100gm. Anthocyanin content decreased by 1.18 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Wojdylo *et al.* (2009) in strawberry where they found 12.9 % decrease in anthocyanin content in microwave dried fruit. Similar decrease in anthocyanin content (35.69 %) has been reported by Wojdylo *et al*. (2014) in microwave dried sour cherries. This decrease in anthocyanin content by thermal process (Juan *et al*.2013) might be due to different factors i.e. heat, oxygen, metal ion, co-pigmentation and pH (Mishra and Yang, 2008), polyphenol oxidase enzymes activity (Kwok *et al*.2004) and browning reaction (Wrolstad *et al.* 2004).

Anthocyanin content of frozen karonda was found to be 55.20 mg /100gm. Anthocyanin content increased by 2.16 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Scibisz and Mitek (2007), where they reported 1.30 % increase in anthocyanin content in frozen blueberries. Similar increase in anthocyanin content (2.16%) has been reported by Mullen *et al.* (2002) in frozen red raspberries. This increase in anthocyanin content might be due to ice crystal formation that favours to reallocation of water molecules in cell structure, that leads to enhance the release of membrane bound anthocyanin (Szczesniak, 1998; Leong and Oey, 2012) and also due to the cellular disruption in fruits (Skrede, 1996) which contributes to increase the cyanidin -3-galactoside content in fruits (Scibisz and Mitek, 2007).

5.2 (i) Mineral composition of karonda

The mineral composition of karonda fruit is depicted in Table 5.10. Calcium content of fresh karonda was found to be 29.00 mg /100gm. Similar results, i.e. 28.89 mg/100gm was reported

by Ara *et al*. (2014) in "*Carissa carandas"* a variety of karonda fruit. Calcium content increased significantly ($p<0.05$) in microwave dried karonda sample, the increasing order being FRS<FS<SD<MDS.

Table 5.10 Effect of processing methods on mineral composition of karonda

Drying methods	FS	SD	FRS	MDS
Calcium- (mg/100g)	29.00 ± 0.57^{a}	275.67 ± 0.00^{b}	28.9 ± 0.05^{c}	286.35 ± 0.00^{cd}
Iron- (mg/100g)	3.45 ± 0.00^{a}	12.43 ± 0.00^{b}	3.40 ± 0.05^{c}	12.82 ± 0.00^{cd}
Phosphorus- (mg/100g)	32.10 ± 0.05^{a}	106.20 ± 0.00^{b}	31.90 ± 0.05^{c}	$108.50\pm .00^{cd}$

Mineral composition might be increased or decreased by different processing methods (Rickman *et al.* 2007). The calcium content of sun dried karonda was found to be 275.67 mg /100gm. Calcium content increased by 850.6 % in sun dried karonda as compared to fresh ones. Calcium content of microwave dried karonda was found to be 286.35 mg /100gm. Calcium content increased by 887.44 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015), where they found 1028.09 % increase calcium content in microwave dried okra and Incedayi *et al.* (2016), wherein they reported 70.93 % increase in calcium content in microwave dried apricot fruit. This increase in calcium content by thermal process might be due to increasing of dry matter content. Ozcan *et al.* (2004) also reported that changes in the concentration of minerals are also depending on the method and the drying temperature used (Ozcan *et al.* 2004).

Calcium content of frozen karonda was found to be 28.9 mg /100gm. Calcium content decreased by 0.34 % in frozen storage karonda as compared to fresh ones. Similar results were reported by Zolfaghari *et al*. (2010), where they reported 1.53 % decrease in calcium content

in frozen kiwi fruit of "Monty" cultivar. Similar decrease in calcium content (5.23%) has been reported by Bouzari *et al*.(2014) in frozen strawberries.

Iron content of fresh karonda was found to be 3.45 mg /100gm. Similar results, i.e. 6.24 mg/100gm was reported by Dalal *et al*. (2010) in fresh "*Carissa carandas"* a variety of karonda fruit. Iron content increased significantly ($p<0.05$) in microwave dried karonda sample, the increasing order being FRS<FS<SD<MDS. The iron content of sun dried karonda was found to be 12.43 mg /100gm. Iron content increased by 260.28 % in sun dried karonda as compared to fresh ones. Iron content of microwave dried karonda was found to be 12.82 mg /100gm. Iron content increased by 271.59 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015) in okra where they found 963.75 % increase in iron content during thermal process. Similar increase in iron content (395.06%) has been reported by Jung *et al*. (2005) in microwave dried persimmon fruit. Iron content of frozen karonda was found to be 3.40 mg /100gm. Iron content decreased by 1.44 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Musa (2013) in *Amaranthus cruentus* leaf where they found 33.19 % decrease in iron content in frozen storage.

Phosphorus content of fresh karonda was found to be 32.10 mg /100gm. Similar results, i.e. 38 mg/100gm was reported by "CSIR NEW DELHI" (1950) in "*Carissa carandas"* a variety of karonda fruit. Phosphorus content increased significantly ($p<0.05$) in microwave dried karonda sample, the increasing order being FRS<FS<MDS<SD. The phosphorus content of sun dried karonda was found to be 106.20 mg /100gm. Phosphorus content increased by 230.85 % in sun dried karonda as compared to fresh ones. Phosphorus content of microwave dried karonda was found to be 108.50 mg/100gm. Phosphorus content increased by 238.01 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015) in okra where they found 811.45 % increase in phosphorus content during microwave heat treatment. Phosphorus content of frozen karonda was found to be 31.90 mg /100gm. Phosphorus content decreased by 1.42 % in frozen storage karonda as compared to fresh ones. Similar decrease in phosphorus content (0.62 %) has been reported by Zolfaghari *et al*.(2010) in frozen kiwi fruit and Ogbadoyi and Musa (2013), wherein they reported reduction in mineral content in frozen storage "*Amaranthus cruentus".* This may be attributed to the fact

that frozen storage leads to decrease in iron content of fruits as high moisture content that leads to form ice crystals and causes leakage from the cell membranes (Baker and Gawish, 1997) that leads reduction in mineral elements (Hui *et al*. 2004; McDonald *et al.* 2006).

5.3 Experimental Design

5.3 (a) Effect of fig (*Ficus carica)* methanolic extract on fasting blood glucose (FBG) level on diabetic and normoglycemic rats

The aim of the present study is to explored the scientific basis of the utility of fig (*Ficus carica*) fruit methanolic extract to improve FBG level in selected group of rats. The calculated percentage yield of methanolic extract of fig fruit was 31.6 per cent. Acute toxicity test revealed non toxic nature of fig fruit methanolic extract on rats. There was no lethality and toxic reactions at any dose.

The effect of fig methanolic fruit extract on fasting blood glucose level in rats is depicted in **Table 5.11**. FBG level was found highest on 21th day (277.45 mg/dl) and lowest on 0 day (259.35 mg/dl). FBG level in normal control group ranged from 95.61 to 97.27 mg/dl. The FBG level were increased in diabetic rats whose having streptozotocin intraperitoneal injection, ranged from 259.35 to 277.45 mg/dl. FBG level significantly ($p<0.05$) increased (171.25%) on starting 0 day in diabetic control group as compared to normal group. And, on 7th day (1.98 %), 14th day (5.20 %) and 21th day (6.97%), FBG level increased after 3 days of streptozotocin intraperitoneal injection to rats as compared to 0 day. FBG level was highest on 21 th day (277.45 mg/dl) and lowest on 0 day before the start of treatment (259.35 mg/dl). The increase in fasting blood glucose level might be due to streptozotocin injection which causes death of β-cells that leads insufficient production of insulin and elevates blood glucose level (Shen *et al.* 2010).

Metformin treated diabetic rats fasting glucose level ranged from 266.27 to 90.34 mg/dl. FBG level significantly ($p<0.05$) reduced on 7 th day (59.06 %), 14th day (63.62 %) and 21th day (66.07 %) with repeated oral dose administration of metformin (50 mg/kg b.wt.) as compared to 0 day. This decrease in fasting blood glucose level might be due to metformin suppress hepatic glucose production (Stumvoll *et al.*1995) and improved the insulin sensitivity that leads enhancement in binding of insulin to its receptors in several cell (Yanardag *et al.* 2005).

Table 5.11 : Effect of fig (*Ficus carica)* methanolic extract on FBG level in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14Day	21 Day
	Diabetic					
I	Control	35mg/kg	259.35±6.11^{a} (↑171.25%)*	264.50±5.08^{b} (↑ 173.10%)*	272.86±3.79^{bc} (↑181.79%)*	277.45±4.05^{bc} (↑ 185.23%)*
II	Metformin	50 mg/kg	266.27±6.61^{a}	109.0± 5.81^{b} (↓58.79 %)$^{\#}$	96.85±1.61^{bc} (↓64.50 %)$^{\#}$	90.34±3.36^{bc} (↓ 67.43 %)$^{\#}$
III	Fig extract	500 mg/kg	255.33± 1.90^{a}	197.0± 2.25^{b} (↓ 25.51%)$^{\#}$	187.13±2.38^{bc} (↓31.41 %)$^{\#}$	169.64±4.56^{bc} (↓38.85%)$^{\#}$
	Normoglycemic					
IV	Control group	_	95.61±1.78^{a}	96.85±1.61^{a}	96.83±1.84^{a}	97.27±1.59^{b}
V	Fig extract	500 mg/kg	96.87± 1.34^{a}	96.86±1.43^{a} (↓ 0.01%)*	94.42±4.45^{a} (↓2.48%)*	91.30±5.23^{ab} (↓ 6.13%)*

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

Administration of repeated dose of fig methanolic extract (500 mg/kg) body weight of rats had significantly ($p<0.05$) reduced the FBG level in diabetic rats after seven days. The FBG level significantly ($p<0.05$) reduced on7th day (22.84 %), 14 th day (26.71%) and 21 th day (33.56%) as compared to 0 day. This reduction in FBG level might be due to methanolic fruit extract creates anti- hyperglycemic effect by increasing pancreatic secreation of insulin from β cells (Stanley *et al.* 2004).

Administration of repeated oral dose of fig methanolic extract significantly ($p<0.05$) proved effective for the reduction of FBG level in normal group of rats after seven days. The FBG level reduced on 7 th day (0.01 %), 14th day (2.52 %) and 21th day (5.74 %) as compared to 0 day. As per standard protocol, we used to perform activity for 21 days (Girija *et al*. 2011; Kumar *et al*.2012). Drug treatment for diabetes, if normalizes the effect within 21 days only and significant improvement in all parameters of diabetes were improving so that study was conducted these many days only.

5.3 (b) Effect of fig (*Ficus carica)* methanolic extract on body weight in diabetic and normoglycemic rats

The effect of selected fruit methanolic extract on the body weight in diabetic and normoglycemic rats are depicted in **Table 5.12.** Normal group of rats body weight was significantly ($p<0.05$) increased on 7th day (1.37 %), 14 th day (2.32 %) and 21th day (3.02 %) as compared to 0 day.

The body weight was significantly ($p<0.05$) reduced (4.13 %) on starting 0 day in diabetic control group as compared to normal control group and on 7th day (1.59 %), 14 th day (2.23 %) and 21 thday (3.85 %) as compared to 0 day. The reduction in body weight might be due to muscle wasting (Islam, 2011). Repeated administration of metformin dose was significantly reduced the body weight in diabetic rats on 7th day (0.58 %), 14 th day (1.04 %) but showed improvement on 21 th day (1.24 %) as compared to 0 day. The reduction in body weight in diabetic rats might be due to breakdown of tissue protein (Andulla and Varadacharyulu, 2003).

Table 5.12 : Effect of fig (*Ficus carica)* methanolic extract on body weight in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14 Day	21 Day
	Diabetic					
I	Control	35mg/kg	241.0±4.08[a] (↓4.13 %)[*]	238.40±3.41[a] (↓ 6.37 %)[*]	235.61±4.31[ab] (↓ 8.40 %)[*]	231.72±4.10[b] (↓ 10.53%)[*]
II	Metformin	50 mg/kg	240.10±1.07[a]	238.70±1.78[a] (↑ 0.64 %)	237.60± 2.31[ab] (↑0.84 %)	237.11±3.36[ab] (↑ 2.32 %)[#]
III	Fig extract	500 mg/kg	244.76±1.87[a]	246.13±2.20[a] (↑ 3.24 %)[#]	249.43±2.60[b] (↑ 5.86 %) [#]	252.44±2.09[bc] (↑ 8.94%)[#]
	Normoglycemic					
IV	Control group	-	251.40±1.35[a]	254.85±2.17[b]	257.24 ±1.89[bc]	259.0±1.69[bc]
V	Fig extract	500 mg/kg	252.56±1.35[a]	256.46±1.95[b] (↑ 0.63 %)	258.23±1.43[bc] (↑ 0.38 %)	260.17± 1.01[bc] (↑ 0.45 %)

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

The effect of repeated fig methanolic extract (500 mg/kg b.wt) had significantly ($p<0.05$) improved diabetic rats body weight on 7th day (0.56 %), 14 th day (1.90 %) and 21 th day (3.13 %) as compared to 0 day. This increase in body weight might be due to improved metabolic disturbance by given fruit extract that leads reduction in polyphagia, polyuria and polydipsia. It also helps to control muscle wasting (Whitton and Hems, 1975). Repeated oral dose of fig methanolic extract (500 mg/kg) according to body weight of rats proved very effective to increase the body weight in normal rats on7th day (1.54 %), 14 th day (2.24 %) and 21 th day (3.01%) as compared to 0 day.

5.4 Experimental Design

5.4 (a) Effect of karonda (*Carissa spinarum)* methanolic extract on fasting blood glucose level in diabetic and normoglycemic rats

The aim of the present study is to explored the scientific basis of the utility of karonda (*Carissa spinarum*), fruit methanolic extract to improve FBG level in selected group of rats. The calculated percentage yield of methanolic extract of karonda fruit was 29 per cent. Acute toxicity test revealed non toxic nature of karonda fruit methanolic extract on rats. There was no lethality and toxic reactions at any dose.

The effect of karonda methanolic fruit extract on fasting blood glucose level in rats is depicted in **Table 5. 13**. FBG level was found highest on 21th day (277.45 mg/dl) and lowest on 0 day (259.35 mg/dl). FBG level in normal control group ranged from 95.61 to 97.27 mg/dl. The FBG level were increased in diabetic rats whose having streptozotocin intraperitoneal injection, ranged from 259.35 to 277.45 mg/dl. FBG level significantly ($p<0.05$) increased (171.25%) on starting 0 day in diabetic control group as compared to normal group. And, on 7th day (1.98 %), 14th day (5.20 %) and 21th day (6.97%), FBG level increased after 3 days of streptozotocin intraperitoneal injection to rats as compared to 0 day. The increase in fasting blood glucose level might be due to streptozotocin injection which causes death of β-cells that leads insufficient production of insulin and elevated blood glucose level (Rossetti *et al.* 1990).

Metformin treated diabetic rats fasting blood glucose level ranged from 266.27 to 90.34 mg/dl. FBG level significantly ($p<0.05$) reduced on 7 th day (59.06 %), 14th day (63.62 %) and 21th day (66.07 %) with repeated oral dose administration of metformin (50 mg/kg b.wt.) as compared to 0 day. This decrease in fasting blood glucose level might be due to metformin suppress hepatic glucose production (Stumvoll *et al*.1995) and improved the insulin sensitivity that leads enhancement in binding of insulin to its receptors in several cell (Yanardag *et al.* 2005).

Table 5.13 : Effect of karonda (*Carissa spinarum)* methanolic extract on fasting blood glucose level in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14Day	21 Day
	Diabetic					
I	Control	35mg/kg	259.35±6.11[a] (↑171.25%)[*]	264.50±5.08[b] (↑ 173.10%)[*]	272.86±3.79[bc] (↑181.79%)[*]	277.45±4.05[bc] (↑ 185.23%)[*]
II	Metformin	50 mg/kg	266.27±6.61[a]	109.0± 5.81[b] (↓58.79 %)[#]	96.85±1.61[bc] (↓64.50 %)[#]	90.34±3.36[bc] (↓ 67.43 %)[#]
III	karonda extract	500 mg/kg	264.90±5.50[a]	192.73±6.12[b] (↓ 27.10 %)[#]	178.88±5.39[bc] (↓ 34.44%)[#]	168.22±5.23[bc] (↓39.36%)[#]
	Normoglycemic					
IV	Control group	_	95.61±1.78[a]	96.85±1.61[a]	96.83±1.84[a]	97.27±1.59[b]
V	Karonda extract	500 mg/kg	95.70±1.63[a]	90.10±5.38[b] (↓ 6.96 %)	85.63±2.39[bc] (↓11.56%)	81.72±3.52[bc] (↓ 15.98%)[*]

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

Administration of repeated dose of karonda methanolic extract (500 mg/kg) body weight of rats had significantly ($p< 0.05$) reduced the FBG level in diabetic rats after seven days. The FBG level significantly ($p< 0.05$) reduced on 7 th day (27.24 %), 14th day (32.47 %) and 21th day (36.49%) as compared to 0 day. Administration of repeated oral dose of karonda methanolic extract significantly ($p<0.05$) proved effective for the reduction of FBG level in normal group of rats after seven days. The FBG level reduced on 7 th day (5.85 %), 14th day (10.52%) and 21th day (14.60%) as compared to 0 day. This reduction in FBG level might be due to methanolic fruit extract creates anti- hyperglycemic effect by increasing pancreatic secreation of insulin from β cells (Stanley *et al.* 2004) and due to the presence of flavonoid content and tannin content in methanolic extract of selected fruits (Sanwal and Chaudhory, 2011).

5.4 (b) Effect of karonda (*Carissa spinarum)* methanolic extract on body weight in diabetic and normoglycemic rats

The effect of selected fruit methanolic extract on the body weight in diabetic and normoglycemic rats are depicted in **Table 5.14.**

Table 5.14 : Effect of karonda (*Carissa spinarum)* methanolic extract on body weight in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14Day	21 Day
	Diabetic					
I	Control	35mg/kg	241.0±4.08^{a} (↓4.13 %)*	238.40±3.41^{a} (↓ 6.37 %)*	235.61±4.31^{ab} (↓ 8.40 %)*	231.72±4.10^{b} (↓ 10.53%)*
II	Metformin	50 mg/kg	240.10±1.07^{a}	238.70±1.78^{a} (↑ 0.64 %)	237.60± 0.31^{ab} (↑0.84 %)	237.11±3.36^{ab} (↑ 2.32 %)$^{\#}$
III	karonda extract	500 mg/kg	240.22±7.62^{a}	246.27±2.21^{ab} (↑ 3.30 %) $^{\#}$	248.67±2.71^{bc} (↑ 5.54 %) $^{\#}$	252.27±2.68^{b} (↑ 8.86 %)$^{\#}$
	Normoglycemic					
IV	Control group	-	251.40±1.35^{a}	254.85±2.17^{b}	257.24 ±1.89^{bc}	259.0±1.69^{bc}
V	Karonda extract	500 mg/kg	252.35±1.50^{a}	256.13±2.29^{ab} (↑0.50 %)	257.58±2.30^{b} (↑ 0.13 %)	259.53±1.59^{bc} (↑ 0.20 %)

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

Normal group of rats body weight was significantly ($p<0.05$) increased on 7th day (1.37 %), 14 th day (2.32 %) and 21th day (3.02 %) as compared to 0 day. The body weight was significantly ($p <0.05$) reduced (4.13 %) on starting 0 day in diabetic control group as compared to normal control group and on 7th day (1.59 %), 14 th day (2.23 %) and 21 th day (3.85 %) as compared to 0 day. The reduction in body weight might be due to muscle wasting (Swanston *et al*.1990). Repeated administration of metformin dose was significantly reduced the body weight in diabetic rats on 7th day (0.58 %), 14 th day (1.04 %) but showed improvement on 21 th day (1.24 %) as compared to 0 day. The reduction in the body weight due to breakdown of protein in diabetic rats (Andulla and Varadacharyulu, 2003).

The effect of repeated karonda methanolic extract (500 mg/kg b.wt) had significantly ($p<0.05$) improved diabetic rats body weight on 7th day (2.51 %), 14 th day (3.39 %) and 21 th day (4.77 %) as compared to 0 day. Repeated oral dose of karonda methanolic extract (500 mg/kg) according to body weight of rats proved very effective to increase the body weight in normal rats on7th day (1.49 %), 14 th day (2.07 %) and 21 th day (2.84 %) as compared to 0 day. This increase in body weight might be due to improved metabolic disturbance by given fruit extract that leads reduction in polyphagia, polyuria and polydipsia. It also helps to control muscle wasting (Whitton and Hems, 1975).

5.5 Formulation of value added products with the substitution of fig

5.5 (a) Bun

5.5 (b) Nutritional composition

The moisture content (**Table 5.15**) of wheat flour bun substituted with fresh fig ranged from 6.47 per cent to 8.41 per cent. In control it was only 6.47 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of moisture content i.e. 8.41 per cent was noted in T4. Similar increase in moisture content i.e. 5.96 per cent was reported in bread substituted with bread fruit flour (Malomo *et al*. 2015). This increase in moisture content might be due to high moisture content in fresh fruit (Raj and Masih, 2014).

The ash content of wheat flour bun substituted with fresh fig ranged from 1.10 per cent to 1.19 per cent. The result of ash content increased non significantly ($p<0.05$) in bun samples substituted with fresh fig. Similar increase in ash content i.e. 1.02 to 1.04 per cent was reported in bread substituted with bread fruit flour (Alice *et al*. 2012). Romjaun and Prakash (2015) also reported similar increase in ash content i.e. 0.82 to 1.31 per cent in bread substituted with carrot powder. This increase in ash content might be due to the high mineral content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.15**) of wheat flour bun substituted with fresh fig ranged from 75.52 per cent to 104.58 per cent. In control it was only 75.52 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of carbohydrate content i.e. 104.58 per cent was noted in T4. Similar increase in carbohydrate content i.e.78.69 per cent was reported in cookies substituted with unripe plantain flour(Chinma*etal*.2012). This increase in carbohydrate content might be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour bun substituted with fresh fig ranged from 6.64 per cent to 7.84 per cent. The result of protein content increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. Similar increase in protein content i.e. 4.39 to 7.25 per cent

was reported in bread substituted with soursop fruit flour (Zabidi *et al*. 2014). This increase in protein content might be due to higher addition of fruits at the time of bun development that leads to increase in protein content (Thorvaldsson and Skjoldebrand, 1998).

Table 5.15 Nutritional composition of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
Moisture (%)	6.47± 0.02[a]	6.84±0.01[c] (5.71%)↑	8.26±0.00[b] (27.66%)↑	8.41±0.01[cd] (29.98%)↑
Ash (%)	1.10±0.05[a]	1.13±0.10[a] (2.27 %)↑	1.16±0.05[a] (5.45%)↑	1.19±0.05[a] (8.18 %)↑
Carbohydrate (%)	75.52±0.01[a]	85.85±0.30[b] (13.67 %)↑	95.6±0.1[c] (26.58%)↑	104.58±0.07[cd] (38.47%)↑
Protein (%)	6.64±0.14[a]	7.44±0.08[a] (12.04 %)↑	7.69±0.95[a] (15.81%)↑	7.84±0.08[a] (18.07%)↑
Fat (%)	1.62±0.07[a]	1.73±0.04[a] (6.79 %)↑	1.80±0.38[a] (11.11%)↑	1.92±0.28[a] (18.51%)↑

Where, T1 (control sample) = 100% wheat flour bun, T2=15 % fig, T3=30% fig, T4 =45 % fig)

The fat content (**Table 5.15**) of wheat flour bun substituted with fresh fig ranged from 1.62 per cent to 1.92 per cent. Similar results, i.e. 1.57 per cent was reported by Michael *et al*. (2013) in wheat flour bread. The result of fat content increased non significantly ($p>0.05$) in bun sample substituted with fresh fig. The fat content was highest in T4 (1.92 %) and lowest in T1(1.62%). Similar increase in fat content i.e. 2.55 per cent was reported in bread substituted with pumpkin flour (See *et al.* 2007). This increase in fat content may be due to relative increase of fat content in fruits (Asp and Bjorck, 1992).

5.5 (c) Dietary fiber

The neutral detergent fiber (**Table 5.16**) of wheat flour bun substituted with fresh fig ranged from 23.73 per cent to 24.83 per cent. Similar results, i.e. 23.16 per cent was reported by Krishan *et al*. (1987) in wheat flour bread. NDF increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. The NDF was highest in T4 (24.83 %) and lowest in T1(23.73 %). Similar increase in dietary fiber i.e. 24.20 per cent was reported in bread substituted with watermelon rind (Ho and Dahri, 2016). Lopez *et al.* (2011) also reported similar increase i.e. 25.2 per cent was reported in bread substituted with orange powder. This increase in dietary fiber might be due to high dietary fiber in fruits (Sudha *et al.*2007).

The acid detergent fiber (ADF) of wheat flour bun substituted with fresh fig ranged from 1.30 per cent to 1.60 per cent. The results of ADF increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. ADF increased with increase in fresh fig fruit substitution. Similar increase in dietary fiber i.e. 0.75 to 1.13 per cent was reported in wheat flour cookie substituted with mango seed kernel (Legesse and Emire, 2012).

Hemicellulose content (**Table 5.16**) of wheat flour bun substituted with fresh fig ranged from 23.39 per cent to 23.22 per cent. Hemicellulose content increased significantly ($p<0.05$) in bun samples substituted with fresh fig. The hemicellulose content was highest in T4 (23.22 %) and lowest in T1(22.39 %).

The cellulose content of wheat flour bun substituted with fresh fig ranged from 2.48 per cent to 2.62 per cent. The result of cellulose increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. The cellulose content increased with increase in fresh fig fruit

substitution. Similar increase in cellulose content i.e. 0.02 to 4.40 per cent was reported in cookies substituted with raspberry pomace fruit (Gorecka *et al.* 2010). This increase in dietary fiber might be due to addition of dietary fiber rich fruits in bun, especially cellulose content (Thorvaldsen and Skjoldebrand, 1998).

Table 5.16 Dietary fiber of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
NDF (%)	23.73±0.05[a]	23.80±0.10[a] (0.29%)↑	24.23±0.05[a] (2.10%)↑	24.83±0.98[a] (4.63%)↑
ADF (%)	1.30±0.34[a]	1.40±0.45[a] (7.69%)↑	1.53±0.23[a] (17.69%)↑	1.60±0.17[a] (23.07%)↑
Hemicellulose (%)	22.39±0.00[a]	22.42±0.00[b] (0.13%)↑	22.56±0.00[c] (0.75%)↑	23.22±0.00[cd] (3.70%)↑
Cellulose(%)	2.48±0.10[a]	2.51±0.07[a] (1.20%)↑	2.56±0.03[a] (3.22%)↑	2.62±0.01[a] (5.64%)↑
Lignin (%)	1.23±0.63[a]	1.60±0.10[a] (30.08%)↑	1.73±0.05[a] (40.65%)↑	1.76±0.05[a] (43.08%)↑

The lignin content (**Table 5.16**) of wheat flour bun substituted with fresh fig ranged from 1.23 per cent to 1.76 per cent. The results of lignin content increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. The lignin content was highest in T4 (1.70 %) and lowest in T1(1.56 %). Similar increase in lignin content i.e. 3.98 per cent was reported in cookies substituted with raspberry pomace fruit (Gorecka *et al.* (2010).

5.5 (d) Mineral composition

The calcium content (**Table 5.17**) of wheat flour bun substituted with fresh fig ranged from 10.80 mg/100gm to 73.61 mg/100gm. Similar results, i.e. 10.70 mg/100gm was reported by Surekha *et al*. (2013) in wheat flour cookies. In control it was only 10.80 mg/100gm and increased significantly with more replacement of fresh fig fruit. Maximum value of calcium content i.e. 73.61 mg/100gm was noted in T4. Similar increase in calcium content i.e. 14.0 per cent was reported in wheat flour muffin substituted with pumpkin (Krishanaprabha and Kiruthiga, 2015). Waghray *et al.* (2011) also reported similar increase i.e. 70.80 per cent in wheat flour chapatti substituted with date pulp. This increase in calcium content might be due to high mineral content in fruits i.e. iron, phosphorus and calcium (Armeu *et al.* 2006; Niemen *et al*. 1992). Zabidi and Yunus (2014) also reported increase in mineral content in bun substituted with fruits.

Table 5.17 Mineral composition of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	10.80 ± 0.00^{a}	14.96 ± 0.00^{b} (38.51%)↑	70.14 ± 0.00^{c} (549.44%)↑	73.61 ± 0.00^{cd} (581.57%)↑
Iron (mg/100gm)	25.83 ± 0.00^{a}	284.91 ± 0.00^{b} (1003.01%)↑	310.75 ± 0.00^{c} (1103.05) ↑	344.83 ± 0.00^{cd} (1234.99%)↑
Phosphorus (mg/100gm)	333.39 ± 0.00^{a}	371.70 ± 0.00^{b} (11.49%)↑	423.54 ± 0.00^{c} (27.04%)↑	444.00 ± 0.00^{cd} (33.18%)↑

The iron content of wheat flour bun substituted with fresh fig ranged from 25.83 mg/100gm to 344.83 mg/100gm. The result of iron content increased significantly ($p<0.05$) in bun samples substituted with fresh fig. The iron content increased with increase in fresh fig fruit substitution. Similar increase in iron content i.e. 21 to 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

The phosphorus content (**Table 5.17**) of wheat flour bun substituted with fresh fig ranged from 333.39 mg/100gm to 444.00 mg/100gm.The results of the phosphorus content increased significantly ($p<0.05$) in bun samples substituted with fresh fig. The phosphorus content was highest in T4 (444.00 mg/100gm) and lowest in T1(333.39 mg/100gm). Similar increase in phosphorus content i.e. 377.15 per cent was reported in wheat flour chapatti substituted with date pulp (Waghray *et al.* 2011).

5.5 (e) Organoleptic analysis of bun

Table 5.18 Organoleptic analysis of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
Appearance	7.4±0.69[a]	7.2±0.63 [a]	7.4±0.69 [a]	7.2 ±0.63 [a]
Colour	7.2±0.42 [a]	7.0±0.47 [a]	7.1±0.31 [a]	7.0 ±0.66 [a]
Texture	7.2±0.63 [a]	7.2±0.63 [a]	7.3±0.48 [a]	7.1 ±0.31[a]
Flavour	7.5±0.52 [a]	7.2±0.42 [a]	7.3±0.67 [a]	7.1 ±0.31 [a]
Overall Acceptability	7.3±0.48 [a]	7.2±0.42 [a]	7.3±0.48 [a]	7.0 ±0.66 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant($p<0.05$)

Where, T1 (control sample) = 100% wheat flour bun, T2=15 % fig, T3=30% fig, T4 =45 % fig)

As shown in Table 5.18, sensory characteristics of wheat flour bun substituted with fresh fig T2, T3 and T4 were non significantly ($p>0.05$) different from wheat flour bun T1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour bun substituted

with fresh fig were not affected by increased concentration of fresh fig. . However, all samples were found to be acceptable.

Fig. 5.9 T1 (control sample) = 100% wheat flour bun,

T2=15 % fig,T3=30% fig, T4 =45 % fig)

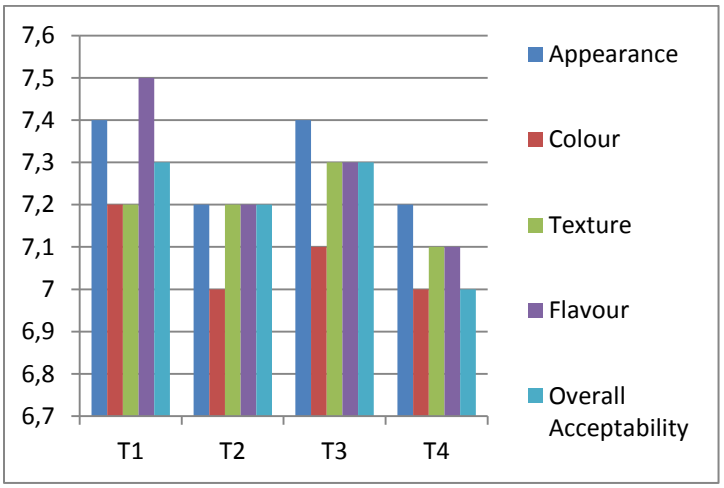

Fig. 5.10 Sensory scores of bun samples

5.6 Muffin

5.6 (a) Nutritional composition

The moisture content (**Table 5.19**) of wheat flour muffin substituted with fresh fig ranged from 10.80 per cent to 20.80 per cent. Similar results, i.e. 10.96 per cent was reported by Uchenna *et al*. (2013) in wheat flour muffin. In control it was only 10.80 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of moisture content i.e. 20.80 per cent was noted in T4. Similar increase in moisture content i.e.20.65 per cent was reported in muffin substituted with young corn powder (Jauharah *et al*. 2014). This increase in moisture content might be due to the presence of fiber content in fruits that leads to enhance the water absorption capacity by hydroxyl group (Rosell *et al.* 2011).

Table 5.19 Nutritional composition of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
Moisture (%)	10.80 ± 0.1^{a}	19.85 ± 0.09^{b} (83.79%)↑	20.15 ± 0.09^{ac} (86.57%)↑	20.80 ± 0.00^{cd} (92.59%)↑
Ash (%)	1.12 ± 0.11^{a}	1.16 ± 0.05^{a} (3.57 %)↑	1.19 ± 0.05^{a} (6.25 %)↑	1.29 ± 0.05^{a} (15.17 %)↑
Carbohydrate (%)	45.45 ± 0.48^{a}	52.48 ± 2.11^{b} (15.46%)↑	62.50 ± 2.54^{c} (37.51%)↑	71.95 ± 2.58^{cd} (58.30%)↑
Protein (%)	6.42 ± 0.12^{a}	6.92 ± 0.11^{a} (7.78%)↑	7.17 ± 0.05^{a} (11.68%)↑	7.38 ± 0.16^{a} (14.95%)↑
Fat (%)	10.33 ± 0.11^{a}	10.73 ± 0.11^{b} (3.87%)↑	11.13 ± 0.11^{c} (7.74%)↑	11.33 ± 0.11^{cd} (9.68%)↑

The ash content of wheat flour muffin substituted with fresh fig ranged from 1.12 per cent to 1.29 per cent. The ash content increased non significantly ($p>0.05$) in muffin samples substituted with fresh fig. Similar increase in ash content i.e. 0.82 to 1.31 per cent was reported in muffin substituted with carrot powder (Romjaun and Prakash, 2014). Mc Clements (2003)

also reported similar increase in ash content in muffin substituted with corn powder. This increase in ash content might be due to high ash content in fruit (Seleem, 2015).

The carbohydrate content (**Table 5.19**) of wheat flour muffin substituted with fresh fig ranged from 45.45 per cent to 71.95 per cent. Similar results, i.e. 45.08 per cent was reported by Krishanaprabha and Kiruthiga (2015) in wheat flour muffin. In control it was only 45.45 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of carbohydrate content i.e. 71.95 per cent was noted in T4. Similar increase in carbohydrate content i.e. 64.81 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).Legesse and Emire (2012) also reported similar increase i.e. 72.12 per cent in wheat flour biscuit substituted with breadfruit flour. Adubofuor and Mensah (2012) also reported increase in carbohydrate content i.e. 51.86 per cent in wheat flour cake substituted with ripe pawpaw pulp. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour muffin substituted with fresh fig ranged from 6.42 per cent to 7.38 per cent. Similar results, i.e. 6.73 per cent was reported by Jauharah *et al.* (2014) in wheat flour muffin. The protein content increased non significantly ($p>0.05$) in protein content was observed in muffin samples substituted with fresh fig. Similar increase in protein content i.e. 6.6 to 7.4 per cent was reported in wheat flour panjiri substituted with potato flour (Kaur and Kochhar, 2014). Jauharah *et al.* (2014) also reported similar increase in protein content in muffin substituted with corn powder. This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.19**) of wheat flour muffin substituted with fresh fig ranged from 10.33 per cent to 11.33 per cent. The fat content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The fat content was highest in T4(11.33 %) and lowest in T1(10.33 %). Similar increase in fat content i.e. 12.50 per cent was reported in muffin substituted with pumpkin powder (Krishanaprabha and Kiruthiga, 2015). Chuen and Aziz (2009) also reported similar increase i.e. 9.23 per cent in muffin substituted with mango pulp flour. This increase in fat content may be due to high fat content in fruits (Seleem, 2015).

5.6 (b) Dietary fiber

The neutral detergent fiber (**Table 5.20**) of wheat flour muffin substituted with fresh fig ranged from 23.66 per cent to 24.46 per cent. NDF increased non significantly ($p>0.05$) in muffin substituted with fresh fig. The NDF was highest in T4 (24.46 %) and lowest in T1(23.66 %). Similar increase in NDF i.e. 24.68 per cent was reported in wheat flour cookie substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to proportionally increase in dietary fiber in fruit mixture (Seleem, 2015).

Table 5.20 Dietary fiber of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
NDF(%)	23.66 ± 0.15^{a}	23.76 ± 0.11^{a} (0.42%)↑	24.06 ± 0.32^{a} (1.69%)↑	24.46 ± 0.86^{a} (3.38%)↑
ADF(%)	5.46 ± 0.63^{a}	5.73 ± 0.56^{a} (4.94%)↑	5.83 ± 0.63^{a} (6.77%)↑	6.03 ± 0.86^{a} (10.43%)↑
Hemicellulose (%)	17.86 ± 0.00^{a}	18.19 ± 0.00^{b} (1.84%)↑	18.32 ± 0.00^{c} (2.57%)↑	18.42 ± 0.00^{cd} (3.13%)↑
Cellulose(%)	4.18 ± 0.19^{a}	4.19 ± 0.19^{a} (0.23%)↑	4.20 ± 0.19^{a} (0.47%)↑	4.24 ± 0.19^{a} (1.43%)↑
Lignin (%)	1.60 ± 0.01^{b}	1.70 ± 0.00^{ab} (6.25%)↑	1.71 ± 0.02^{ac} (6.8%)↑	1.72 ± 0.02^{cd} (7.5%)↑

The acid detergent fiber (ADF) of wheat flour muffin substituted with fresh fig ranged from 5.46 per cent to 6.03 per cent. The ADF increased non significantly ($p>0.05$) in muffin samples substituted with fresh fig. ADF increased with increase in fresh fig fruit substitution. Similar increase in ADF i.e. 1.11 to 8.05 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010).

Hemicellulose content (**Table 5.20**) of wheat flour muffin substituted with fresh fig ranged from 17.86 per cent to 18.42 per cent. Hemicellulose content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The hemicellulose content was highest in T4 (18.42 %) and lowest in T1(17.86 %). Similar increase in dietary fiber i.e.19.00 per cent was reported in wheat flour biscuit substituted with grape pomace (Szkudlarz *et al.* 2013).

The cellulose content of wheat flour muffin substituted with fresh fig ranged from 4.18 per cent to 4.24 per cent. Similar results, i.e. 4.50 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. The cellulose content increased non significantly ($p>0.05$) in muffin samples substituted with fresh fig. The cellulose content increased with increase in fresh fig fruit substitution. Similar increase in dietary fiber i.e. 1.44 to 4.24 per cent was observed in wheat flour cookie substituted with unripe plantain flour (Chinma *et al.* 2012).Similar increase i.e. 0.02 to 4.07 per cent was reported in wheat flour cookie substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to high dietary fiber in fruits(Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.20**) of wheat flour muffin substituted with fresh fig ranged from 1.60 per cent to 1.72 per cent. Similar results, i.e. 1.80 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. Lignin content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The lignin content was highest in T4 (1.72 %) and lowest in T1(1.60 %). Similar increase in dietary fiber i.e. 1.28 per cent was reported in wheat flour mathri substituted with potato flour (Kaur and Kochhar,2014). Gorecka *et al.* (2010) also reported similar increase i.e. 3.98 per cent in wheat flour cookies substituted with raspberry pomace.

5.6 (c) Mineral composition

The calcium content (**Table 5.21**) of wheat flour muffin substituted with fresh fig ranged from 146.79 mg/100gm to 339.29 mg/100gm. In control it was only 146.79 mg/100gm increased significantly with more replacement of fresh fig fruit. Maximum value of calcium content i.e. 339. 29 mg/100gm was noted in T4. Similar increase in calcium content i.e. 148.33 per cent was reported in muffin substituted with carrot powder (Romjaun and Prakash, 2013). This increase in calcium content might be due to high mineral content in fruits (Saunders, 1990).

Table 5.21Mineral composition of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	146.79±0.00^{a}	241.01±0.00^{b} (64.18%)↑	307.95±0.00^{c} (109.78%)↑	339.29±0.00^{cd} (131.13%)↑
Iron (mg/100gm)	10.92±0.00^{a}	16.04±0.00^{b} (46.88%)↑	18.14±0.00^{c} (66.11%)↑	19.88±0.00^{cd} (82.05%)↑
Phosphorus (mg/100gm)	62.40±0.00^{a}	86.65±0.00^{b} (38.86%)↑	120.42±0.00^{c} (92.98%)↑	175.43±0.00^{cd} (181.13%)↑

The iron content of wheat flour muffin substituted with fresh fig ranged from 10.92 mg/100gm to 19.88 mg/100gm. The iron content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The iron content increased with increase in fresh fig fruit substitution. Similar increase in iron content i.e. 21 to 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

The phosphorus content (**Table 5.21**) of wheat flour muffin substituted with fresh fig ranged from 62.40 mg/100gm to 175.43 mg/100gm.The results of the phosphorus content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The phosphorus content was highest in T4 (175.43 mg/100gm) and lowest in T1(62.40 mg/100gm). Similar increase in phosphorus content i.e. 170.22per cent was reported in wheat flour biscuit substituted with date palm fruit (Sharnouby *et al.* 2012). Romjaun and Prakash (2013) also reported similar increase i.e. 119 per cent in wheat flour muffin substituted with carrot powder.

5.6 (d) Organoleptic analysis of muffin

Table 5.22 Organoleptic analysis of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
Appearance	7.9±0.31 [a]	7.4±0.51 [a]	7.7±0.48 [a]	7.4±0.51 [a]
Colour	7.2±0.42 [a]	7.6±0.51 [a]	7.4±0.51 [a]	7.2±0.42 [a]
Texture	7.3±0.48 [a]	7.4±0.51 [a]	7.4±0.51 [a]	7.3±0.48 [a]
Flavour	7.8±0.42 [a]	7.3±0.48 [a]	7.6±0.51 [a]	7.4±0.51 [a]
Overall Acceptability	7.6±0.48 [a]	7.4±0.52 [a]	7.5±0.48 [a]	7.3±0.48 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant($p<0.05$)

Where, T1 (control sample) = 100% wheat flour muffin, T2=15 % fig, T3=30% fig, T4 =45 % fig)

As shown in Table 5.22, sensory characteristics of wheat flour muffin substituted with fresh fig T2, T3 and T4 were non significantly ($p>0.05$) different from wheat flour muffin T1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour muffin substituted with fresh fig were not affected by increased concentration of fresh fig. In conclusion, T2 and T3 was found to be most acceptable as compared to T4, so wheat flour muffin sample was only substituted till 45 per cent.

Fig. 5.11 T1 (control sample) = 100% wheat flour muffin,

T2=15 % fig, T3=30% fig, T4 =45 % fig)

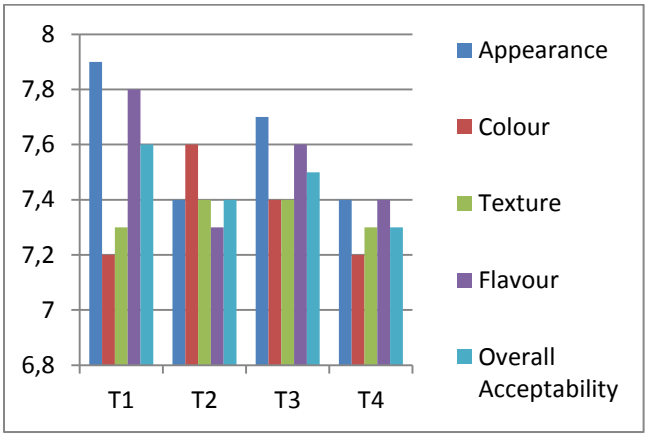

Fig. 5.12 Sensory scores of muffin samples

5.7 Noodles

5.7 (a) Nutritional composition

The moisture content (**Table 5.23**) of wheat flour noodles substituted with dried fig ranged from 6.61 per cent to 8.75 per cent. In control it was only 6.61 per cent increased non significantly with more replacement of dried fig fruit. Maximum value of moisture content i.e. 8.75 per cent was noted in T4. Similar increase in moisture content i.e. 11.35 per cent was reported in noodles substituted with sweet potato powder (Ibitoye *et al*. 2013). Taneya *et al.* (2014) also reported similar increase i.e. 6.27 per cent in wheat flour noodles substituted with potato flour. Similar increase i.e.8.67 per cent was reported in wheat flour noodles substituted with unripe banana flour (Ritthiruangdej *et al*. 2011).This increase in moisture content might be due to high moisture content in fruits (Mansour *et al*. 1999).

Table 5.23 Nutritional composition of noodles substituted with dried fig

Parameters	T1	T2	T3	T4
Moisture (%)	6.61 ± 0.16 [a]	8.26± 0.13 [a] (24.96%)↑	8.45± 0.12 [a] (27.83%)↑	8.75±3.24 [a] (32.37%)↑
Ash(%)	2.13 ± 0.00[a]	2.51± 0.10 [a] (17.84%)↑	2.84 ±0.09 [a] (33.33%)↑	3.67± 1.33 [a] (72.30%)↑
Carbohydrate (%)	85.53±0.01 [a]	95.85±0.30 [b] (12.06%)↑	105.60±0.1 [c] (23.46%)↑	114.58±0.07 [cd] (33.96%)↑
Protein (%)	6.51±0.11 [a]	7.44±0.08 [b] (14.28%)↑	7.48±1.05[bc] (14.90%)↑	7.84±0.08 [cd] (20.43%)↑
Fat (%)	1.56±0.02 [a]	1.62±0.07 [a] (3.84%)↑	1.73±0.04 [ab] (10.89%)↑	1.82±0.05 [bc] (16.66%)↑

The ash content of wheat flour noodles substituted with dried fig ranged from 2.13 per cent to 3.61 per cent. Similar results, i.e. 2.21 per cent was reported by Taneya *et al*. (2014) in wheat flour noodles. The ash content increased non significantly ($p>0.05$)in noodles samples. The ash content increased with increase in dried fig fruit substitution. Similar increase in ash content i.e. 2.21 to 2.44 per cent was reported in wheat flour noodles substituted with potato flour(Taneya *et al*.2014).Similar increase i.e. 0.93 to 1.04 per cent was reported in wheat flour bread substituted with bread fruit flour (Alice *et al.* 2012). Similar increase in ash content i.e. 2.17 to 2.39 per cent was reported in wheat flour cookies substituted with pitaya peel flour (Ho and Latif,2016). This increase in ash content might be due to high ash content in fruit (Brito *et al*.2006).

The carbohydrate content (**Table 5.23**) of wheat flour noodles substituted with dried fig ranged from 85.53 per cent to 114.58 per cent. In control it was only 85.53 per cent increased significantly with more replacement of dried fig fruit. Maximum value of carbohydrate content i.e. 114.58 per cent was noted in T4. Similar increase in carbohydrate content i.e. 97.57 per cent was reported in wheat flour bread substituted with breadfruit flour (Alice *et al.*2012).Ariffin *et al.* (2015) also reported similar increase in carbohydrate content i.e. 86.75 per cent in wheat flour bread substituted with durian flour. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour noodles substituted with dried fig ranged from 6.51 per cent to 7.84 per cent. Similar results, i.e. 6.73 per cent was reported by Ho and Latif (2016) in wheat flour cookies. The protein content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The protein content increased with increase in dried fig fruit substitution. Similar increase in protein content i.e.7.59 to 7.82 per cent was reported in wheat flour cookies substituted with breadfruit flour (Ojinnaka *et al.*2013).Similar increase in protein content i.e. 6.73 to 7.04 per cent was reported in wheat flour cookies substituted with pitaya peel flour (Ho and Latif,2016). This increase in protein content might be due to high protein content in fruits (Brito *et al*.2006).

The fat content (**Table 5.23**) of wheat flour noodles substituted with dried fig ranged from 1.56 per cent to 1.82 per cent. Similar results, i.e. 1.56 per cent was reported by Hardi *et al*. (2007) in wheat flour noodles. The fat content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The fat content was highest in T4 (1.82 %) and lowest in T1(1.56 %). Similar increase in fat content i.e. 1.3 to 3.9 per cent was reported in wheat flour noodles substituted with banana peel (Singh *et al*. 2015). This increase in fat content may be due to high fat content in fruits (Vinod *et al*. 2015).

5.7 (b) Dietary fiber

The neutral detergent fiber (**Table 5.24**) of wheat flour noodles substituted with dried fig ranged from 21.93 per cent to 23.90 per cent. NDF increased non significantly ($p>0.05$) in noodles substituted with dried fig. The NDF was highest in T4 (23.90 %) and lowest in T1(21.93 %). Similar increase in dietary fiber i.e. 24.20 per cent was reported in wheat flour noodles substituted with watermelon rind powder (Ho and Dahri, 2016). This increase in dietary fiber might be due to high dietary fiber in fruit mixture (Nwanekezi *et al.* 2015).

Table 5.24 Dietary fiber of noodles substituted with dried fig

Parameters	T1	T2	T3	T4
NDF (%)	21.93±1.90 [a]	22.50±2.16 [a] (2.59%)↑	23.70±1.70 [a] (8.07%)↑	23.90±0.26 [a] (8.98%)↑
ADF (%)	1.53±0.05 [a]	1.60±0.10 [a] (4.57 %)↑	1.76±0.11 [a] (15.03 %)↑	1.83±0.11 [ab] (19.60%)↑
Hemicellulose (%)	21.4±4.35 [a]	21.90±4.35 [b] (2.33%)↑	22.94±0.00 [c] (7.19%)↑	23.07±4.35 [cd] (7.80%)↑
Cellulose (%)	3.14±0.18 [a]	3.17±0.03 [b] (0.95%)↑	3.21±0.01 [a] (2.22%)↑	3.33±0.10 [a] (6.05%)↑
Lignin (%)	1.46±0.05 [a]	1.50±0.10 [a] (2.73 %)↑	1.53±0.05 [a] (4.79 %)↑	1.63±0.05 [a] (11.64 %)↑

The acid detergent fiber (ADF) of wheat flour noodles substituted with dried fig ranged from 1.53 per cent to 1.83 per cent. The ADF increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The ADF increased with increase in dried fig fruit substitution.

Hemicellulose content (**Table 5.24**) of wheat flour noodles substituted with dried fig ranged from 21.40 per cent to 23.07 per cent. Hemicellulose content increased significantly ($p<0.05$) in muffin samples substituted with dried fig. The hemicellulose content was highest in T4 (23.07%) and lowest in T1(21.40 %).

The cellulose content of wheat flour noodles substituted with dried fig ranged from 3.14 per cent to 3.33 per cent. The cellulose content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The cellulose content increased with increase in dried fig fruit substitution. This increase in dietary fiber might be due to the addition of dietary fiber rich fruits in noodles (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.24**) of wheat flour noodles substituted with dried fig ranged from 1.46 per cent to 1.63 per cent. Similar results, i.e. 1.08 per cent was reported by Gorecka *et al.* (2010) in wheat flour cookies. The results of the lignin content increased non significantly ($p>0.05$) in noodles samples substituted with dried fig. The lignin content was highest in T4 (0.63 %) and lowest in T1(0.46 %). Similar increase in dietary fiber i.e. 3.34 per cent was reported in wheat flour cookies substituted with potato flour (Pratyush *et al*. 2015). Similar increase in dietary fiber i.e. 0.75 per cent was reported in wheat flour biscuits substituted with jackfruit powder (Butool and Butool,2013).

5.7 (c) Mineral composition

The calcium content (**Table 5.25**) of wheat flour noodles substituted with dried fig ranged from 18.96 mg/100gm to 33.91 mg/100gm. In control it was only 18.96 mg/100gm increased significantly with more replacement of dried fig fruit. Maximum value of calcium content i.e. 33.91 mg/100gm was noted in T4. Similar increase in calcium content i.e. 32 per cent was reported in wheat flour cake substituted with beetroot powder (Pinki and Awasthi, 2014).Seleem (2015) also reported increase in calcium content i.e. 20.40 per cent in wheat flour cake

substituted with doum fruit powder. This increase in calcium content might be due to high mineral content in fruits (Seleem, 2015).

Table 5.25 Mineral composition of noodles substituted with dried fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	18.96±0.00 [a]	23.80±0.00 [b] (25.52%)↑	27.89±0.00 [c] (47.09%)↑	33.91±0.00 [cd] (78.85%)↑
Iron (mg/100gm)	10.92± 0.00[a]	14.96 ±0.00 [b] (36.99%)↑	18.14 ±0.00 [c] (66.11%)↑	70.14 ±0.00 [c] (542.30 %)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	333.39±0.00 [b] (2.86 %)↑	444.00±0.00 [c] (36.99%)↑	666.54±0.00 [cd] (105.65%)↑

The iron content of wheat flour noodles substituted with dried fig ranged from 10.92 mg/100gm to 70.14 mg/100gm. The iron content increased significantly ($p<0.05$) in all noodles samples substituted with dried fig. The iron content increased with increase in dried fig fruit substitution. Similar increase in iron content i.e. 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

The phosphorus content (**Table 5.25**) of wheat flour noodles substituted with dried fig ranged from 324.1 mg/100gm to 666.54 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The phosphorus content was highest in T4 (0.16 mg/100gm) and lowest in T1(0.11 mg/100gm).Similar increase in phosphorus content i.e. 467 per cent was reported in wheat flour cakes substituted with beetroot powder (Pinki and Awasthi, 2014).

Fig. 5.13 T1 (control sample = 100% wheat flour noodles,

T2=15 % fig, T3=30% fig, T4 =45 % fig)

5.8 Nugget

5.8 (a) Nutritional composition

The moisture content (**Table 5.26**) of green gram nugget substituted with dried fig ranged from 19.80 per cent to 20.80 per cent. In control it was only 19.80 per cent increased significantly with more replacement of dried fig fruit. Maximum value of moisture content i.e. 20.80 per cent was noted in T4. Similar increase in moisture content i.e.22.98 per cent was reported in composite pulse flour chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in moisture content might be due to high moisture content in fruits (Nwanekezi *et al.* 2015).

Table 5.26 Nutritional composition of nugget substituted with dried fig

Parameters	T1	T2	T3	T4
Moisture (%)	19.80±0.1 [a]	19.85±0.09 [a] (0.25%)↑	20.15±0.09 [b] (1.76%)↑	20.80±0.00 [b c] (5.05%)↑
Ash (%)	1.10±0.05 [a]	1.16±0.05 [a] (5.45%)↑	1.19±0.05 [a] (8.18 %)↑	1.29±0.20 [a] (17.27%)↑
Carbohydrate (%)	65.64±0.22 [a]	72.48±2.11 [b] (10.42%)↑	82.50±1.09 [c] (25.68%)↑	93.78±0.63 [cd] (42.87%)↑
Protein (%)	13.34±0.08 [a]	13.59±0.08 [b] (1.87%)↑	14.39±0.08 [c] (7.87%)↑	14.72±0.08 [cd] (10.34%)↑
Fat (%)	1.85±2.71 [a]	2.20±0.05 [b] (18.91%)↑	2.27±0.02 [bc] (22.70%)↑	2.33± 0.07 [bd] (25.94%)↑

The ash content of green gram nugget substituted with dried fig ranged from 1.37 per cent to 1.77 per cent. The ash content increased non significantly ($p>0.05$) in nugget samples substituted with dried fig. The ash content increased with increase in dried fig fruit substitution. Similar increase in ash content i.e. 1.20 to 1.72 per cent was reported in gram composite flour

chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in ash content might be due to high ash content in fruit(Nwanekezi *et al.* 2015).

The carbohydrate content (**Table 5.26**) of green gram nugget substituted with dried fig ranged from 65.64 per cent to 93.78 per cent. Similar results, i.e. 65.50 per cent was reported by Aziz *et al*. (2012) in nugget. In control it was only 65.64 per cent increased significantly with more replacement of fresh dried fruit. Maximum value of carbohydrate content i.e. 93.78 per cent was noted in T4. Similar increase in carbohydrate content i.e. 65.78 per cent was reported in pulse based weaning food substituted with banana fruit (Mishra *et al.* 2014). Singh *et al.*(2014) also reported similar increase in carbohydrate content i.e. 70.72 per cent in bengal gram dal substituted with kondhara leaves. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of green gram nugget substituted with dried fig ranged from 13.34 per cent to 14.72 per cent. The protein content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The protein content increased with increase in dried fig fruit substitution. Similar increase in protein content i.e. 11.48 to 30.44 per cent protein content was reported in bengal gram dal substituted with kondhara leaves (Sultana *et al.* 2014). Similar increase in protein content i.e. 14.26 to 14.80 per cent was reported in legume composite flour thalipeeth (pan cake like product) substituted with green leafy vegetables (Gupta and Prakash,2011). This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.26**) of green gram nugget substituted with dried fig ranged from 1.85 per cent to 2.33 per cent. Similar results, i.e. 1.30 per cent was reported by Pardeshi *et al*. (2013) in nugget. The fat content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The fat content was highest in T4 (2.33 %) and lowest in T1(1.85 %). Similar increase in fat content i.e. 1.28 per cent was reported in composite gram flour based chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in fat content may be due to high fat content in fruits (Nwanekezi *et al.* 2015).

5.8 (b) Dietary fiber

The neutral detergent fiber (**Table 5.27**) of green gram nugget substituted with dried fig ranged from 23.56 per cent to 24.20 per cent. NDF increased non significantly ($p>0.05$) in nugget samples substituted with dried fig. The NDF was highest in T4 (24.20 %) and lowest in T1 (23.56 %). Similar increase in dietary fiber i.e. 18.15 per cent was reported in composite gram flour chakli (Rosy *et al.* 2015). This increase in dietary fiber might be due to proportionally increase in dietary fiber in fruits (Rupasinghe *et al.* 2008).

Table 5.27 Dietary fiber of nugget substituted with dried fig

Parameters	T1	T2	T3	T4
NDF (%)	23.56±0.11 [a]	23.63±0.11 [a] (3.94%)↑	24.06±0.32 [a] (2.12%)↑	24.20±1.04 [a] (2.71%)↑
ADF (%)	21.06±0.92 [a]	21.33±1.15 [a] (1.28%)↑	21.73±0.23 [a] (3.18%)↑	21.76±1.85 [a] (3.32%)↑
Hemicellulose (%)	1.97±0.00 [a]	2.36±0.00 [b] (19.79%)↑	2.47±0.00 [c] (25.38%)↑	2.50±0.00 [cd] (26.90%)↑
Cellulose (%)	11.88±0.65 [a]	11.51±0.65 [a] (3.11%)↑	11.89±0.61 [a] (0.08%)↑	12.54±0.66 [a] (5.55%)↑
Lignin (%)	1.68±0.00 [b]	1.70±0.00 [a] (1.19%)↑	1.71±0.00 [ac] (1.78%)↑	1.73±0.01 [a] (2.97%)↑

The acid detergent fiber (ADF) of nugget substituted with dried fig ranged from 21.06 per cent to 21.76 per cent. The ADF content increased non significantly ($p>0.05$) in nugget samples substituted with dried fig. The ADF increased with increase in dried fig fruit substitution.

Hemicellulose content (**Table 5.27**) of nugget substituted with dried fig ranged from 1.97 per cent to 2.50 per cent. Hemicellulose content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The hemicellulose content was highest in T4 (2.50 %) and lowest in T1(1.97 %).Similar increase in hemicellulose content i.e.0.38 to 0.51 per cent was reported in gram dal substituted with bathua leaves (Singh *et al.* 2007). Singh *et al.*(2014) also reported similar increase i.e. 0.25 to 5.75 per cent dietary fiber in bengal gram dal substituted with kondhara leaves.

The cellulose content of nugget substituted with dried fig ranged from 11.88 per cent to 12.54 per cent. The cellulose content increased non significantly ($p<0.05$) in cellulose content was observed in all nugget samples substituted with dried fig. The cellulose content increased with increase in dried fig fruit substitution. This increase in cellulose content might be due to addition of dietary fiber rich fruits in nugget (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.27**) of nugget substituted with dried fig ranged from 1.68 per cent to 1.73 per cent. The results of the lignin content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The lignin content was highest in T4 (1.73 %) and lowest inT1(1.68 %). Similar increase in dietary fiber i.e. 1.82 per cent was reported in gram composite flour khakara substituted with carrot powder (Surekha and Naik, 2014).Verma and Singh (2014) also reported similar increase in lignin content i.e. 1.28 per cent in besan laddu substituted with mushroom powder.

5.8 (c) Mineral composition

The calcium content (**Table 5.28**) of nugget substituted with dried fig ranged from 146.79 mg/100gm to 333.29 mg/100gm.In control it was only 146.79 mg/100gm increased significantly with more replacement of dried fig fruit. Maximum value of calcium content i.e. 333.29 mg/100gm was noted in T4. Similar increase in calcium content i.e. 335.0 per cent was

reported in bengal gram dal substituted with kondhara leaves (Singh *et al.*2014).This increase in calcium content might be due to high mineral content in fruits (Armeu *et al.* 2006).

Table 5.28 Mineral composition of nugget substituted with dried fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	146.79± 0.00 [a]	241.01±0.00 [b] (64.18%)↑	307.95±0.00 [c] (109.78%)↑	339.29±0.00 [cd] (131.13%)↑
Iron (mg/100gm)	10.92±0.00 [a]	16.04±0.00 [b] (46.61%)↑	18.14±0.00 [c] (66.11%)↑	19.88±0.00 [cd] (82.05%)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	666.54±0.00 [b] (105.65%)↑	704.27±0.00 [c] (117.30%)↑	754.35±0.00 [cd] (132.75%)↑

The iron content of nugget substituted with dried fig ranged from 10.92 mg/100gm to 19.88 mg/100gm. The iron content significantly increase ($p<0.05$) in nugget samples substituted with dried fig. The iron content increased with increase in dried fig fruit substitution. Similar increase in iron content i.e. 3.90 to 8.99 per cent was reported in legume composite flour thalipeeth (pan cake like product) substituted with green leafy vegetables (Gupta and Prakash, 2011). Singh *et al.*(2014) also reported similar increase in iron content i.e. 7.25 to 28.77 per cent in bengal gram dal substituted with kondhara leaves. Similar increase in iron content i.e. 6.10 to 6.34 per cent was reported in gram composite flour khakara substituted with carrot powder (Surekha and Naik, 2014).

The phosphorus content (**Table 5.28**) of nugget substituted with dried fig ranged from 324.1 mg/100gm to 754.35 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$)in nugget samples substituted with dried fig. The phosphorus content increased with increase in dried fig fruit substitution. The phosphorus content was highest in T3 (754.35 mg/100gm) and lowest in T1(324.1 mg/100gm). Similar increase in phosphorus content i.e. 320 to 378 per cent was reported in gram composite flour roti substituted with methi powder (Kadam *et al*.2012).

Fig. 5.14 T1 (control sample = 100% green gram nugget,

T2=15 % fig, T3=30% fig, T4 =45 % fig)

5.9 Formulation of value added products with the substitution of karonda

5.9 (a) Bun

5.9 (b) Nutritional composition

The moisture content (**Table 5.29**) of wheat flour bun substituted with fresh karonda fruit ranged from 6.47 per cent to 9.87 per cent. In control it was only 6.47 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of moisture content i.e. 9.87 per cent was noted in B4. Similar increase in moisture content i.e. 9.50 per cent was reported in biscuit substituted with date palm fruit (Sharnouby *et al.* 2012). This increase in moisture content might be due to high moisture content in fresh fruit (Rosell *et al.* 2011).

The ash content of wheat flour bun substituted with fresh karonda ranged from 1.10 per cent to 1.29 per cent. The ash content increased non significantly ($p>0.05$) in bun samples substituted with fresh karonda. The ash content increased with increase in fresh karonda fruit substitution. Similar increase in ash content i.e. 1.30 to 1.60 per cent was reported in wheat flour bun substituted with ripe pawpaw pulp (Adubofuor and Mensah, 2012). See *et al.* (2007) also reported similar increase in ash content i.e.1.83 to 2.43 per cent in bread substituted with pumpkin flour. This increase in ash content might be due to the high ash content in fruit (El-Sharnouby *et al.* 2012).

The carbohydrate content (**Table 5.29**) of wheat flour bun substituted with fresh karonda ranged from 75.52 per cent to 107.56 per cent. In control it was only 75.52 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of carbohydrate content i.e. 107.56 per cent was noted in B4. Similar increase in carbohydrate content i.e. 78.69 per cent was reported in cookies substituted with unripe plantain flour (Chinma *et al*. 2012). This increase in carbohydrate content may be due to high carbohydrate content in fruits (Kulkarni and Joshi, 2014).

Table 5.29 Nutritional composition of bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
Moisture (%)	6.47± 0.02[a]	7.45±0.01[b] (15.14%) ↑	8.24±0.66[cd] (52.55%)↑	9.87±0.02[c] (27.35%)↑
Ash (%)	1.10±0.05[a]	1.16±0.05[a] (3.59 %)↑	1.19±0.05[a] (7.91 %)↑	1.29±0.20[a] (23.74 %)↑
Carbohydrate (%)	75.52±0.01[a]	89.58±0.07[b] (18.61%)↑	98.05±0.05[c] (29.83%)↑	107.56±0.05[cd] (42.42%)↑
Protein (%)	6.64±0.14[a]	6.79±0.08[a] (2.25%)↑	7.10±0.1[b] (6.92%)↑	7.52±0.08[bc] (13.25%)↑
Fat (%)	1.62±0.07[a]	1.73±0.04[a] (6.79%)↑	1.82±0.05[a] (12.34%)↑	1.92±0.28[a] (18.52%)↑

Where, B1 (control sample) = 100% wheat flour bun, B2= 15% karonda, B3=30% karonda, B4= 45% karonda)

The protein content of wheat flour bun substituted with fresh karonda ranged from 6.64 per cent to 7.52 per cent. The protein content significantly increase ($p<0.05$) in all bun samples substituted with fresh karonda. The protein content increased with increase in fresh karonda fruit substitution. Similar increase in protein content i.e. 7.01 to 7.69 per cent was reported in bread substituted with bread fruit flour (Alice *et al*. 2012). Youssef *et al.* (2012) also reported similar increase in protein content i.e. 7.01 to 7.69 per cent in wheat flour biscuit substituted with citrus peels powder. This increase in protein content might be due to high protein content in fruits (Thorvaldsson and Skjoldebrand, 1998).

The fat content (**Table 5.29**) of wheat flour bun substituted with fresh karonda ranged from 1.62 per cent to 1.92 per cent. Similar results, i.e. 1.57 per cent was reported by Michael *et al*. (2013) in wheat flour bread. The fat content non significantly increase ($p>0.05$) in bun samples substituted with fresh karonda. The fat content was highest in B4 (1.92 %) and lowest in B1(1.62 %). Similar increase in fat content i.e. 1.41 per cent was reported in wheat flour cookie substituted with unripe plantain flour (Chinma *et al*. 2012). This increase in fat content may be due to relative increase in fat content in fruits (Kulkarni and Joshi, 2014).

5.9 (c) Dietary fiber

The neutral detergent fiber (**Table 5.30**) of wheat flour bun substituted with fresh karonda ranged from 23.73 per cent to 25.66 per cent. Similar results, i.e. 23.16 per cent was reported by Krishan *et al.* (1987) in wheat flour bread. NDF increased significantly ($p<0.05$)in bun samples substituted with fresh karonda. The NDF was highest in B4 (25.66 %) and lowest in B1(23.73 %). Similar increase in dietary fiber i.e. 24.20 per cent was reported in bread substituted with watermelon rind (Ho and Dahri, 2016). Lopez *et al.* (2011) also reported similar increase i.e. 25.20 per cent in bread substituted with orange powder (Lopez *et al.* 2011). This increase in dietary fiber might be due to high dietary fiber in fruits (El- Sharnouby *et al.* 2012).

The acid detergent fiber (ADF) of wheat flour bun substituted with fresh karonda ranged from 1.30 per cent to 1.66 per cent. The ADF content increased non significantly ($p>0.05$)in bun samples substituted with fresh karonda. ADF increased with increase in fresh karonda fruit substitution. Similar increase in dietary fiber i.e. 0.75 to 1.13 per cent was reported in wheat flour cookie substituted with mango seed kernel (Legesse and Emire, 2012).

Table 5.30 Dietary fiber of bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
NDF (%)	23.73±0.10[a]	24.23±0.05[a] (2.10%)↑	24.83±0.98[a] (4.63%)↑	25.66±0.23[ab] (8.13%)↑
ADF (%)	1.30±0.45[a]	1.56±0.20[a] (20.0%)↑	1.60±0.17[a] (23.07%)↑	1.66±0.11[a] (27.69%)↑
Hemicellulose (%)	22.39±0.00[a]	22.69±0.00[a] (1.33%)↑	23.22±0.00[a] (3.70%)↑	23.99±0.00[a] (7.14%)↑
Cellulose (%)	2.48±0.10[a]	2.59±0.04[a] (4.43%)↑	2.64±0.05[a] (6.45%)↑	2.83±0.10[b] (14.11%)↑
Lignin (%)	1.23±0.63[a]	1.63±0.05[a] (32.52%)↑	1.66 ±0.05[a] (34.95 %)↑	1.73±0.05[a] (40.65 %)↑

Hemicellulose content (**Table 5.30**) of wheat flour bun substituted with fresh karonda ranged from 23.39 per cent to 23.99 per cent. Hemicellulose content increased non significantly ($p>0.05$) in bun samples substituted with fresh karonda. The hemicellulose content was highest in B4 (23.99 %) and lowest in B1(22.39 %).

The cellulose content of wheat flour bun substituted with fresh karonda ranged from 2.48 per cent to 2.83 per cent. The cellulose content significantly increased ($p<0.05$) in bun samples substituted with fresh karonda. The cellulose content increased with increase in fresh karonda fruit substitution. Similar increase in cellulose content i.e. 0.02 to 7.66 per cent was reported in

cookies substituted with raspberry pomace fruit (Gorecka *et al.* 2010). This increase in dietary fiber might be due to addition of cellulose rich fruits (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.30**) of wheat flour bun substituted with fresh karonda ranged from 1.23 per cent to 1.73 per cent. The results of the lignin content increased non significantly ($p>0.05$)in bun samples substituted with fresh karonda. The lignin content was highest in B4 (0.75 %) and lowest in B1(0.56 %). Similar increase in lignin content i.e.3.98 per cent was reported in wheat flour biscuits substituted with raspberry pomace fruit (Gorecka *et al.* (2010).

5.9 (d) Mineral composition

The calcium content (**Table 5.31**) of wheat flour bun substituted with fresh karonda ranged from 10.80 mg/100gm to 94.05 mg/100gm. Similar results, i.e. 10.70 mg/100gm was reported by Surekha *et al*. (2013) in wheat flour cookie. In control it was only 10.80 mg/100gm increased significantly with more replacement of fresh karonda fruit. Maximum value of calcium content i.e. 94.05 mg/100gm was noted in B4. Similar increase in calcium content i.e. 32 per cent was reported in wheat flour cake substituted with beetroot powder (Pinki and Awasthi, 2014). Seleem (2015) also reported similar increase in calcium content i.e. 20.40 per cent in wheat flour cake substituted with doum fruit powder. This increase in calcium content might be due to high mineral content in fruits (Kulkarni and Joshi, 2013).

The iron content of wheat flour bun substituted with fresh karonda ranged from 25.83 mg/100gm to 369.12 mg/100gm. The iron content significantly increase ($p<0.05$) in bun samples substituted with fresh karonda. The iron content increased with increase in fresh karonda fruit substitution. Similar increase in iron content i.e. 21 to 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

Table 5.31 Mineral composition of bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
Calcium (mg/100gm)	10.80 ± 0.00^{a}	49.57 ± 0.00^{b} (358.98%)↑	57.40 ± 0.00^{c} (431.48%)↑	94.05 ± 0.00^{cd} (770.83%)↑
Iron (mg/100gm)	25.83 ± 0.00^{a}	307.61 ± 0.00^{b} (1090.90%)↑	355.43 ± 0.00^{c} (1276.03%)↑	369.12 ± 0.00^{cd} (1329.0%)↑
Phosphorus (mg/100gm)	333.39 ± 0.00^{a}	416.77 ± 0.00^{b} (25.0%)↑	443.73 ± 0.00^{c} (33.09%)↑	501.13 ± 5.77^{cd} (50.31%)↑

The phosphorus content (**Table 5.31**) of wheat flour bun substituted with fresh karonda ranged from 333.39 mg/100gm to 501.13 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in bun samples substituted with fresh karonda. The phosphorus content was highest in B4 (501.13 mg/100gm) and lowest in B1(333.39 mg/100gm). Similar increase in phosphorus content i.e.377.15 per cent was reported in wheat flour chapatti substituted with date pulp (Waghray *et al.*2011). Similar increase in phosphorus content i.e. 540 per cent was reported in wheat bran biscuit substituted with palm fruit (El- Sharnouby *et al*. 2012).

5.9 (e) Organoleptic Analysis

Table 5.32 Bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
Appearance	7.4±0.69[a]	7.5±0.52 [a]	7.4±0.51 [a]	7.2±0.42 [a]
Colour	7.2±0.42 [a]	7.4±0.51 [a]	7.6±0.52 [a]	7.2±0.42 [a]
Texture	7.2±0.63 [a]	7.5±0.52 [a]	7.5±0.52 [a]	7.2±0.42 [a]
Flavour	7.5±0.52 [a]	7.4±0.51 [a]	7.6±0.51 [a]	7.3±0.48 [a]
Overall Acceptability	7.3±0.48 [a]	7.5±0.52 [a]	7.5±0.52 [a]	7.2±0.63 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant($p<0.05$)

Where, B1 (control sample) = 100% wheat flour bun, B2=15 % karonda, B3=30% karonda, B4 =45 %karonda)

As shown in Table 5.32, sensory characteristics of wheat flour bun substituted with fresh karonda B2, B3 and B4 were non significantly ($p>0.05$) different from wheat flour bun B1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour bun substituted with fresh karonda were not affected by increased concentration of fresh karonda. However, all samples were found to be acceptable.

Fig. 5.15 B1(control sample) = 100% wheat flour bun,

B2=15 % karonda,B3=30% karonda, B4 =45 % karonda)

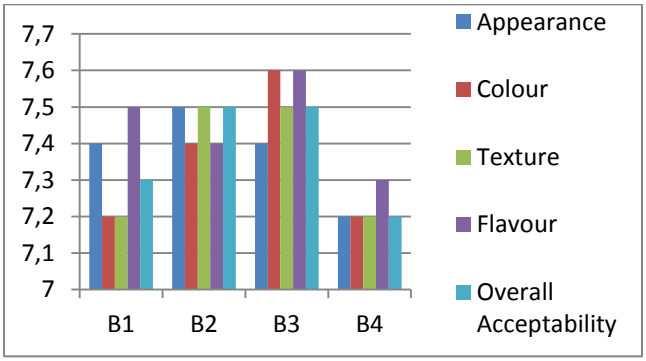

Fig. 5.16 Sensory scores of bun samples

5. 10 Muffin

5.10 (a) Nutritional composition

The moisture content (**Table 5.33**) of wheat flour muffin substituted with fresh karonda ranged from 10.80 per cent to 20.80 per cent. Similar results, i.e. 10.96 per cent was reported by Uchenna *et al*. (2013) in wheat flour muffin. In control it was only 10.80 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of moisture content i.e. 20.80 per cent was noted in B4.Similarincrease in moisture content i.e. 9.50 per cent was reported in wheat bran biscuits substituted with date palm powder (El- Sharnouby *et al.* 2012). Mansour *et al.* (1999) also reported similar increase in moisture content in wheat flour muffin substituted with pumpkin powder. This increase in moisture content might be due to high moisture content in fruits (Rosell *et al.* 2011).

Table 5.33 Nutritional composition of muffin substituted with fresh karonda

Parameters	B1	B2	B3	B4
Moisture (%)	10.80 ± 0.1^{a}	20.66 ± 0.05^{b} (91.29%)↑	19.68 ± 0.09^{c} (102.12%)↑	21.83 ± 0.00^{ad} (82.22%)↑
Ash(%)	1.12 ± 0.11^{a}	1.13 ± 0.10^{a} (0.89 %)↑	1.19 ± 0.05^{a} (6.25 %)↑	1.28 ± 0.19^{a} (14.28 %)↑
Carbohydrate (%)	45.45 ± 0.48^{a}	52.29 ± 2.22^{b} (15.04%)↑	61.16 ± 3.20^{c} (34.56%)↑	70.07 ± 0.02^{cd} (54.16%)↑
Protein (%)	6.42 ± 0.12^{a}	7.16 ± 0.05^{a} (11.52%)↑	7.52 ± 0.08^{b} (17.13%)↑	7.76 ± 0.08^{bc} (20.87%)↑
Fat (%)	10.33 ± 0.11^{a}	11.53 ± 0.11^{b} (11.61%)↑	12.53 ± 0.11^{c} (21.29%)↑	12.73 ± 0.11^{cd} (23.23%)↑

The ash content of wheat flour muffin substituted with fresh karonda ranged from 1.12 per cent to 1.28 per cent. The ash content non significantly increase ($p>0.05$) in muffin samples substituted with fresh karonda. The ash content increased with increase in fresh karonda fruit

substitution. Similar increase in ash content i.e.1.42 to 1.52 per cent was reported in muffin substituted with apple skin powder (Rupasinghe *et al.* 2008). Lopez *et al.* (2011) also reported similar increase in ash content i.e. 2.20 to 3.70 per cent in muffin substituted with orange powder. This increase in ash content might be due to high ash content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.33**) of wheat flour muffin substituted with fresh karonda ranged from 45.45 per cent to 70.07 per cent. Similar results, i.e. 45.08 per cent was reported by Krishanaprabha and Kiruthiga (2015) in wheat flour muffin. In control it was only 45.45 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of carbohydrate content i.e. 70.07 per cent was noted in B4. Similar increase in carbohydrate content i.e. 64.81 per cent was reported in wheat flour biscuit substituted with pumpkin powder (Kulkarni and Joshi, 2013). This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour muffin substituted with fresh karonda ranged from 6.42 per cent to 7.76 per cent. Similar results, i.e. 6.73 per cent was reported by Jauharah *et al.* (2014) in wheat flour muffin. The protein content significantly increase ($p<0.05$) in muffin samples substituted with fresh karonda. The protein content increased with increase in fresh karonda fruit substitution. Similar increase in protein content i.e.6.10 to 7.0 per cent was reported in wheat flour cake substituted with beetroot powder (Pinki and Awasthi, 2014). Jauharah *et al.* (2014) also reported similar increase in protein content in muffin substituted with corn powder. This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.33**) of wheat flour muffin substituted with fresh karonda ranged from 10.33 per cent to 12.73 per cent. The fat content significantly increase ($p<0.05$) in muffin samples substituted with fresh karonda. The fat content was highest in B4 (12.73 %) and lowest in B1(10.33 %). Similar increase in fat content i.e. 12.80 per cent was reported in wheat flour cookies substituted with mango kernel seed (Legesse and Emire,2012). Waghray *et al.* (2011) also reported similar increase in fat content i.e. 7.54 per cent in wheat flour chapatti substituted with dates. This increase in fat content may be due to high fat content in fruits (Asp and Bjorck, 1992).

5. 10 (b) Dietary fiber

The neutral detergent fiber (**Table 5.34**) of wheat flour muffin substituted with fresh karonda ranged from 23.66 per cent to 25.30 per cent. NDF increased non significantly ($p>0.05$) in muffin samples substituted with fresh karonda. The NDF was highest in B4 (25.30 %) and lowest in B1(23.66 %). Similar increase in NDF i.e. 24.68 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to relative increase of fiber content in fruits (Sadiq*et al.* 2003).

Table 5.34 Dietary fiber of muffin substituted with fresh karonda

Parameters	B1	B2	B3	B4
NDF(%)	23.66 ± 0.15^{a}	24.10 ± 0.34^{a} (1.85%)↑	24.46 ± 0.86^{a} (3.38%)↑	25.30 ± 0.86^{a} (6.93) ↑
ADF(%)	5.46 ± 0.63^{a}	6.06 ± 0.63^{a} (10.98%)↑	6.20 ± 1.10^{a} (13.55%)↑	6.56 ± 0.63^{a} (20.14%)↑
Hemicellulose (%)	17.86 ± 0.00^{a}	18.03 ± 0.00^{b} (0.95%)↑	18.25 ± 0.00^{c} (2.18%)↑	18.32 ± 0.00^{cd} (2.57%)↑
Cellulose(%)	4.18 ± 0.19^{a}	4.22 ± 0.19^{a} (0.95%)↑	4.26 ± 0.19^{a} (1.91%)↑	4.27 ± 0.19^{a} (2.15%)↑
Lignin (%)	1.60 ± 0.01^{b}	1.72 ± 0.02^{a} (7.50%)↑	1.73 ± 0.01^{a} (8.12%)↑	1.74 ± 0.01^{ab} (8.75%)↑

The acid detergent fiber (ADF) of wheat flour muffin substituted with fresh karonda ranged from 5.46 per cent to 6.56 per cent. The ADF content non significantly increase ($p>0.05$) in muffin samples substituted with fresh karonda. ADF increased with increase in fresh karonda fruit substitution. Similar increase in ADF i.e. 1.11 to 8.05 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010).

Hemicellulose content (**Table 5.34**) of wheat flour muffin substituted with fresh karonda ranged from 17.86 per cent to 18.32 per cent. Hemicellulose content increased significantly ($p<0.05$) in muffin samples substituted with fresh karonda. The hemicellulose content was highest in B4 (18.32 %) and lowest in B1(17.86 %). Similar increase in dietary fiber i.e. 19.00 per cent was reported in wheat flour biscuit substituted with grape pomace (Szkudlarz *et al.* 2013).

The cellulose content of wheat flour muffin substituted with fresh karonda ranged from 4.18 per cent to 4.27 per cent. Similar results, i.e. 4.50 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. The cellulose content non significantly increase ($p>0.05$) in cellulose content was observed in muffin samples substituted with fresh karonda. The cellulose content increased with increase in fresh karonda fruit substitution. Similar increase in dietary fiber i.e. 1.44 to 4.24 per cent was observed in wheat flour cookies substituted with unripe plantain flour (Chinma *et al.* 2012). Similar increase in cellulose content i.e. 0.02 to 4.07 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to addition of dietary fiber rich fruits in muffin, especially cellulose content (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.34**) of wheat flour muffin substituted with fresh karonda ranged from 1.60 per cent to 1.74 per cent. Similar results, i.e. 1.80 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. The results of lignin content increased significantly ($p<0.05$) in muffin samples substituted with fresh karonda. The lignin content was highest in B4 (1.74 %) and lowest in B1(1.60 %). Similar increase in dietary fiber i.e. 1.28 per cent was reported in wheat flour mathri substituted with potato flour (Kaur and Kochhar,2014).

5.10 (c) Mineral composition

The calcium content (**Table 5.35**) of wheat flour muffin substituted with fresh karonda ranged from 146.79 mg/100gm to 234.41 mg/100gm. In control it was only 146.79 mg/100gm increased significantly with more replacement of fresh karonda fruit. Maximum value of calcium content i.e. 234.41 mg/100gm was noted in B4. Similar increase in calcium content i.e. 148.33 per cent was reported in muffin substituted with carrot powder (Romjaun and

Prakash, 2015). This increase in calcium content might be due to high mineral content in fruits (Waghray *et al.* 2011).

Table 5.35 Mineral composition of muffin substituted with fresh karonda

Parameters	B1	B2	B3	B 4
Calcium (mg/100gm)	146.79±0.00^{a}	148.16±0.00^{a} (0.93%)↑	172.97±0.00^{a} (17.83%)↑	234.41±51.96^{ab} (59.69%)↑
Iron (mg/100gm)	10.92±0.00^{a}	11.33±0.00^{b} (3.75%)↑	12.07±0.00^{c} (10.53%)↑	13.31±0.00^{cd} (21.88%)↑
Phosphorus (mg/100gm)	62.40±0.00^{a}	72.28±0.00^{b} (15.83%)↑	76.86±0.00^{c} (23.17%)↑	81.74±0.00^{cd} (30.99%)↑

The iron content of wheat flour muffin substituted with fresh karonda ranged from 10.92 mg/100gm to 13.31 mg/100gm. The result of iron content significantly increase ($p<0.05$) in muffin samples substituted with fresh karonda. The iron content increased with increase in fresh karonda fruit substitution. Seleem (2013) also reported similar increase in iron content i.e. 4.80 to 5.03 per cent in wheat flour muffin substituted with doum fruit powder.

The phosphorus content (**Table 5.35**) of wheat flour muffin substituted with fresh karonda ranged from 62.40 mg/100gm to 81.74 mg/100gm.The results of the phosphorus content increased significantly ($p<0.05$)in muffin samples substituted with fresh karonda. The phosphorus content was highest in B4 (81.74 mg/100gm) and lowest in B1(62.40 mg/100gm).

5.10 (d) Organoleptic analysis

Table 5.36 Muffin substituted with fresh karonda

Parameters	B1	B2	B3	B4
Appearance	7.9±0.31 [a]	7.4±0.51 [a]	7.4±0.48 [a]	7.2±0.42 [a]
Colour	7.2±0.42 [a]	7.4±0.51 [a]	7.6±0.51 [a]	7.1±0.56 [a]
Texture	7.3±0.48 [a]	7.7±0.48 [a]	7.5±0.52 [a]	7.4±0.51 [a]
Flavour	7.8±0.42 [a]	7.5±0.52 [a]	7.4±0.51 [a]	7.3±0.48 [a]
Overall Acceptability	7.6±0.51 [a]	7.6±0.51 [a]	7.5±0.52 [a]	7.4±0.51 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant ($p<0.05$)

Where, B1 (control sample) = 100% wheat flour bun, B2=15 % karonda, B3=30% karonda, B4 =45 % karonda)

As shown in Table 5.36, sensory characteristics of wheat flour muffin substituted with fresh karonda B2, B3 and B4 were non significantly ($p>0.05$) different from wheat flour muffin B1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour muffin substituted with fresh karonda were not affected by increased concentration of fresh karonda. However, all samples were found to be acceptable.

Fig. 5.17 B1 (control sample) = 100% wheat flour muffin,

B2 =15 % karonda, B3 =30% karonda, B4 =45 % karonda)

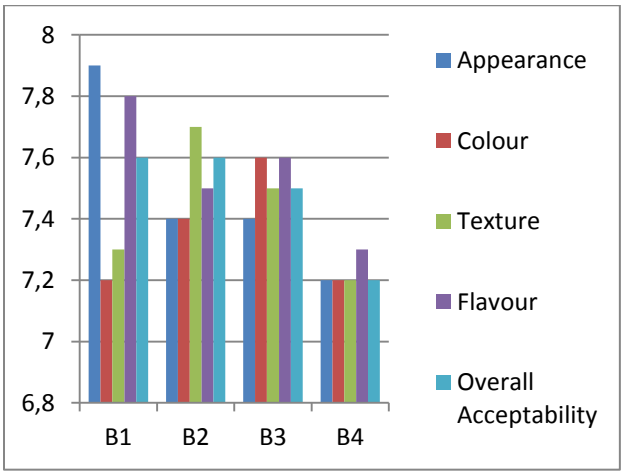

Fig. 5.18 Sensory scores of muffin samples

5.11 Noodles

5.11 (a) Nutritional composition

The moisture content (**Table 5.37**) of wheat flour noodles substituted with dried karonda ranged from 6.61 per cent to 9.88 per cent. In control it was only 6.61 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of moisture content i.e. 9.88 per cent was noted in B4. Similar increase in moisture content i.e. 9.73 per cent in wheat flour pasta substituted with orange fiber (Crizel *et al.* 2015). Similar increase in moisture content i.e. 8.67 per cent was also reported in wheat flour noodles substituted with unripe banana flour (Ritthiruangdej *et al*. 2011). This increase in moisture content might be due to relative increase of moisture content in fruits (Raj and Masih, 2014).

The ash content of wheat flour noodles substituted with dried karonda ranged from 2.00 per cent to 2.13 per cent. Similar results, i.e. 2.21 per cent was reported by Taneya *et al*. (2014) in wheat flour noodles. The ash content non significantly increase ($p>0.05$) in noodles samples substituted with dried karonda. The ash content increased with increase in dried karonda fruit substitution. Similar increase in ash content i.e. 0.87 to 1.64per cent was reported in wheat flour spaghetti substituted with banana flour (Diaz *et al.*2014). This increase in ash content might be due to high ash content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.37**) of wheat flour noodles substituted with dried karonda ranged from 85.53 per cent to 112.56 per cent. In control it was only 85.53 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of carbohydrate content i.e. 112.56 per cent was noted in B4. Similar increase in carbohydrate content i.e. 97.57 per cent was reported in wheat flour bread substituted with breadfruit flour (Alice *et al.* 2012). Ariffin *et al.* (2015) also reported similar increase in carbohydrate content i.e. 86.75 per cent in wheat flour bread substituted with durian fruit flour. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

Table 5.37 Nutritional composition of noodles substituted with dried karonda

Parameters	B1	B2	B3	B4
Moisture (%)	6.61 ± 0.16 [a]	7.44± 0.01 [b] (12.56%)↑	7.65 ± 0.99 [cd] (49.47%)↑	9.88 ± 0.04 [c] (15.73%)↑
Ash(%)	2.00± 0.05 [a]	2.04 ± 0.10 [a] (2.00%)↑	2.11 ± 0.05 [a] (5.50%)↑	2.13 ± 0.00[a] (6.50%) ↑
Carbohydrate (%)	85.53±0.01 [a]	94.58±0.07 [b] (10.58%)↑	103.05±0.05[c] (20.48%)↑	112.56±0.05 [cd] (31.60%)↑
Protein (%)	6.51±0.11 [a]	6.79±0.08 [b] (4.30%)↑	7.10±0.1 [c] (9.06%)↑	7.52±0.08 [cd] (15.51%)↑
Fat (%)	1.56±0.02 [a]	2.20±0.07 [b] (41.02%)↑	2.70±0.39[bc] (73.07%)↑	3.59±0.03 [cd] (130.12%)↑

The protein content of wheat flour noodles substituted with dried karonda ranged from 6.51 per cent to 7.52 per cent. Similar results, i.e. 6.73 per cent was reported by Ho and Latif (2016) in wheat flour cookies. The protein content significantly increase ($p<0.05$) in noodles samples substituted with dried karonda. The protein content increased with increase in dried karonda fruit substitution. Similar increase in protein content i.e. 6.73 to 7.04 per cent was reported in wheat flour cookies substituted with pitaya peel flour (Ho and Latif, 2016). This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.37**) of wheat flour noodles substituted with dried karonda ranged from 1.56 per cent to 3.59 per cent. Similar results, i.e. 1.56 per cent was reported by Hardi *et al*. (2007) in wheat flour noodles. The fat content significantly increase ($p<0.05$) in noodles samples substituted with dried karonda. The fat content was highest in B4 (3.59 %) and lowest in B1(1.56 %). Similar increase in fat content i.e. 5.20 per cent was reported in wheat flour noodles substituted with banana peel (Singh *et al.* 2015). This increase in fat content may be due to relative increase of fat content in fruits (Vinod *et al*. 2015).

5.11 (b) Dietary fiber

The neutral detergent fiber (**Table 5.38**) of wheat flour noodles substituted with dried karonda ranged from 21.93 per cent to 25.16 per cent. NDF increased non significantly ($p>0.05$) in noodles substituted with dried karonda. The NDF was highest in B4 (25.16 %) and lowest in B1 (21.93 %). Similar increase in dietary fiber i.e. 24.2 per cent was reported in wheat flour noodles substituted with watermelon rind powder (Ho and Dahri, 2016). This increase in dietary fiber might be due to high dietary fiber in fruits (Vinod *et al*. 2015).

Table 5.38 Dietary fiber of noodles substituted with dried karonda

Parameters	B1	B2	B3	B4
NDF (%)	21.93±1.90 [a]	23.36±1.53 [a] (6.52%)↑	23.70±1.70 [a] (8.07%)↑	25.16±0.77 [a] (14.72%)↑
ADF (%)	1.53±0.05 [a]	1.63±0.11 [a] (6.53 %)↑	1.70±0.20 [a] (11.11%)↑	1.83±0.11 [a] (19.60%)↑
Hemicellulose (%)	21.4±4.35 [a]	21.73±0.00 [a] (1.54%)↑	23.00±0.00 [a] (7.47%)↑	24.33±0.00 [a] (13.69%)↑
Cellulose (%)	3.14±0.18 [a]	3.18±0.22 [a] (1.27%)↑	3.20±0.02 [a] (1.91%)↑	3.23±0.00 [a] (2.86%)↑
Lignin (%)	1.46±0.05 [a]	1.56±0.05 [a] (6.84%)↑	1.63±0.05 [ab] (11.64 %)↑	1.76±0.05 [b] (20.54 %)↑

The acid detergent fiber (ADF) of wheat flour noodles substituted with dried karonda ranged from 1.53 per cent to 1.83 per cent. The ADF non significantly increase ($p>0.05$) in ADF was observed in noodles samples substituted with dried karonda. The ADF increased with increase in dried karonda fruit substitution.

Hemicellulose content (**Table 5.20**) of wheat flour noodles substituted with dried karonda ranged from 21.40 per cent to 24.33 per cent. Hemicellulose content increased non significantly ($p>0.05$) in noodles substituted with dried karonda. The hemicellulose content was highest in B4 (24.33%) and lowest in B1 (21.40 %).

The cellulose content of wheat flour noodles substituted with dried karonda ranged from 3.14 per cent to 3.23 per cent. The cellulose content non significantly increase ($p>0.05$) in noodles samples substituted with dried karonda. The cellulose content increased with increase in dried karonda fruit substitution. This increase in dietary fiber might be due to addition of dietary fiber rich fruits (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.38**) of wheat flour noodles substituted with dried karonda ranged from 1.46 per cent to 1.76 per cent. Similar results, i.e. 1.08 per cent was reported by Gorecka *et al.* (2010) in wheat flour cookies. The results of the lignin content increased significantly ($p<0.05$) in noodles samples substituted with dried karonda. The lignin content was highest in B4 (0.76 %) and lowest in B1(0.46 %). Similar increase in dietary fiber i.e. 0.75 per cent was reported in wheat flour biscuits substituted with jackfruit powder (Butool and Butool, 2013).

5.11 (c) Mineral composition

The calcium content (**Table 5.39**) of wheat flour noodles substituted with dried karonda ranged from 18.96 mg/100gm to 22.67 mg/100gm. In control it was only 18.96 mg/100gm increased significantly with more replacement of dried karonda fruit. Maximum value of calcium content i.e. 22.67 mg/100gm was noted in B4. Similar increase in calcium content i.e. 20.40 per cent was reported in wheat flour cake substituted with doum fruit powder. This increase in calcium content might be due to high mineral content in fruits (Niemen *et al*. 1992).

Table 5.39 Mineral composition of noodles substituted with dried karonda

Parameters	B1	B2	B3	B4
Calcium (mg/100gm)	18.96±0.00 [a]	19.71±0.00 [b] (3.95%)↑	22.19±0.00 [c] (17.03%)↑	22.67±0.00 [cd] (19.56%)↑
Iron (mg/100gm)	10.92±0.00 [a]	16.04±0.00 [b] (11.11%)↑	19.88±0.00 [cd] (33.33%)↑	23.80±0.00 [b] (77.77%)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	344.83±0.00 [cd] (9.09%)↑	423.54±0.00 [c] (36.36%)↑	513.20±0.00 [b] (45.45%)↑

The iron content of wheat flour noodles substituted with dried karonda ranged from 10.92 mg/100gm to 23.80 mg/100gm. The iron content significantly increase ($p<0.05$) in noodles samples substituted with dried karonda. The iron content increased with increase in dried karonda fruit substitution.

The phosphorus content (**Table 5.39**) of wheat flour noodles substituted with dried karonda ranged from 324.1 mg/100gm to 513.20 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in noodles samples substituted with dried karonda. The phosphorus content was highest in B4 (0.16 mg/100gm) and lowest in B1(0.11 mg/100gm). Similar increase in phosphorus content i.e. 467 per cent was reported in wheat flour cakes substituted with beetroot powder (Pinki and Awasthi, 2014).

Fig. 5.19 B1 (control sample = 100% wheat flour noodles, B2 =15 % karonda, B3 =30% karonda, B4 =45 % karonda)

5.12 Nugget

5.12 (a) Nutritional composition

The moisture content (Table 5.40) of green gram nugget substituted with dried karonda ranged from 19.68 per cent to 21.83 per cent. In control it was only 19.68 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of moisture content i.e. 21.83 per cent was noted in B4. Similar increase in moisture content i.e. 22.98 per cent was reported in composite pulse flour chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in moisture content might be due to high moisture content in fruits (Raj and Masih, 2014).

Table 5.40 Nutritional composition of nugget substituted with dried karonda

Parameters	B1	B2	B3	B4
Moisture (%)	19.68±0.09 ^{ac}	19.80±0.1 ^{a} (0.60%)↑	20.66±0.05 ^{b} (4.97%)↑	21.83±0.00 ^{c} (10.92%)↑
Ash (%)	1.10±0.05 ^{a}	1.13±0.10 ^{a} (2.72 %)↑	1.16±0.05 ^{a} (5.45 %)↑	1.19±0.05 ^{a} (8.18 %)↑
Carbohydrate (%)	65.64±0.22 ^{a}	74.53±0.40 ^{b} (13.54%)↑	82.99±0.24 ^{c} (26.43%)↑	93.30±1.04 ^{cd} (42.13%)↑
Protein (%)	13.34±0.08 ^{a}	14.00±0.1 ^{b} (4.94%)↑	14.10±0.1 ^{bc} (5.69%)↑	14.37±0.12 ^{cd} (7.72%)↑
Fat (%)	1.85±2.71 ^{a}	2.74±0.05 ^{b} (48.10%)↑	3.31±0.24 ^{c} (78.91%)↑	3.96±0.30 ^{cd} (114.05%)↑

The ash content of green gram nugget substituted with dried karonda ranged from 1.10 per cent to 1.19 per cent. Similar results, i.e. 1.64 per cent was reported by Sharma and Chopra (2015) in nugget. The ash content non significantly increase ($p>0.05$) in nugget samples substituted with dried karonda. The ash content increased with increase in dried karonda fruit substitution. Similar increase in ash content i.e. 0.76 to 2.30 per cent was reported in green gram

dal substituted with bathua leaves (Singh *et al.* 2007). This increase in ash content might be due to high ash content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.40**) of green gram nugget substituted with dried karonda ranged from 65.64 per cent to 93.30 per cent. Similar results, i.e. 65.50 per cent was reported by Aziz *et al*. (2012) in nugget. In control it was only 65.64 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of carbohydrate content i.e. 93.30 per cent was noted in B4. Similar increase in carbohydrate content i.e. 70.72 per cent was reported in bengal gram dal substituted with kondhara leaves (Singh *et al.* 2014). This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of green gram nugget substituted with dried karonda ranged from 13.34 per cent to 14.37 per cent. Similar results, i.e. 12.86 per cent was reported by Singh and Sharma (2003) in bengalgram roll. The protein content significantly increase ($p<0.05$) in nugget samples substituted with dried karonda. The protein content increased with increase in dried karonda fruit substitution. Similar increase in protein content i.e. 11.48 to 30.44 per cent was reported in bengal gram dal substituted with kondhara leaves (Sultana *et al.* 2014). This increase in protein content might be due to high protein content in fruits (Waghray *et al.* 2011).

The fat content (**Table 5.40**) of green gram nugget substituted with dried karonda ranged from 1.85 per cent to 3.96 per cent. Similar results, i.e. 1.30 per cent was reported by Pardeshi *et al*. (2013) in nugget. The fat content significantly increase ($p<0.05$) in fat content was observed in nugget samples substituted with dried karonda. The fat content was highest in B4 (3.96%) and lowest in B1(1.85 %). Similar increase in fat content i.e. 1.28 per cent was reported in gram flour based chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in fat content may be due to high fat content in fruits (Vinod *et al*. 2015).

5.12 (b) Dietary fiber

The neutral detergent fiber (**Table 5.41**) of green gram nugget substituted with dried karonda ranged from 23.56 per cent to 25.30 per cent. NDF increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The NDF was highest in B4 (25.30 %) and lowest in B1 (23.56 %). This increase in dietary fiber might be due to high dietary fiber in fruits (Choo and Aziz, 2010).

Table 5.41 Dietary fiber of nugget substituted with dried karonda

Parameters	B1	B2	B3	B4
NDF (%)	23.56±0.11 [a]	23.93±0.32 [a] (1.57%)↑	24.30±0.95 [a] (3.14%)↑	25.30±0.86 [ab] (7.38%)↑
ADF (%)	21.06±0.92 [a]	21.73±0.23 [a] (3.18%)↑	21.76±1.85 [a] (3.32%)↑	22.63±1.45 [a] (7.45%)↑
Hemicellulose (%)	1.97±0.00 [a]	2.20±0.00 [b] (11.67%)↑	2.33±0.00 [c] (18.27%)↑	2.54±0.00 [cd] (28.93%)↑
Cellulose (%)	11.88±0.65 [a]	12.23±0.00 [a] (2.94%)↑	12.67±0.58 [a] (6.64%)↑	12.97±0.63 [a] (9.17%)↑
Lignin (%)	1.68±0.00 [a]	1.72±0.01 [a] (1.17%)↑	1.73±0.01 [a] (1.76%)↑	1.74±0.01 [ab] (2.35%)↑

The acid detergent fiber (ADF) of nugget substituted with dried karonda ranged from 21.06 per cent to 22.63 per cent. The ADF increased non significantly ($p>0.05$) in nugget samples substituted with dried karonda. The ADF increased with increase in dried karonda fruit substitution.

Hemicellulose content (**Table 5.41**) of nugget ranged from 1.97 per cent to 2.54 per cent. Hemicellulose content increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The hemicellulose content was highest in B4 (2.54 %) and lowest in B1(1.97

%). Similar increase in hemicellulose content i.e. 0.25 to 5.75 per cent was reported in dietary fiber in bengal gram dal substituted with kondhara leaves (Singh *et al.* 2014). Singh *et al.* (2007) also reported similar increase i.e. 0.38 to 0.51 per cent in green gram dal substituted with bathua leaves.

The cellulose content of nugget ranged from 11.88 per cent to 12.97 per cent. The cellulose content non significantly increase ($p>0.05$) in all nugget samples substituted with dried karonda. The cellulose content increased with increase in dried karonda fruit substitution. This increase in dietary fiber might be due to presence of high dietary fiber in fruits (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.41**) of nugget ranged from 1.68 per cent to 1.74 per cent. The results of the lignin content increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The lignin content was highest in B4 (1.74 %) and lowest in B1(1.68 %). Similar increase in lignin content i.e. 1.28 per cent was reported in besan laddu substituted with mushroom powder (Verma and Singh, 2014).

5.12 (c) Mineral composition

The calcium content (**Table 5.42**) of nugget ranged from 146.79 mg/100gm to 204.41 mg/100gm. In control it was only 146.79 mg/100gm increased significantly with more replacement of dried karonda fruit. Maximum value of calcium content i.e. 204.41 mg/100gm was noted in B4. Similar increase in calcium content i.e.116.93 per cent was reported in legume based pan cake (thalipeeth) substituted with shepu dried greens (Gupta and Prakash, 2011).

The iron content of nugget ranged from 10.92 mg/100gm to 13.31mg/100gm. The iron content significantly increase ($p<0.05$) in nugget samples substituted with dried karonda. The iron content increased with increase in dried karonda fruit substitution. Similar increase in iron content i.e. 3.90 to 8.99 per cent was reported in legume composite flour thalipeeth (pan cake like product) substituted with green leafy vegetables (Gupta and Prakash, 2011). Singh *et al.*(2014) also reported similar increase in iron content i.e. 7.25 to 28.77 per cent in bengal gram dal substituted with kondhara leaves .

Table 5.42 Mineral composition of nugget substituted with dried karonda

Parameters	B1	B2	B3	B4
Calcium (mg/100gm)	146.79± 0.00 [a]	148.16±0.00 [b] (0.93%)↑	172.97±0.00 [c] (16.74%)↑	204.41±0.00 [cd] (39.25%)↑
Iron (mg/100gm)	10.92±0.00 [a]	11.33±0.00 [b] (3.75%)↑	12.07±0.00 [c] (210.53%)↑	13.31±0.00 [cd] (21.88%)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	422.81±0.00 [b] (30.45%)↑	468.62±0.00 [c] (44.59%)↑	517.43±0.00 [cd] (59.65%)↑

The phosphorus content (**Table 5.42**) of nugget ranged from 324.1 mg/100gm to 517.43 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The phosphorus content was highest in B4 (517.43 mg/100gm) and lowest in B1(324.1 mg/100gm). Similar increase in phosphorus content i.e. 320 to 378 per cent was reported in gram composite flour roti substituted with methi powder (Kadam *et al*.2012).

Fig. 5.20 B1 (control sample) = 100% green gram nugget,

B2 =15 % karonda, B3 =30% karonda, B4 =45 % karonda)

2. REVIEW OF LITERATURE

A review of the literature related to different aspects of the present thesis is presented in this chapter. This includes the importance of underutilized fruits, fig and karonda fruit characteristics (morphological, nutritional and phytochemical), value added products development, experimental designs and influence of processing methods on selected fruits are also discussed.

Importance of fruits

Fruits are known as protective foods (Nicoli *et al.*, 1999). According to the Recommended Dietary Allowances (RDA), the consumption of fruits may increased in our daily diet. World Health Organization (2003) reported that fruits are richest source of dietary fiber, antioxidants and phytochemicals. As underutilized fruits contained folic acid, dietary fiber, proteins, vitamins, carbohydrate, minerals (Nandal and Bhardwaj, 2014) and contributed to control many chronic diseases of ageing (Pandey *et al*., 2014). Its increased fruit consumption has been recommended for the primary prevention of many diseases. Underutilized food crops are lesser known plant species in terms of marketing and research (Thakur, 2014). Underutilized crops are contributed 3.14 per cent of the total geographical area (Rai *et al*., 2005). According to Indian Government Economics statistics the area and production data for the underutilized crops was estimated 25.67 million ha and 43.05 tons in 2013-2014 (Ahmad and Raj, 2012). Today, consumers are becoming more conscious for their health and nutrition. Underutilized fruits are proved beneficial, therapeutically and nutritionally to satisfied consumers demand (Gajana and Godwa, 2010) and played very important role to control many diseases (Gajanana *et al*., 2010). These fruits are contributed great role to supplement human diet also (Vazhacharickal *et al*., 2015). Some fruits, which are at present underutilized and poorly addressed by the researcher (Gajanana *et al*., 2010) and needs to be acknowledged, employed and explored today's for future generation (Padulosi, 2008).

2.2 *FICUS CARICA* (FIG)

Fig characteristics (Morphological, nutritional and phytochemical)

Ficus carica is commonly known as "Fig "(Jander and Machado, 2008). Fruit has different colour (green, brown and purple) and contained numerous seed from 30-1600 per fruit bound with jelly like flesh (Joseph and Raj, 2011). It is a deciduous and cultivated fruit tree which belonging to Moraceae family. It is 50 feet tall and cultivated in Southwest Asia, India commercially only in some centres near Pune (Maharastra) and Anantpur district (South India). Mostly it is grown in Uttar Pradesh, Mysore, Punjab and Himachal Pradesh (The Wealth of India, 2001) ; (Tous and Ferguson,1996). It is richest source of mineral elements, calcium and fiber content (Vinson, 1999). Fig fruits are very nutritious and mainly used to made food products (Guesmi *et al.*,2006). It can be consumed in dried and as well as in preserved forms (Neal, 1965) because of limited intake due to seasonal availability, market accessibility and shelf life (Schmidt *et al.*, 2005). Dried fig could be stored for 6-8 months (Venkatartnam, 1988).

According to United States Department of Agriculture (USDA) dried figs are rich in fiber content and potassium content (Gilani *et al*., 2008) and also contained high quality of calcium (Vinson *et al.,* 2005). It contained total carbohydrate (24.27 mg/100gm), protein content (1.27 mg/100gm), calcium content (44.00 mg/100gm); (Zaenuri *et al.*,2014), iron content (4.09 mg/100gm) and potassium content (194 mg/100gm) in fresh fig fruit, respectively (Morton,1987). Fig fruits are fat as well as sodium free and cholesterol free (Vinson *et al*., 2005; Lianju *et al.*,2003). Dried fig contained higher polyphenol content and it is considered as functional foods (Solomon *et al.,* 2006; Vinson *et al.*,2005). It contained moderately higher content of crude fiber (5.8 %) and more than (28 %) of it is soluble type, which has been supported to control blood sugar (Sadhu,1990). *Ficus carica* have an antioxidant effect, which act as antibacterial, hypoglycemic effect, anti cancerous effect and hypotriglyceridaemic effects etc. (Wang *et al*., 2004). For that reason, it is consumed as fresh, dried and in the preserved form also (Mehraj *et al*., 2013).

In morphological characteristics of fig (*Ficus carica L.)*; Darjazi *et al.* (2011) showed that fresh fig fruit has (8.0 to 43.5 gm/100gm) weight and (21 to 45mm) diameter. Shobaki *et al.*

(2010) reported 82.20 per cent-moisture content, 0.65 per cent-ash content, 12.90 per cent-carbohydrate content, 1.00 per cent - protein content, 1.70 per cent- fat content and 1.55 per cent-fiber content in fig fruit. Similarly Khan *et al*. (2011) mentioned the nutritional composition of local variety of Pakistan fig contained 1.90 g/ 100 gm-ash content, 78.84mg/100gm- calcium content and 5.95 mg/100gm-iron content. Bhogaonkar *et al*. (2014) studied the nutritional potential of fresh *Ficus carica L*. fruits and reported 88.1 gm/100gm- moisture content, 1.3 gm/100gm- protein content, 0.2 gm/100gm-fat content,7.6 gm/100gm- carbohydrate content, 80 mg/100gm- calcium content, 30 mg/100gm- phosphorus content and 1.0 mg/100gm-iron content. Aljane *et al*. (2007) evaluated the atomic absorption analysis of mineral salts in fresh *Ficus carica* (Tunisian cultivars) and mentioned (304.57 mg/100gm) calcium content.

Solomon *et al*. (2006) mentioned that edible portion of fig contained 21.5 mg/100gm-flavonoids content and 11.0 mg/100gm – anthocyanins content. Duenas *et al*. (2008) reported *Ficus carica* fruit skin contained (97 µg/100gm) and pulp (15 µg/100gm) anthocyanin content.

Value added product development

Fruits are perishable in nature (Pathak *et al*., 2009), have short life span (7-10 days of post harvest life); (Sozzi *et al.,* 2005) and it affects the storage ability, physiological, nutritional and chemical properties of fruits (Orsat *et al.,*2006). Some fruits are astringent in taste and accepted less. Nowadays, these fruits are commonly used to prepared value added products, which improves nutritional value and acceptance level of the products (Goyal *et al.,* 2008; Singh *et al*.,2009). However, given studies have shown that the formation of innovative value added product with the incorporation of fruits. Khapre and Satwadhar, (2010) estimated the physico-chemical characteristics of *Ficus carica* fruit cv. DINKAR and its cabinet dried powder. Result showed fig fruit which was dried in a cabinet at temperature 60 °C (20-24 hours) contained 15.41 gm/100gm – fiber content, 22 gm/100gm – potassium and utilized in various value added products viz., icecream, milk shake, burfi and toffee. Chauhan *et al.* (2010) determined the development of food products incorporated with dried fig powder. Five products *viz., Idli, Biryani,* cake, *Gujiya* and *Ladoo* were prepared with the incorporation of *5* per cent, 10 per cent and 15 per cent dried fig powder. Results revealed that in case of sensory attributes, all the products which were incorporated by fig powder were accepted well. Khapre *et al.* (2011)

studied the development of technology for the preparation of *Ficus carica* fruit powder and its utilization in toffee. Fresh sample of Dinkar variety of figs were dried at temperature 60 °C in a cabinet drier for 20–24 hours. The products were prepared by processing of figs *viz.* fig powder and fig toffee. Sakhale *et al.* (2012) evaluated the consistency of fig- mango mixed toffee preparation process. In this study, mango and fig pulp was used in different proportions to prepare mixed toffee. In result, they mentioned that the toffee (80:20) proportions which made with the substitution of fig and mango pulp reported better organoleptic evaluation. Mhalaskar *et al.* (2012) studied the development of technology for fortification of fig (*Ficus carica*) fruit into its value added product- fig toffee. It was prepared with the incorporation of ground fig pulp and other ingredients (liquid glucose, sucrose, edible fat and skim milk powder) were added in suitable amounts. The fig pulp was incorporated with soy protein isolate, ragi powder, papaya pulp and mixture was heated in a cabinet drier for 2 hours at 60 °C temperature. Result showed that the products prepared by the incorporation of figs *viz.*, fig toffees were assessed and found rich in their physico-chemical and sensory parameters. Reddy *et al.* (2014) studied the utilization of an underexploited fruit fig as a preserved product. They studied the process for the preparation of preserved product jam from fig by using pectin source from apple. They found that fig fruit contained calcium, iron, and low fat content and high amount of fiber content. Due to its high nutritional value it was considered to preserve the fruit by preparing jam with many textures, flavors and colours. In this study, fig jam was developed and the quality parameters were assessed. Mule *et al.* (2014) described the preparation, proximate composition and sensory evaluation of buffalo milk shake was incorporated with dried fig fruit with proportion of 5 per cent, 7.5 per cent and 10 per cent. In result, proximate composition of 10 per cent fig contained 4.52 per cent - protein content and 12.78 per cent - sugar content as compared to 5 per cent and 7.5 per cent fig. Result revealed that the overall acceptability score (8.3) was the highest in the sample with 7.5 per cent fig and milk shake prepared from buffalo milk with the incorporation of 5 per cent. *Ficus carica* was more consumer-friendly than buffalo milk shake (control) due to its high nutritive value and better sensory attributes. Tanwar *et al*. (2014) studied the effect of different processing methods on fig product (physicochemical, nutritional and phytochemical composition). They mentioned that processing of fig fruit pulp into jam and nector was resulted to increase the carbohydrates content. Verma and Gupta, (2015) studied the estimation of

phytochemical, nutritional and antioxidant activity of figs (*Ficus religiosa*) and formulated value added product (Hard Candy). Result showed that fig was used for the preparation of hard boiled candies was made with the incorporation of glucose syrup and lemon juice with dried powder of fig incorporated with flavoring and coloring agents. In sensory evaluation, it showed very good acceptability by the panelists. Khapre *et al.* (2015) studies the standardization of *Ficus carica* powder enriched cookies and its composition. In this study fig powder was incorporated in cookies at 0,6,12 and 18 per cent level for nutritional and sensory evaluation. Result showed that cookies were incorporated with 12 per cent fig powder showed that 3.1 per cent- dietary fiber, 6.9 per cent- protein content, 1.1per cent- potassium content and organoleptically accepted well.

Experimental design

Ficus carica have an antioxidant effect, which act as antibacterial, hypoglycemic effect, anti cancerous effect and hypotriglyceridaemic effects etc. (Wang *et al*., 2004). They are used as a source of traditional medicine (Jain *et al.*, 2013) to cure many health problems (Mahapatra *et al.*, 2012). The reports of different studies have shown that therapeutical used of fruits. Perez *et al.* (2000) studied the hypoglycemic effect of fig leaves to control sugar levels in rats and observed for 3 weeks. They selected four groups and each groups contained 13 rats. Result revealed that given aqueous extract was decreased the sugar levels in diabetic rats as compared to other groups. In conclusion, fig leaves proved beneficial for hypoglycemic effect. Shobaki *et al*. (2010) studied the effect of different level of fig leaves on diabetic rats. In this forty eight male rats were divided into two groups. Group first contained (n=6) which was fed on basal diet. Second group (n=46) was injected with 150 mg/kg body weight alloxan to induce hyperglycemia and further divided into seven equal subgroups. One subgroup (n=6) was fed on basal diet and other six subgroups (1-3) were fed on basal diet contained (5%,10%, 20%) levels of *Ficus carica* leaves groups (4-6) were also fed on basal diet contained (4%, 6%, 8%) levels of *Ficus carica* leaves, respectively. Result revealed that Ficus *carica* leaves act as antidiabetic effect. Choudhary *et al*. (2011) studied *Ficus religiosa* Linn effect on diabetes. In this study, the ethanolic extract of fruits was orally given to diabetic and normal rats. They measured of their blood glucose lowering activity. Rats were treated with higher dosages of 250 mg and lower dose of 100 mg according to body weight of rats. Result reported that ethanolic extract of fruits with

higher dose was proved effective for antidiabetic activity as compared to lower dose and showed no effect on the normal rats. Rashidi and Noureddini, (2011) studied the effect fig leaves on sugar levels of diabetic rats. Result showed that diabetic rats that were administered with 0.4 mg/dl of extract proved effective to decrease the blood glucose levels. Statin *et al.* (2012) studied effect of fig extract to control diabetes in diabetic rats. They administered methanolic *Ficus carica* extract dose of 100 mg and dose of 200 mg according to body weight of rats. In result, dose of 200 mg reduced more diabetes as compared to dose of 100 mg. Results indicated that, dose of fig proved to be very effective for antidiabetic activity. Ahmad *et al*. (2013) studied the effect of stem bark of fig to control diabetes. They administered orally prepared extract to diabetic induced rats. Study, concluded that stem bark showed effective results to control diabetes. Kanuur *et al.* (2014) found dried Ficus *carica* fruits were subjected to extraction using (90 %) ethanol and this extract was further evaluated for the adaptogenic activity in rats. In this study, they were analyzed sugar levels. In results, Ficus *carica* extract treated rats were proved effective to reduce sugar levels and act as antidiabetic activity. Ibrahmin *et al*. (2014) determined the effect of fig leaves to control diabetes in rabbits. They selected diabetic rabbits for the study. They have been started to given different selected dosages after seven days of alloxan injection and observed for 6 weeks. They had given 0.3gm fig leaves prepared extract to rats according to their body weight. Study concluded that, *Ficus carica* leaves aqueous extract proved very effective for the reduction of glucose level. It showed better effect by supplementing with insulin to cure diabetes. Jayakumar *et al*. (2014) studied the effect of leaves of *Ficus carica* to control diabetes. In this study, extract was orally given to diabetic rats with selected dosages 200 mg and 400 mg according to body weight of rats. Result mentioned that *Ficus carica* leaves extract proved beneficial to control over polyphagia.

2.3 *CARISSA SPINARUM (*KARONDA)

Karonda characteristics (Morphological, nutritional and phytochemical)

Carissa spinarum is an erect thorny shrub with forked branches (light brown to green colour) usually about 2-3 meter height. Fruits (ovoid berry) are blue in colour, 9 mm in length and 6mm in diameter. Seed has black colour, 5-6 mm in length and 4 mm in diameter (Fatima *et al.*, 2013). Karonda has 1.08 cm-length, 219.6 mg-fresh weight, 2.53 per cent- ash content, 16.0 per cent-

protein content and 16.0 per cent- calcium content (Mishra and Gupta, 2005). *Carissa spinarum* is proved to be an important source of nutrition for the poor people. It contained 73.2 per cent-moisture content, 12.43 per cent-carbohydrate, 3.64 per cent- protein content and 0.72 per cent-phenolic content (Mahapatra *et al.,* 2012). Fresh riped fruit contained (0.73g GAE/100gm) phenolic content, (2118 µM AEAC/g dry wt.) ferric reducing power assay and (1013 mg AEAC/100g dry wt.) DPPH antioxidant activity on dry basis as milligram of ascorbic acid equivalent per 100 grams of sample (Nayak and Basak, 2015).

Value added product development

Value added products played very important role to improve nutritional value and acceptance level of the products (Singh *et al*., 2009). Mentioned studies are explained the formation of many innovative value added products. Hanwate (2005) studied extracted *Carissa caranda* juice at different per cent level of milk along with suitable stabilizer gelatin (0.5%) were added. Result revealed that according to 9 point hedonic scale *Carissa caranda* 10 per cent juice and 7.5 per cent sugar were produced the flavoured milk which was accepted with the highest score of 7.60 amongst the nine different combinations. It was highly accepted in flavoured milk prepared with the use of 10 per cent *Carissa caranda* juice and 7.5 per cent sugar along with 0.5 per cent gelatin on the basis of overall acceptability. Yadav *et al*. (2005) explored the feasibility of the incorporation *Carissa caranda* pulp used as natural flavouring agent in ice-cream. In this study, (0%), (10%), (20%) and (30%) selected fruit pulp was used to prepared for different types of ice-cream. The sample which made with the incorporation of (20%) pulp had contained highest rating (49.15%) and overall acceptability was (7.515) as compared to control and other treatments. Result showed that the incorporation of fruit pulp in ice-cream as natural flavouring agent at 20 per cent was proved to be most desirable and acceptable. Wani *et al.* (2013) studied the shelf life of Karonda jams (*Carissa caranda*) under ambient temperature. The study was based on the variations of sugar and the 5 levels of addition of sugar (850 gm, 950gm, 1050 gm,1150 gm and 1250 gm) were mixed with 1.0 kg of fruit pulp .They were known as 1, 2, 3, 4 and 5 treatment, respectively to obtained data and analyzed it. Result showed that treatment 4 (1150 gm sugar) possessed an ideal value of moisture content, ascorbic acid and overall acceptability. Study concluded that treatment 4th was the best as compared to other treatment in

case of physical, chemical and sensory parameters of jam. Shaheel *et al*. (2015) evaluated the effect of blending of karonda (*Carissa caranda*) juice incorporated with guava, papaya and pineapple juice on its quality and organoleptic evaluation. They evaluated their physico-chemical properties and organoleptic evaluation. They incorporated 25 per cent karonda juice with 75 per cent pineapple juice. Result revealed that it was contained 10.35 per cent- total sugar, 6.96 per cent- reducing sugars and 7.42 - organoleptic score was followed by 50 per cent karonda juice with 50 per cent guava juice of 7.18.

2.3 (e) Experimental designs

Fruits are nutritionally beneficial for the people and play an important role to improve human health (Williams *et al*., 2002). Given studies are well explained, the effects of fruits effects to control diseases. Swami *et al.* (2010) studied *Carissa caranda* effect on diabetic rats. Different dosages (250, 500 and 1000 mg) were selected according to body weight of rats and given orally to rats for the examination of glucose level. The 500 mg and 1000 mg of extract was proved to be very effective to decrease the blood glucose levels after 4 hours, 8 hours and 24 hours in normoglycemic rats as compared to 250 mg/kg extract. In result it revealed that doses of extract proved beneficial to control sugar. Itankar *et al.* (2011) evaluated the unripe *Carissa caranda* fruits effect to control diabetes. They studied the effect of selected fruit effect in alloxan induced diabetic rats. In this study, 400mg according to body weight of rat's drug was orally given to diabetic rats. After that it was observed for 24 hours and decreased the blood glucose levels by 48 per cent and 64.5 per cent. Rahman *et al*. (2011) studied the antihyperglycemic effect of *Carissa caranda L*. leaves in swiss albino mice. Selected extract was administered orally to glucose-loaded mice at dosages 50 mg, 100 mg and 400 mg according to body weight of rats. Result revealed that serum glucose levels were found to be reduced by 15.6 per cent, 17.8 per cent, 20.0 per cent and 47.8 per cent. Present study, concluded that selected methanolic extract was proved very effective to diminished the glucose parameters and act as antidiabetic drug. Fatima *et al.* (2013) examined the effect of *Carissa spinarum* leaves to control sugar levels in alloxan-induced diabetic rats. The extract was given orally at dosages 200,400 and 600 according to body weight of rats. Result revealed that extract at higher dose was proved to be effective than lower dosages.

Influence of processing methods on fruits

Fresh fruits are classified as perishable commodities due to presence of higher moisture content (Orsat *et al.* 2006). Locally available fruits are very cheap, fresh but have short life span. Therefore, processing methods are used to enhance their shelf life. Nowadays, perishable crops are dried in the world (Grabowski *et al.* 2003).

Sun drying

Drying is a technique which is used mainly to dry agricultural products, storage and to extend shelf life. Drying method proved to be one of the oldest method for food preservation (Papu *et al.* 2014). The reports of different studies have shown the influence of drying on nutritional and phytochemical composition of fruits. Farsi *et al.* (2005) studied the comparison of fresh and dried date was grown in Oman for the phenolic content. Selected fruit sample was sun dried at temperature 50°C for 7-10 days. Result showed that after drying process phenolic content was increased and proved that sun dried dates have higher phenolic content as compared to fresh sample. Similar result were reported by Jung *et al*. (2005) for fresh and dried persimmon fruits for their phytochemicals and the antioxidant compounds. Result concluded that dried fruit contained higher amount of bioactive compounds as compared to fresh. Noutchogoue *et al*. (2005) studied the biochemical changes related to hardening phenomenon in Aiele fruit (*Canarium schweinfurthii Eng)*. Sample was collected from West Cameroon and kept for 7 days for the storage, given heat treatment at 45°C temperature for 40 minutes, 70°C for 40 minutes and room temperature at 22°C for a period of 7 days and fourth group was raw fruits. Result revealed that after storage and heating treatment was responsible to increase the lignin content and cellulose content as compared to controlled sample. Xu *et al*. (2007) evaluated the effect of heat treated citrus peel extract for their phenolic compounds and antioxidant capacity. Huyou fresh fruit sample was selected from a farm in China and dried by hot air at temperature 45 °C for 48 hours. After that it was again, oven dried at temperature 120 °C for 60 minutes and 90 minutes. Result revealed that there was found enhancement in antioxidant capacity and phenolic content. Dangcham *et al*. (2008) studied temperature effect on lignin content of mangosteen fruit (red-brown stage) at low storage temperature. Sample was collected from Thailand and stored at temperature 6 °C and 12 °C for 12 days. Result reported that lignin content was increased from

0.57 to 0.725 g/100kg and 0.587 to 0.643 g/100kg at storage temperature 6 °C and 12 °C from 0 to 12 days. Monica *et al*. (2009) evaluated the antioxidant activity of heat treated apricots. Selected sample was air dried at different temperature 55°C and 75°C. In this study they reported higher antioxidant activity at temperature 75°C as compared to 55°C. Wang *et al*. (2009) studied blueberry changes in the phenol and antioxidant capacity by the exposure of ultraviolet light (UV-C). Sample was collected from the orchards in Maryland and illuminated by UV-C device with different UV dosages (6.45 kJ/m^2) at temperature 20°C as compared to control. Result showed that after UV treatment increased phenol from 3.12 to 4.72 mg/100gm and antioxidant capacity from 30.5 to 34.6 µ mol gallic acid equivalent/gm. Patras *et al*. (2010) determined the effect of heat treatment on anthocyanin stability. Thermal processing was responsible for the reduction of anthocyanin pigment and caused major effect on the colour quality due to the presence of some conjugated bond in their structures, which absorbed light at 500 nm , on the basis of red, blue and purple colour in the fruits. In result, study concluded that heating played an important role for the degradation of the anthocyanin pigments. Slatnar *et al.* (2011) studied the impact of fig (*Ficus carica*) drying on the contents of organic acids and phenolic compounds. Selected fruits were processed under sun-drying and oven-drying method. Phenolic compounds of the samples were analyzed three times in a year by using high-performance liquid chromatography. Result mentioned that dried fruits contained higher source of organic acids and phenolic compounds as compared to fresh one. Zivkovic *et al*.(2011) estimated the temperature effect on physical changes in Plum (*Prunus domestica L*.) "Pozegaca variety". In this study selected fruits were dried at temperature 75°C . Result showed that physical characteristics (length and width) was decreased after drying as compared to fresh. Sharifian *et al*.(2012) studied the microwave drying effect on moisture content of fig fruit (*Ficus carica).* In this study weight and temperature of the sample was recorded at regular intervals of 10 seconds to investigate the moisture variation. The result reported that raised the temperature in the microwave proved better removal of the moisture content. Kamiloglu (2012) studied the effect of sun drying on polyphenols and in *vitro* bioavailability of "*Bursa Siyahi"* figs *(Ficus carica L.).* Sample was collected from orchards located in Turkey. Fruits were dried in the sunlight for 8 days at temperature 31°C to 34°C in day time. In this study, they estimated sun drying effect on moisture content, flavonoid content and anthocyanin content. Result revealed

that heating treatment was responsible to reduced the moisture content from 81.4 to 49.7 per cent and also showed reduction in the flavonoid content, anthocyanin content. Mithanka(2012) studied the polyphenol content of *Pseudolachinostylis Maprouneifolia Pax Var* Dikindtii. Fruit sample was selected from a village in Eastern Botswana from a city Gaborone. Fruit sample was sun dried for eight days and used for further analysis. Result showed that phenolic content of sun dried sample was higher (1240.3 mg gallic acid equivalents/l) as compared fresh (838.6 mg gallic acid equivalents/l) and flavonoid content was higher i.e. 159.9 mg quercetin equivalents/l for sun dried sample, 139.1 quercetin equivalents/l for fresh fruit. Amalina *et al*.(2013) evaluated the modification of oil palm mesocarp fiber characteristics using superheated treatment. Sample was collected from Malaysia and dried in the sun light and kept at temperatures 190°C, 210°C and 230°C to analyzed lignin content. Result showed that lignin content of oil palm mesocarp fiber was increased from 28.44 per cent, 45.19 per cent and 49.73 per cent at different temperatures 190°C, 210°C and 230°C. Garcia *et al*. (2013) studied the drying effect on functional properties of (*Ficus carica L.)* var mission. In this study, *Ficus carica* was dried at temperature 45℃ in a thin layer drying equipment for 24 hours. Result revealed that drying process was mainly contributed to increase the phenolic content, antioxidant activity and decreased the anthocyanin content. Moldovan and David, (2014) studied the effect of heat treatment on anthocyanin stability of "Cornelian" cherries. Sample was selected from a local market in Romania and studied its anthocyanin degradation at 2°C temp., 22°C temp. and 75° C temp. Result showed that highest degradation rate of anthocyanin content was at temperature 75°C as compared to 2°C and 22°C. Anantawat (2015) determined the antioxidant activity of gac fruit aril powder by the effect of spray drying condition. Fully riped fruit was used as a sample and dried in a spray dryer at temperature 120°C, 150°C and 170°C. Result revealed that antioxidant activity was increased with increased temperature and ranged from (2758.33, 2797.50 and 2808.33) μg Trolox equivalent/100 gm at temperature 120°C, 150°C and 170°C. Mrabet *et al*.(2015) studied the effect of hydrothermal treatments on date varieties (*Phoenix dactylifera L*.) Garen Gaze. This variety was selected from Southern Tunisia. Dates were treated with direct heating contact at temperature 190°C and analyzed their lignin content and cellulose content. Result showed that increased lignin was 50.38 per cent, 60.80 per cent and cellulose content was 14.36 per cent, 16.34 per cent at temperature 180 °C and 200°C.

Hussain *et al*.(2015) reported the effect of sun drying methods on dates. Sample was selected from Pakistan and dried for 6 to 8 days by direct exposure of sun light during the day time. They analyzed the total phenolic content with their antioxidant activity. Result revealed that, drying process was responsible to increase the total phenolic compounds from 166.80 to 181.50 mg gallic acid equivalent /100 gm and antioxidant activity from 32.35 to 51.31 per cent. Kamiloglu and Capanoglu, (2015) investigated the sun drying effect on anthocyanin content of *Ficus carica.* Samples were collected from Aydin and dried in the sunlight for 8 days at temperature 31 to 34 °C. In result, drying process helped to decrease the anthocyanin content. Sieminska *et al.* (2015) studied the content of phenol and antioxidant activity of wild "Yellow Wonder" strawberry fruits *(Fragaria vesca L.).* Sample was air dried at temperature 40°C till constant weight achieved. They analyzed the content of phenol and antioxidant activity, DPPH (diphenylpicrylhydrazine) in fresh and air died sample. Result revealed that after drying the phenolic content was increased from 1.64 to 4.483 mg/100gm and antioxidant content (DPPH) was also increased from 13.63 to 25.70 per cent.

2.4 (b) Microwave drying

Drying method played very important role for food preservation and to increase the shelf life of the product (Papu *et al.* 2014). Ariffin *et al*. (2000) studied the effect of heat treatment on cellulose content of oil palm empty fruit bunch fiber. Sample was selected from Selangor and dried by using thermal treatment. First sample was dried at temperature 121°C for 15 minutes and another sample was heated at temperature 240°C for 1 hours and 15 minutes. Result reported that heating temperature was responsible to increase the cellulose content. It showed that cellulose content was 51.49 per cent at heating temperature 121°C and increased 54.67 per cent with heating temperature 240°C. Pragati et *al*. (2003) evaluated the heat treatment on nutritional composition of aonla fruit *(Emblica officinalis Garten)* during storage. Fruit samples (riped) were dried by using different methods viz., direct solar and oven drying. Result showed that the level of tannin content was found to be lower in solar drying method (13.60 %) as compared to oven drying method (14.60 %) due to leaching process. Jeong *et al*. (2004) studied the phenolic content and antioxidant activity of citrus peels extract under heat treatment. 5 gm weighed sample was taken in a Pyrex petri dishes and heated at different increased heating temperature in

a pre heated muffle furnace. Result indicated that the antioxidant activities were increased with increased heating temperature. In case of selected sample total phenolic content was also increased from 84.4 to 204.9 mg/100gm and reducing power from 0.27 to 0.96 mg/100gm at temperature 150 °C for 60 min. Study mentioned that heating proved to be a major tool to increase the antioxidant activity. Laleh *et al.* (2006) studied the temperature effect on anthocyanin stability in *Berberis.* Sample was dried in a vacuum evaporator at different heating temperatures. Result reported that anthocyanin content degradation was increased with increased heating temperature. Anthocyanin content loss was observed 41.05 per cent at 5°C temperature, 52.09 per cent at 15°C temperature, 62.33 per cent at 25°C temperature and 89.42 per cent at temperature 35°C. Clary *et al.* (2007) determined the improving grape quality by using microwave vacuum drying. In this study, fresh seedless grapes were dried at temperature 66°C in the microwave. Result showed that microwave dried grapes contained higher nutritional composition. Pacco *et al.* (2007) studied the drying treatment influence on kinetics of 'Gigante de Valinhos' figs. Fig sample was selected from Brazil and dried at temperature 60 °C in an oven for 24 to 48 hours. Result showed that moisture content was decreased from 1.9 to 0.03 per cent with increased temperature and decreased relative humidity. Drying process was caused to increase the apparent density (1.025 to 1.186 gm/ml). Result showed that drying temperature proved effective for the maintance of quality products. Mori *et al*. (2007) studied the loss of anthocyanins in *Vitis vinifera* L. cv. *Cabernet Sauvignon* red- wine grape berries under high temperature. Sample was dried at (15°C, 25°C and 35 °C) temp. in an oven. Result revealed the concentration of anthocyanin (3-glucoside,3-acetylglucoside and3-p-coumaroylglucoside) content was decreased at higher temperature. Anthocyanin content was degraded more at temperature 35 °C as compared to 15°C and 25°C temperature. Data suggested that higher heating temperature was proved effective for the degradation of anthocyanin content due to the inhibition of mRNA transcription of the anthocyanin biosynthetic genes. Elhana (2008) determined microwave drying of apple. In this study, sample was dried in an oven at temperature 100 W and 200W to observe product drying time. Result showed that at 55 per cent of water was removed from the sample at temperature 100W. At 200W, drying constantly increased with the increased microwave output power. Study concluded that 35 per cent drying rate increase with relative increased of density power (W/g). Wojdylo *et al*. (2009) evaluated the influence of

microwaves heat (480 W) on strawberry fruits bioactive compounds. Whole fresh and dried fruits were determined for phenolics (anthocyanins, flavanols and flavonols). Result revealed that heating process affect the ellagic acid, caused degradation of the flavanols and anthocyanins content. Simonyan *et al.* (2009) studied the influence of water content on physical parameters of *Lablab purpureus* (L.) sweet seeds. Sample was oven dried at 130 ^{o}C temperature for 24 hours. They measured the density of the sweet seeds. Result showed that the bulk density was decreased with the improvement of the moisture content. Somsong *et al*. (2010) estimated the influence of preconditioning on dried blueberries. Selected mature fruits were dried at high temperature 70ºC and 90 ºC in a cabinet dryer. Result revealed that the anthocyanin content was decreased by heating process as compared to non heating process i.e. 14.5 mg/100gm-fresh (non heating), 4.9 mg/100gm- dried (at 70ºC) and 6.2 mg/100gm (at 90 ºC) heating temperature. Khanal *et al.* (2010) evaluated the effect of heating on grapes and blueberry pomace fruit anthocyanin content stability. These selected samples were heated in an oven. Result showed reduction in anthocyanin content. In result, total anthocyanin loss was highest at temperature of 105°C, 120°C as compared to temperature 40°C and 60°C. Musto and Satriano, (2010) studied the characteristics of heat- treated strawberry (*Fragaria xananassa*) cv. '*Candonga*' fruits. Selected sample was oven dried at temperature 45°C for 0 hour and 4 hours to analyzed the phenolic content and anthocyanin content. Result revealed that after heat treatment phenolic content was increased from (1.968 to 2.576) mg gallic acid equivalent/100 gm and anthocyanin content was decreased from (0.201 to 0.170) mg of pelargonidin-3-glucoside/ 100gm at temperature 45°C for 0 hour and 4 hours of heating treatment . Akhijahani and Khodaei, (2011) studied some physical properties of strawberry fruit (Kurdistan variety). Sample was selected from a local market in Iran (June, 2010). Fruit sample was oven dried at 75°C temperature for 24 hours. In this study, they determined the physical properties as a function of moisture content. Result revealed that length of the selected fruit was 18.22 mm, 19.54 mm and width was 11.01mm, 13.62 mm at moisture content 24.85 per cent and 66.33 per cent. Study concluded that physical properties (length and width) were improved as the moisture content was increased. Borchani *et al.* (2011) studied the influence of heat treatment on physical and chemical properties of date "Alligh" fiber concentrates. Sample was selected from Tunisia and dried by using sun dried and oven dried method for 48 hours at temperature 40 °C. In this study,

they analyzed the total dietary fiber. Result revealed that drying method contained significantly higher dietary fiber. Cheng (2011) studied the influence of heating treatment on citrus fruit peel phenolic content. They investigated the effects of different drying temperatures in an oven to analyzed the phenolic content and antioxidative activities. Result revealed that at lower temperature (50, 60) °C phenolic content was decreased and at higher temperature (70, 80, 90) °C and 100°C the phenolic content was increased. Jin *et al*. (2011) studied the influence of cultural and temperature on strawberries phenolic compounds and antioxidant activity. In this study, sample was selected from a United States Department of Agriculture (USDA), which was certified organic farm and stored at different temperature in a plastic trays in conventional cultural system. Result revealed that strawberry stored at higher temperature 10°C, had higher antioxidant activity and phenolic content as compared to less storage temperature 0°C and 5°C. Sunmola *et al*. (2011) analyzed the biochemical influence of processing treatment on under-utilized *Carissa papaya* seed. These seeds were dried in oven at temperature 50°C for 48 hours. Result revealed that mature riped fruit seed was contained 1.46 mg/100gm-tannin content and 0.18 mg/100gm- protein content. After processing the tannin content was found to be decreased (1.31 mg/100gm) and protein content was increased (0.41 mg/100gm). Nithiyanantham *et al*. (2012) investigated the differential effects of processing methods on antioxidant activity of species Solanum. Selected samples were dried at temperature 40°C. Result reported that raw fruit was contained 5.3 gm/100gm- tannin content and 7.2 mmol Fe(II) /micromol extract-FRAP (antioxidant activity). After drying tannin content (4.5 gm/100gm) was decreased and antioxidant activity was (28.9 2 mmol Fe (II) /micromol extract, ferric reducing scavenging activity) was increased. Johnson *et al.* (2012) studied the evaluation of anti-nutrient contents of watermelon *Citrullus lanatus.* In this study fresh sample was oven dried at temperature 50°C to measure the phenolic content and flavonoid content. Result revealed that drying process led to increase the phenolic content and decreased the flavonoid content. Sultana *et al*. (2012) analyzed the influence of drying techniques on phenolic content of fruits and their antioxidant activity. Fresh apricot was dried at ambient temperature 30°C for 7 days and oven dried at temperature 80°C for 2 days. Result revealed that after drying the phenolic content and DPPH scavenging capacity was increased from 0.59 to 0.72 gallic acid equivalent gm /100g and 58.7 to 60.8 per cent. Avil *et al*. (2012) studied the effect of different time duration of heat processing on

"Murtanr" berries fruit. Sample was selected from a local market of Poland and lyophilized for 48 hours and dried in an oven at temperature 100°C for different period of time as 10 minutes and 60 minutes. They analyzed the bioactive compounds (flavonoids, tannins and anthocyanins) of berries. Result showed that heat treatment affect the bioactive compounds i.e. flavonoid content was 11.47 mg catechin equivalent/gm and 5.99 47 mg catechin equivalent/gm, tannin content was 8.91 catechin equivalent/gm and 4.94 catechin equivalent/gm, anthocyanin content was 16.7 cyanidin-3-glucoside equivalent/gm and 9.9 cyanidin-3-glucoside equivalent/gm at heating period 10 minutes and 60 minutes. Liu *et al.* (2012) investigated the influence of heating time on citrus fruit (*Citrus sinensis* (L.) by products phenolic content. Sample was selected from Taiwan and orange extract was prepared with heating process. Samples were oven dried at temperature 50 ºC. After 40 hours, the dried by-products were heated again at temperature 100 ºC for (0, 30, 90 and 180) minutes and converted into a fine powder. Phenolic content was (21.65, 24.16, 26.59 and 27.99) mg gallic acid equivalents/100gm at (0, 30, 90 and 180) minutes heating time. Result reported that phenolic content was increased with increased heating temperature. Sharifian *et al.* (2012) reported the effects of microwave heat intensity and pulsing ratio on *Ficus carica* fruit drying process. Weighed sample at regular intervals of ten seconds. Result showed that at pulsing ratio of 1.5 W/g to 4 W/g the drying time of products 200 per cent was increased. And, at pulsing ratio 0.5 W/g to 2.5 W/g the drying time of product 500 per cent was decreased. Study concluded that microwave heat intensity resulted in the raised temperature was responsible for the better removal of moisture content. Wich *et al*. (2012) studied the effect of drying on *Carissa spinarum.* The sample was oven dried at different temperatures in an oven to reach the final moisture content (not more than 5 per cent). Selected fruits were dried at optimum condition, 60°C for 200 minutes. Result revealed that dried *Carissa spinarum* contained highest antioxidant properties and total phenolic content. Lopez *et al.* (2013) estimated the heating effect on phenols and antioxidant activity of goldenberry (*Physalis peruviana* L.). Sample was purchased from Chile and dried at temperature 90 ºC in a convective dryer to analyzed the phenols and antioxidant activity (FRAP). Result showed that heating process increased the phenolic content from 321.05 to 356.68 mg gallic acid/100 gm and antioxidant activity (FRAP) from 99.70 to 109.81 milimoles of Trolox equvivalents/100gm. Irondi *et al*. (2013) evaluated the influence of heat treatment on *Carica papaya* seed

phytochemical composition and antioxidant activities. Fresh sample was collected from Nigeria, June (2012). Sample was dried by two methods. First it was dried for 3 days under direct exposure of sunlight and second was oven dried. Result predicted that oven dried sample led highest phenolic content and antioxidant activity (FRAP) as compared to sun dried sample. Sarkis *et al*. (2013) studied the effects of electric heating on anthocyanin content degradation during the processing of blueberry pulp. Sample was purchased from Italbraz Company (Brazil) and dried by using the selected heating treatment at temperature 60 Hz. The anthocyanin content was studied by using high performance liquid chromatography. Result reported that degradation of anthocyanin content was noticed higher with increased voltage and also showed reduction with decreased voltage. Study, concluded that heating treatment was helped to decrease the anthocyanin content. Kamiloglu *et al.* (2013) estimated the polyphenol composition of black mulberry (*Morus nigra L.).* Sample was selected from a local market in Turkey and converted into fine powder for storage at temperature −80°C. They measured the flavonoid content and anthocyanins content by using Spectrophotometric method. Result showed that after drying flavonoid content and anthocyanin content was decreased from 768.0 to 380 mg catechin equivalent /100gm and 1221.0 to 61.3 mg cyanidin-3-O-glucoside equivalent /100 gm. Candrawinata *et al*. (2014) studied apple pomace fruit for its total phenolic content and antioxidant activity. Apple pomace was selected from a local commercial juice manufacturer (Australia). It was homogenized at temperature (20-90) °C for 5 - 60 minutes. Result revealed that the phenolic content and antioxidant activity was increased with increased heating temperature. Bernard *et al*. (2014) mentioned the influence of heating treatment on phytochemical composition of orange fruit peel. The fruit sample was sun dried at temperature 16.5°C and oven at temperature 50°C. Result reported that orange fruit peel sun dried sample was contained 0.72mg/100gm- tannin content and oven dried sample was contained (0.91 mg/100gm). Alkaloid content of sun dried sample - 0.81 mg/100gm and oven dried sample- 0.99 mg/100gm. Study concluded that tannin and alkaloid content was increased in oven dried sample as compared to sun dried sample. Alfaro *et al*. (2014) evaluated the effects of heating techniques on polyphenol and antioxidant activity of Murtilla (*Ugni molinae* Turcz) fruit. Sample was selected from an Agricultural Research Institute (INIA-Carillanca) and dried by using convective dryer at temperature 65 ºC. Result revealed that after drying the total polyphenolic content and

antioxidant (DPPH) activity was increased from 0.51 to 2.16 mg/100gm and 2111.1 to 3567.41µmol Trolox equivalent /100 g. Anthocyanin content was decreased from 0.106 to 0.012mg cyanidine-3-glucoside equivalent per 100 gram. Ertekin *et al*. (2014) studied the drying of strawberries. Fruit sample was selected from Turkey and oven dried at temperature 60°C, 70°C by infrared radiation (radiator). They evaluated the total phenolic content at different drying temperature. Result revealed that highest amount of total phenolic content of fruit sample were obtained at different drying temperature i.e. 4.44 mg gallic acid equivalent /100 gm – fresh, 11.03mg gallic acid equivalent /100 gm - at 60°C , and 13.96 mg gallic acid equivalent /100 gm - at 70°C temperature. Oancea *et al*. (2014) determined the effect of frozen storage and oven drying on the total anthocyanin content and antioxidant capacity of raspberries. Selected sample was freezed at temperature – 18 °C, oven dried at temperature 60°C. Result revealed that frozen sample was proved to be effective to maintained good anthocyanin content. In case of anthocyanin content, after drying it was decreased as compared to dried. Oven dried sample was also showed better retension of antioxidant activity. Lutz *et al*. (2015) studied the phenolics and antioxidant capacity of fresh and dry blackberry fruits. Fruits were oven dried at temperature 60°C in an oven for 36 hours. Result revealed that moisture content of fresh sample was 841.3 g/100 kg and after dehydration it was decreased 2.1g/100 kg. Drying process was increased the phenol content (22.1mg gallic acid equivalent/100gm –fresh and 126.3 mg gallic acid equivalent/100gm - dried). In case of antioxidant activity (DPPH) was 295.8 µ mol Trolox equivalent/100gm -fresh and after dehydration it was found to be increased by 1203.8 µ mol Trolox equivalent/100gm. In result, dehydrated food proved to be good as functional foods. Adiletta *et al*. (2015) studied the effect of abrasive pretreatment on hot dried goji berry. Fresh fruit sample was selected from Spa farm in Italy and oven dried at temperature 60 °C for 21 hours. In this study, they evaluated the antioxidant DPPH activity. They showed that after drying antioxidant activity was increased. In result, drying method proved to be very effective for the preservation of nutrients. Rabeta and Lin, (2015) studied the influence of different drying techniques on the antioxidant activities of berries fruit. In this study, sample was selected from Malaysia. Sample was oven dried at temperature 30°C for 2 to 3 days. Result revealed that drying method was increased the antioxidant DPPH activity and phenolic content in selected sample i.e. FRAP value 47.1 µmol Fe II/gm- fresh, 537.0 µmol Fe II/gm - dried, DPPH value

42.22 per cent-fresh, 89.64 per cent- dried, phenolic content was 2.9 gallic acid equivalent /100gm-fresh and 24.7 gallic acid equivalent /100gm - dried. Arslan (2015) evaluated the effects of degradation preventive agents on anthocyanins stability in sour cherry fruit. Sample was stored in a room at temperature 24°C (room temperature), oven dried at temperature 45 °C and refrigerated at temperature 4°C. They analyzed the anthocyanin content (cyanidin-3-glucosylrutinoside) in fruits. Result revealed that anthocyanin content was 77.0 mg/l at temperature 24°C, 63.0 mg/l at temperature 45 °C and 80 mg/l at 4°C (refrigerator). Study, concluded that heating process led anthocyanin content degradation. Zaidel *et al*. (2015) studied the anthocyanin stability of red dragon fruit (*Hylocereus polyrhizus*) by using microwave-assisted technique. Sample was dried in a microwave at different temperature 60°C and 80°C with different drying time 2 minutes and 3 minutes. Result showed that higher temperature was proved more effective for the degradation of anthocyanin content as compared to lower temperature. Anantawat (2015) determined the effect of spray drying on antioxidant activity of gac fruit aril powder. Fully riped fruit was dried in a spray dryer at temperature 120°C, 150°C and 170°C. Result revealed that antioxidant activity was increased with increased temperature, that was (2758.33, 2797.50 and 2808.33)µg Trolox equivalent/100 gm at temperature 120°C, 150°C and 170°C . Sharma and Gupta, (2013) determined the antioxidant activity and polyphenols of *Carissa spinarum* (non- edible parts). Sample was dried by microwave at temperature 300 W for 2 minutes. Antioxidant activity was evaluated by using Ferric reducing activity power (FRAP) assays. Results showed that Carissa *spinarum* contained highest antioxidant activity and polyphenols compounds. Nakilcioglu and Hisil, (2013) studied the research on the flavonoid compounds in Sarilop (*Ficus carica L.)* Fig variety. In this study, fruit sample was selected from Turkey, oven dried at temperature 65℃ in an oven till constant weight. Result revealed that fresh sample was contained 82.69 per cent- moisture content and 147.51 mg/ rutin equivalent/100gm – total flavonoid content. After drying these parameters were decreased i.e. 16.73 per cent- moisture content and 52.23 mg/ rutin equivalent /100gm – total flavonoid content. In result, flavonoid content was decreased after drying as compared to fresh. Reyes *et al.* (2013) investigated the inactivation (polyphenol oxidase) in loquat (*Eriobotrya Japonica)* fruit by microwave heat and its phenolic profile. Fresh and dried sample was selected for the study. Result showed that phenolic content was increased after drying as compared to fresh ones. Study

concluded that drying process proved very effective for the enhancement of phenolic content as compared to fresh sample. Garcia *et al.* (2013) studied the effect of heating temperature 45°C and 55°C (in a convective hair dryer) on functional properties figs (*Ficus carica* L., var. Mission). Result showed that after drying the total phenolic content was increased, 2.62 mg/100gm, 3.13 mg/100gm at temperature 45°C, 55°C. In case of anthocyanin content it was decreased, 1.20 mg/100gm and 1.12 mg/100gm at temperature 45°C and 55°C. Safy (2014) studied the density, phenolic content of loquat slices by using dehydration method. Riped fresh loquat (*Eriobotrya japonica*) fruit samples were obtained from local market in Egypt (May, 2012) and oven dried at temperature 80 °C and 90 °C for 50 minutes. Result revealed that density was increased from 0.846 to 0.861 gm/cm^3 and phenolic content was also increased from 312.66 to 320.31 mg/10gm was increased with the rising heating system from 80 to 90 °C. Ayadi *et al.* (2014) analyzed the influence of microwave and solar drying methods on physicochemical properties of kiwifruit. In this study sample was sun dried and microwave dried. They studied the effect of different drying methods on moisture content and total phenolic contents. Result showed that sun dried and microwave dried sample was contained less moisture content and higher phenolic content as compared to fresh. Duan *et al.* (2015) studied the microwave-assisted extraction of anthocyanin content (Cyanidin-3-O-glucose) of Chinese bayberry. Mature fruit sample was collected from China (June, 2013). Sample was heated in a microwave at temperature (800 W). They studied antioxidant activity and anthocyanin content. Result revealed that microwave heat was increased the antioxidant activity from 63.43 to 64.60 per cent at temperature 40°C and 80 °C for 15 minutes. And, anthocyanin content was decreased from 97.00 to 48.00 mg/100gm at temperature 40°C and 80 °C for 15 minutes. Mechlouch *et al.* (2015) evaluated the changes in the physico-chemical properties of palm date of 'Alligh' cultivar at different drying methods. Sample was dried by using different method i.e. sun drying, solar drying and microwave drying at different temperature 90 °C. Result revealed that after drying the polyphenol content was increased, 244.42 mg/100g - open air sun drying, 140.48 mg/100g - direct sun drying, 540.48 mg/100g - microwave drying and 77.37 mg/100g - fresh sample. In result, microwave heating was responsible to increase the antioxidant activity as compared to other methods. Udomkun *et al.* (2015) investigated the drying effect on sorption behavoiur of papayas fruit Sample was selected from Thailand and dried by convective dryer at

temperature 70°C. Result showed that fresh fruit sample was contained 7.74 kg/kg - moisture content, 0.968 gm/cm^3 - apparent density and 1.038 gm/cm^{3-} solid density. Result showed after drying moisture content was decreased 0.15 kg/kg, apparent density and solid density was found to be increased by 1.124 gm/cm^3 and 1.425 gm/$cm^{3.}$

2.4 (c) Freezing

Freezing is a process which help to reduce the temperature of food and help to increase its storage ability. The reports of different studies have shown the influence of freezing on nutritional and phytochemical composition of fruits. Ramaswamy and Tung, (1981) studied the thermophysical properties of apples in relation to freezing. Sample (Golden and Granny Smith apples) were selected for the study and stored at temperature (1-2) °C. In this study, the density was studied under freezing conditions. Result revealed that in unfrozen state, the density of the Golden apple and Granny apple was 8.45 kg/m^3 and 7.88 kg/m^3 but it was decreased, 829 kg/m^3 and 7.86 kg/m^3 respectively after freezing. Ancos *et al.* (2000) estimated the influence of frozen storage temperature on ellagic acid, total phenolic contents and radical scavenging capacity of raspberry fruit. In this study, the four raspberries from different cultivars were selected and quantified by using high performance liquid chromatography. Fresh, frozen and stored fruits were evaluated at temperature -20 °C for the duration of one year. Result showed that the frozen storage process slightly affect the ellagic acid and total phenolic content. Result showed that 12 months frozen sample (ellagic acid) found to be decreased from 14 per cent -21 per cent. Mullen *et al.* (2002) evaluated the effect of frozen storage red raspberries on phenolic, ellagitannins, flavonoids and antioxidant capacity. Result showed it was contained total flavonols content for fresh- 1.0 nmol/g , frozen- 0.8 nmol/g. Total anthocyanin content in fresh sample was 156 cyanidin-3-glucoside equivalents/100gm and 1049 cyanidin-3-glucoside equivalents /100 gm was in frozen sample. In case of fresh sample total phenolic content was 3383 nmole/gallic equivalent and frozen sample was contained 3321 nmole/gallic equivalent. In result, freezing process proved effective to improve the flavonols and anthocyanin content and caused degradation in phenolic content. Zavala *et al.* (2004) studied the influence of storage temperature on anthocyanin content and aroma compounds in strawberry fruit. Fruit sample was selected from Butler,s Orchards (USA) and stored at different temperature in a cold room. Result

revealed that sample which was stored at higher frozen temperature showed higher anthocyanin content as compared lower frozen storage temperature. Lohachoompol *et al*. (2004) estimated drying and freezing effect on anthocyanins and their antioxidant effect of blueberries. Fresh sample was stored for two weeks at temperature 5°C and frozen sample was stored at 0°C for three months and in another treatment fruit was dried in a cabinet dryer. Result revealed that total anthocyanin content was 7.2 mg/100gm- fresh, 5.7 mg/100gm - fresh (2 weeks storage), 4.3 mg/100gm- dried and 7.9 mg/100gm –frozen (1 month storage), 7.9 mg/100gm - frozen (3 months storage). Study, concluded that drying process was helped to decrease and freezing caused improvement in the anthocyanin content. Skupien (2006) studied the chemical composition of fresh and frozen stored blueberry fruit *(Vaccinium corymbosu L.).*In this study samples were stored for 6 months at temperature -25°C. They analyzed the phenolic content. Result revealed that after frozen storage, phenolic content was decreased from 258.8 to 236.4 mg/100gm. Rickman *et al*. (2007) evaluated the phenolic compounds difference in fresh and frozen stored fruits. These samples were stored at temperature -20°C for one year. Result revealed that frozen product lose fewer nutrients. In case of raspberry and blackberries, freezing caused reduction in the phenolic compounds. It contained phenolic compounds was 0.576 gm gallic acid equivalents/kg – fresh and in frozen state it was decreased 0.565 gm gallic acid equivalents/kg. In case of blackberries phenolic content was 9.777 gm gallic acid equivalents/kg (fresh) and 9.036 gm gallic acid equivalents/kg (frozen) sample. The findings indicated that frozen fruits were contained less phenolic content as compared to fresh. Scibisz *et al. (*2007) studied the influence of long-term frozen storage on antioxidant activity of blueberries (*Vaccinium corymbosum L*.). Selected samples were stored for six months at frozen temperature -18°C for the determination of anthocyanin content and phenolic content. Result revealed that sample contained phenolic content was 427.8 mg/100gm- fresh, 427.0 mg/100gm- freezing (at temperature -18°C). Anthocyanin content was 137.6 mg/100gm - fresh, 140.6 mg/100gm - freezing (at -18°C). Study, concluded freezing process caused reduction in the phenolic content and increased the anthocyanin content. Wetwitayaklung et *al*. (2008) studied fresh and preserved fruits of *Ellaeocarpus hygrophilus Kurz*. for their phenolic content and antioxidant activity. Sample was selected from a local market in Nakhon- Pathom province. The fruits were stored at frozen temperature -4°C for 6 months. Result revealed that after freezing the phenolic content

was decreased and antioxidant activity was also low. Poiana *et al*. (2010) examined the effect of freezing method on antioxidant activity of fruits. They selected strawberry as a sample and refrigerated at temperature 5 °C (for 12 hours) and stored for ten months at temperature -18°C. Result revealed that after freezing phenolic content was decreased, 109.212 mg gallic acid equivalent/100gm as compared to fresh 177.43 mg gallic acid equivalent /100gm. Antioxidant activity of fresh sample was 24.37 mM F^{e2}+/kg, after freezing it was decreased (14.22 mM F^{e2}+/kg). Study, concluded that after freezing phenolic content was decreased upto 28 per cent to 47 per cent and caused small losses in the antioxidant activity was recorded. Zheng and Fujan, (2010) studied the fresh *Ficus carica* by treating it with different methods of cold-shock treatment at temperature 0 ℃ for 1.5 hours. Result showed that the effect of the treatment with cold shock at 0 ℃ for 1.5 hours was significantly better to save fruit quality. Study concluded that the fresh keeping effect of cold shock treatment for 1.5 hours was the best, easy and simple way to handle the fruits and not influenced the quality of the *Ficus carica*. Mohammadian *et al*. (2011) determined the bioactive compounds and antioxidant capacities of two citrus cultivars *Citrus sinensis* 'Siavaraz' and *Citrus limon* 'Lisbon'. Fresh sample was collected from Iran and stored at different temperature i.e. (15, 3, 0, -3 and -6) ºC for ten hours to analyze the total flavonoids content and antioxidant capacity. Result reported that freezing temperature was increased the flavonoids content and decreased the antioxidant capacity for both the cultivars. Leong *et al*. (2012) studied the effects of processing on anthocyanins in summer fruits. In this study, they evaluated the effect of freezing at temperature -20°C. Cherries were selected as a sample from Otago region. Result revealed that after processing it was contained anthocyanin content i.e. 207.00 mg/100gm- fresh and 570.08 mg/100gm- freezed. In conclusion, freezing enhanced the release of membrane bound anthocyanins, resulted processing was increased the anthocyanin content as compared to fresh sample. Jan and Rab, (2012) examined the effect of storage period on physical and chemical differences changes in apple fruit. Mature apple was selected as a sample and stored in a cold room for 0, 30, 60, 90, 120 and 150 days. In this study physico-chemical changes were observed in 30 days intervals. Result showed that fruit density was decreased with increased storage period, it was (0.82g/cm^3- at 0 days storage, 0.81 g/cm^3- 30 days storage,0.80 g/cm^3 - 60 days storage, 0.78 g/cm^3 - 90 days storage,0.78 g/cm^3 – 120 days storage, 0.05 g/cm^3 - 150 days storage). Chaparzadesh and Yavari, (2013) evaluated the

antioxidant activity of Golden delicious apple under frozen storage conditions. Sample was selected from orchards in Iran and stored at temperature 1°C for 45 days, 90 days and 135 days in a cold house. Result revealed that during cold storage the content of phenol and antioxidant activity diphenylpicrylhydrazine radical (DPPH) was decreased as storage time increased. Sikora *et al.* (2013) examined chemical composition of fresh and frozen storage blackthorn fruits (*Prunus Spinosa L.).* Fresh sample was collected from a mountain village, in South and frozen at temperature of -18°C. In this study, fresh blackthorn fruit was contained 0.8 gm/100gm- protein content, 0.37 gm/100gm- fat content, 396.19 mg/100gm- anthocyanin content. After freezing it was contained, 0.34 gm/100gm- protein content, 0.33 gm/100gm-fat content, 415.04 mg/100gm-anthocyanin content. In result, due to frozen storage the protein content, fat content was decreased and anthocyanin content was increased.

6. SUMMARY AND CONCLUSIONS

Fruits are important source of vitamins, minerals and fibers. Fresh fruits are classified as perishable commodities due to presence of higher moisture content (Orsat *et al.* 2006). Nowadays, perishable crops are dried in the world (Grabowski *et al.* 2003) and due to their international trade, consumers have access to various unseasonable fruits around the world. In comparison of imported fruits, locally available fruits are very cheap, fresh but short life span. Therefore, processing methods must be use to enhance their shelf life.

So, present investigation entitled **"Influence of processing on nutritional and phytochemical composition of Fig (*Ficus carica*) and Karonda (*Carissa spinarum*)"** was undertaken the thesis work on locally available two underutilized fruits, fig and karonda with following objectives:

1. To evaluate proximate, nutritional, physical and phytochemical composition of fresh fig and karonda fruits.
2. To assess the influence of processing methods viz. sun drying, microwave drying and freezing on physicochemical, nutritional and phytochemical composition of selected fruits.
3. To evaluate the effect of fruit extract of fig and karonda on FBG level of normoglycemic and diabetic wistar rats.
4. To develop various value added products from the selected fruits and analyze their nutritional composition during 6 months of storage.

These two local varieties of fruits were procured from Bilaspur (Himachal Pradesh), India and processed under the influence of freezing, sun drying and microwave drying method and studied for physical composition, nutritional composition, anti- nutritional composition and mineral composition. Results demonstrated a wide variation in the nutrient composition of fresh and processed fruit. Drying method reduced the length, width and density in fruits. Drying method increased significantly ($p<0.05$) the ash content, carbohydrate content, fat content, protein content and dietary fiber (NDF, ADF, hemicellulose, cellulose, lignin) and showed reduction in the moisture content. After processing, microwave dried method

exhibited significantly ($p<0.05$) higher phytochemical composition (phenolic content and flavonoid content). The antioxidant activity was also found to be increased in microwave dried method. Drying method decreased significantly ($p<0.05$) the tannin content, alkaloid content, anthocyanin content and increased the calcium content, iron content and phosphorus content.

Underutilized fruits also proved beneficial to control many diseases. Traditional point of view these fruits are popular with hypoglycemic activities (Perez *et al.* 1999). So, present study examined the influence of these selected fruits (fig and karonda) on FBG level in normoglycemic and diabetic rats.

Animal trial was carried out by using fourty two male albino rats. The rats were weighed and allotted twelve for toxicity test and after that distributed into seven groups (n=6) for further study purpose. Group I as normoglycemic rat group, group II as diabetic group having 35 mg streptozotocin according to body weight of rat, group III as diabetic group having 50 mg metformin according to body weight of rat, group IV as diabetic group having 500 mg fig methanolic extract according to body weight of rat , group V as diabetic group having 500 mg karonda methanolic extract according to body weight of rat, group VI as normoglycemic group having 500 mg fig methanolic extract, group VII as normoglycemic group having karonda methanolic extract (500 mg/kg b.wt.). Fasting blood glucose (FBG) level and body weight of rats were measured after 0 day, 7^{th} day, 14^{th} day and 21^{th} day. In result, methanolic extract of fig and karonda extract decreased significantly ($p<0.05$) higher FBG level on 21^{th} day as compared to 0 day in diabetic control group as well as in normoglycemic group of rats. And, also proved effective to improve higher body weight of rats on 21^{th} day as compared to 0 day in diabetic control group as well as in normoglycemic group of rats.

This study also proved beneficial to explored the possibilities of the utilization of nutrient rich under-utilized fruits to make innovative food products. According to objectives of the study these underutilized fruits were selected for the development of value added products because of their higher nutritional quality and easy availability. Different value added products such as bun, muffin, noodles and nuggets were formulated with the substitution of

15 per cent, 30 per cent and 45 per cent of karonda and fig to improve the overall nutritional quality. And, increased significantly ($p<0.05$) the moisture content, ash content, carbohydrate content, protein content, fat content, dietary fiber (ADF, NDF, hemicellulose, cellulose, lignin), iron content, calcium content and phosphorus content. The value added products, bun and muffin were also evaluated organoleptically for appearance, colour, texture, flavour, overall acceptability and accepted well by panel of judges. Thus, these underutilized fruits could be successfully used in the production of the value added products and proved to be nutritious convenience products for the human consumption.

The study concludes that drying method proved to be more effective for nutrient retension and significantly ($p<0.05$) reduced FBG level in diabetic control group as well as in normoglycemic group of rats. Further, the substitution of fruits showed significant effect to increase the nutritional quality in developed value added products.

TABLE OF CONTENTS

TERMINOLOGY

g	=	Gram
µm	=	Microgram
kg	=	Kilogram
°C	=	Degree Celsius
%	=	Percentage
g/ml	=	gram per milliliter
et al	=	And others
i.e.	=	that is
etc.	=	Et cetera
DPPH	=	2,2-Diphenyl-1picrylhydroxyl
Rpm	=	rotation per minute
WF	=	Wheat flour
CS	=	*Carissa spinarum*
FC	=	*Ficus carica*

ABSTRACT

The present investigation entitled "Influence of processing on nutritional and phytochemical composition of Fig (*Ficus carica*) and Karonda (*Carissa spinarum*)", were carried out in the Department of Food Technology and Nutrition, School of Agriculture, Lovely Professional University, Phagwara, Punjab, during the year 2012-2016. Fruits are known as protective foods. They are rich in antioxidants, vitamins, organic acids, phenolic contents and played important role to improve human health. Various fruits, which are underutilized and poorly addressed by the researcher, needs to be acknowledged, employed and explored today's for future generation. Fruits are perishable in nature, can be preserved for a short time and their availability to the consumers remains seasonal. Therefore, to prolong their shelf life, seasonal fruits must be processed. Thus the present investigation aimed to study the influence of processing (freezing, sun drying and microwave drying) of fig and karonda. Among, all the methods studied, microwave dried method proved effective for nutrient retention. Underutilized fruits are also used as traditional medicine for the treatment of diabetes. So, in this regard, methanolic extract of fig and karonda were proved more effective for the reduction of diabetes in selected group of rats. On the basis of nutritional and sensory evaluation of value added products (bun, muffin, noodles and nuggets) substituted with 15 per cent, 30 per cent and 45 per cent fig and karonda showed better nutritional quality with good acceptability by panel of judges.

ACKNOWLEDGEMENT

I am greatly thankful to my guide **Dr. Beenu Tanwar** for her continuous source of inspiration, knowledge, motivation and encouragement during the entire period of my research work. Despite her busy schedule, she has been available at every steps with me. I had no knowledge before starting the project. Without her guidance, support and encouragement, i could not have finish my research work.

My sincere thanks also goes to the faculty members, lab technicians and animal house staff members of Lovely Professional University for providing me continuous support throughout my research work. Lastly, I would like to thank my family and friends especially, Devika Chaudhary, Mrs. Shakuntala and Mr. Sunny Chopra for their continuous support, love and never give up spirit.

Finally, I think that this accomplishment would have never been possible without God.

Thanks for giving me opportunity that changed my life!!

Ambika
Dated
12-12-2016

Ambika Chauhan

INFLUENCE OF PROCESSING ON NUTRITIONAL AND PHYTOCHEMICAL COMPOSITION OF FIG *(FICUS CARICA*) AND KARONDA (*CARISSA SPINARUM)*

Submitted to

LOVELY PROFESSIONAL UNIVERSITY

in partial fulfillment of the requirements for the award of degree of

DOCTOR OF PHILOSOPHY (Ph.D)

IN

NUTRITION AND DIETETICS

by

Ambika Chauhan

Supervised by

Dr. Beenu Tanwar

Assistant Professor

Department of Food Technology & Nutrition
School of Agriculture
Lovely Professional University, Phagwara
Punjab

2016

CERTIFICATE

I certify that Ambika Chauhan has prepared her thesis titled **" Influence of processing on nutritional and phytochemical composition of Fig (*Ficus carica*) and Karonda (*Carissa spinarum*) "** for the award of Ph.D degree of Lovely Professional University**,** under my guidance and supervision. This present work is mainly the result of her continuous efforts and original investigation under my sincere guidance and supervision.

The research work report is suitable for Ph.D degree award submission in Nutrition and Dietetics.

Beenu

Dr. Beenu Tanwar

Assistant Professor
Department of Dairy Technology
MIDFT, Dudhsagar Dairy
Mehsana, Gujarat

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LIST OF FIGURES

5.20	B1(100% green gram nugget, B2= 15 % Karonda, B3= 30% Karonda, B4= 45 % Karonda)	185

LIST OF TABLES

ABSTRACT

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1. INTRODUCTION

World Health Organization (2003) reported that fruits are rich in fiber, antioxidants, organic acids, vitamins, phenolic contents (Salmanian *et al.,* 2014) and considered to be a protective foods (Nicoli *et al.,*1999). They are used as a source of traditional medicine (Jain *et al.,* 2013) to cure many health problems (Mahapatra *et al.,* 2012) and contributes as a main source of livelihood for the poor people (Gajanana *et al.,* 2010).

Underutilized fruits or neglected crops are not cultivated commercially, not grown and rarely found in the market (Agent, 1994). They are nutritionally beneficial for the people and play an important role in human health. These fruit species may be distributed globally, but still find some restriction in their consumption and production system (Williams *et al*., 2002). Several underutilized fruits are unfamiliar, unknown and less eaten. However, underutilized fruits have not yet received much awareness as antioxidant sources compared to commercial fruits. These fruits are neglected due to ignorance factor, lack of information, unavailability, deficient in these fruits promotional campaigns, difficulty in storage and harvesting (Badola and Aitken, 2010). Now, these fruits may be included in the health promotion campaigns (Rukayah, 1992). Different types of underutilized fruits are grown in India like aonla, tamarind, karonda, fig, citron, jackfruit etc. Some fruits, which are still underutilized and proves effective to satisfied nutrition demand. Recent research has been mentioned *Ficus carica* and *Carissa spinarum* are considered for the research purpose due to their higher nutritional value and medicinal uses (Baliga *et al.*, 2011).

Ficus carica is commonly known as "Fig" (Jander and Machado, 2008). *Ficus carica* called fig in English and anjir in Hindi (Wealth of India, 1999). It is riped from late of July to late of September (Anon, 2011). It is a deciduous and cultivated fruit tree from the family Moraceae. It is richest source of mineral elements, calcium and fiber content (Vinson, 1999). Dried fig can be stored for 6-8 months (Venkatartnam, 1988).

Carissa spinarum is an evergreen shrub and fruits got mature in late April. It is cultivated mainly in parts of dry foothills of the Punjab, also in Himalayan tract (India) and also on the coast of the Southern Andaman Islands (Parmar and Kaushal, 1982). Riped fruit has dark black colour. It is mostly cultivated in garden, as hedges for its edible berries (Van der Piji,1972). They

are highly nutritious and good source of protein. So, it is mainly offered for sale at certain places (Parmar and Kaushal, 1982).

Some of the locally available fruits which are very cheap as compared to unseasonable, imported fruits (Grabowski *et al.*,2003). Fruits are highly perishable in nature (Pathak *et al*., 2009), have short life span (7-10 days of post harvest life); (Sozzi *et al.,* 2005) and it affects the storage ability, physiological, nutritional and chemical properties of fruits (Orsat *et al.*,2006).

To minimize the effect of degradation, processing is considered to be a most effective tool. Several processing methods (freezing, sun drying and microwave drying) have been introduced with the aim to increase the shelf life of fruits. Sun drying and microwave drying method are proved to be a most important drying practice for the fruits (Matazu and Haroun, 2004). These methods are mainly used to produce heat to remove moisture content. Moisture content is removed by evaporation with heating process and played very important role to affect the nutrient content of fruits in different ways. It helps to increase or decrease the concentration of some nutrients (Hassan *et al*., 2007).

This study is mainly to carried out to observe the effects of these processing methods on the nutrients of fruits and to determine the most suitable method for nutrient retension rather than to increase their shelf life. So, the aim of this study is to focus on the influence of processing on nutritional and phytochemical composition of underutilized fruits i.e. fig and karonda.

These fruits, mainly in raw form are astringent in taste and accepted less. Nowadays, these fruits are commonly used to prepared value added products, which improves nutritional value and acceptance level of the products (Goyal *et al.*, 2008; Singh *et al*.,2009).

2. REVIEW OF LITERATURE

A review of the literature related to different aspects of the present thesis is presented in this chapter. This includes the importance of underutilized fruits, fig and karonda fruit characteristics (morphological, nutritional and phytochemical), value added products development, experimental designs and influence of processing methods on selected fruits are also discussed.

Importance of fruits

Fruits are known as protective foods (Nicoli *et al.*, 1999). According to the Recommended Dietary Allowances (RDA), the consumption of fruits may increased in our daily diet. World Health Organization (2003) reported that fruits are richest source of dietary fiber, antioxidants and phytochemicals. As underutilized fruits contained folic acid, dietary fiber, proteins, vitamins, carbohydrate, minerals (Nandal and Bhardwaj, 2014) and contributed to control many chronic diseases of ageing (Pandey *et al*., 2014). Its increased fruit consumption has been recommended for the primary prevention of many diseases. Underutilized food crops are lesser known plant species in terms of marketing and research (Thakur, 2014). Underutilized crops are contributed 3.14 per cent of the total geographical area (Rai *et al*., 2005). According to Indian Government Economics statistics the area and production data for the underutilized crops was estimated 25.67 million ha and 43.05 tons in 2013-2014 (Ahmad and Raj, 2012). Today, consumers are becoming more conscious for their health and nutrition. Underutilized fruits are proved beneficial, therapeutically and nutritionally to satisfied consumers demand (Gajana and Godwa, 2010) and played very important role to control many diseases (Gajanana *et al*., 2010). These fruits are contributed great role to supplement human diet also (Vazhacharickal *et al*., 2015). Some fruits, which are at present underutilized and poorly addressed by the researcher (Gajanana *et al*., 2010) and needs to be acknowledged, employed and explored today's for future generation (Padulosi, 2008).

2.2 *FICUS CARICA* (FIG)

Fig characteristics (Morphological, nutritional and phytochemical)

Ficus carica is commonly known as "Fig "(Jander and Machado, 2008). Fruit has different colour (green, brown and purple) and contained numerous seed from 30-1600 per fruit bound with jelly like flesh (Joseph and Raj, 2011). It is a deciduous and cultivated fruit tree which belonging to Moraceae family. It is 50 feet tall and cultivated in Southwest Asia, India commercially only in some centres near Pune (Maharastra) and Anantpur district (South India). Mostly it is grown in Uttar Pradesh, Mysore, Punjab and Himachal Pradesh (The Wealth of India, 2001) ; (Tous and Ferguson,1996). It is richest source of mineral elements, calcium and fiber content (Vinson, 1999). Fig fruits are very nutritious and mainly used to made food products (Guesmi *et al.*,2006). It can be consumed in dried and as well as in preserved forms (Neal, 1965) because of limited intake due to seasonal availability, market accessibility and shelf life (Schmidt *et al.*, 2005). Dried fig could be stored for 6-8 months (Venkatartnam, 1988).

According to United States Department of Agriculture (USDA) dried figs are rich in fiber content and potassium content (Gilani *et al*., 2008) and also contained high quality of calcium (Vinson *et al.,* 2005). It contained total carbohydrate (24.27 mg/100gm), protein content (1.27 mg/100gm), calcium content (44.00 mg/100gm); (Zaenuri *et al.*,2014), iron content (4.09 mg/100gm) and potassium content (194 mg/100gm) in fresh fig fruit, respectively (Morton,1987). Fig fruits are fat as well as sodium free and cholesterol free (Vinson *et al*., 2005; Lianju *et al.*,2003). Dried fig contained higher polyphenol content and it is considered as functional foods (Solomon *et al.,* 2006; Vinson *et al.*,2005). It contained moderately higher content of crude fiber (5.8 %) and more than (28 %) of it is soluble type, which has been supported to control blood sugar (Sadhu,1990). *Ficus carica* have an antioxidant effect, which act as antibacterial, hypoglycemic effect, anti cancerous effect and hypotriglyceridaemic effects etc. (Wang *et al*., 2004). For that reason, it is consumed as fresh, dried and in the preserved form also (Mehraj *et al*., 2013).

In morphological characteristics of fig (*Ficus carica L.)*; Darjazi *et al.* (2011) showed that fresh fig fruit has (8.0 to 43.5 gm/100gm) weight and (21 to 45mm) diameter. Shobaki *et al.*

(2010) reported 82.20 per cent-moisture content, 0.65 per cent-ash content, 12.90 per cent-carbohydrate content, 1.00 per cent - protein content, 1.70 per cent- fat content and 1.55 per cent-fiber content in fig fruit. Similarly Khan *et al*. (2011) mentioned the nutritional composition of local variety of Pakistan fig contained 1.90 g/ 100 gm-ash content, 78.84mg/100gm- calcium content and 5.95 mg/100gm-iron content. Bhogaonkar *et al*. (2014) studied the nutritional potential of fresh *Ficus carica L*. fruits and reported 88.1 gm/100gm- moisture content, 1.3 gm/100gm- protein content, 0.2 gm/100gm-fat content,7.6 gm/100gm- carbohydrate content, 80 mg/100gm- calcium content, 30 mg/100gm- phosphorus content and 1.0 mg/100gm-iron content. Aljane *et al*. (2007) evaluated the atomic absorption analysis of mineral salts in fresh *Ficus carica* (Tunisian cultivars) and mentioned (304.57 mg/100gm) calcium content.

Solomon *et al*. (2006) mentioned that edible portion of fig contained 21.5 mg/100gm-flavonoids content and 11.0 mg/100gm – anthocyanins content. Duenas *et al*. (2008) reported *Ficus carica* fruit skin contained (97 µg/100gm) and pulp (15 µg/100gm) anthocyanin content.

Value added product development

Fruits are perishable in nature (Pathak *et al*., 2009), have short life span (7-10 days of post harvest life); (Sozzi *et al.,* 2005) and it affects the storage ability, physiological, nutritional and chemical properties of fruits (Orsat *et al.,*2006). Some fruits are astringent in taste and accepted less. Nowadays, these fruits are commonly used to prepared value added products, which improves nutritional value and acceptance level of the products (Goyal *et al.,* 2008; Singh *et al*.,2009). However, given studies have shown that the formation of innovative value added product with the incorporation of fruits. Khapre and Satwadhar, (2010) estimated the physico-chemical characteristics of *Ficus carica* fruit cv. DINKAR and its cabinet dried powder. Result showed fig fruit which was dried in a cabinet at temperature 60 °C (20-24 hours) contained 15.41 gm/100gm – fiber content, 22 gm/100gm – potassium and utilized in various value added products viz., icecream, milk shake, burfi and toffee. Chauhan *et al.* (2010) determined the development of food products incorporated with dried fig powder. Five products *viz., Idli, Biryani,* cake, *Gujiya* and *Ladoo* were prepared with the incorporation of *5* per cent, 10 per cent and 15 per cent dried fig powder. Results revealed that in case of sensory attributes, all the products which were incorporated by fig powder were accepted well. Khapre *et al.* (2011)

studied the development of technology for the preparation of *Ficus carica* fruit powder and its utilization in toffee. Fresh sample of Dinkar variety of figs were dried at temperature 60 °C in a cabinet drier for 20–24 hours. The products were prepared by processing of figs *viz.* fig powder and fig toffee. Sakhale *et al.* (2012) evaluated the consistency of fig- mango mixed toffee preparation process. In this study, mango and fig pulp was used in different proportions to prepare mixed toffee. In result, they mentioned that the toffee (80:20) proportions which made with the substitution of fig and mango pulp reported better organoleptic evaluation. Mhalaskar *et al.* (2012) studied the development of technology for fortification of fig (*Ficus carica*) fruit into its value added product- fig toffee. It was prepared with the incorporation of ground fig pulp and other ingredients (liquid glucose, sucrose, edible fat and skim milk powder) were added in suitable amounts. The fig pulp was incorporated with soy protein isolate, ragi powder, papaya pulp and mixture was heated in a cabinet drier for 2 hours at 60 °C temperature. Result showed that the products prepared by the incorporation of figs *viz.*, fig toffees were assessed and found rich in their physico-chemical and sensory parameters. Reddy *et al.* (2014) studied the utilization of an underexploited fruit fig as a preserved product. They studied the process for the preparation of preserved product jam from fig by using pectin source from apple. They found that fig fruit contained calcium, iron, and low fat content and high amount of fiber content. Due to its high nutritional value it was considered to preserve the fruit by preparing jam with many textures, flavors and colours. In this study, fig jam was developed and the quality parameters were assessed. Mule *et al.* (2014) described the preparation, proximate composition and sensory evaluation of buffalo milk shake was incorporated with dried fig fruit with proportion of 5 per cent, 7.5 per cent and 10 per cent. In result, proximate composition of 10 per cent fig contained 4.52 per cent - protein content and 12.78 per cent - sugar content as compared to 5 per cent and 7.5 per cent fig. Result revealed that the overall acceptability score (8.3) was the highest in the sample with 7.5 per cent fig and milk shake prepared from buffalo milk with the incorporation of 5 per cent. *Ficus carica* was more consumer-friendly than buffalo milk shake (control) due to its high nutritive value and better sensory attributes. Tanwar *et al*. (2014) studied the effect of different processing methods on fig product (physicochemical, nutritional and phytochemical composition). They mentioned that processing of fig fruit pulp into jam and nector was resulted to increase the carbohydrates content. Verma and Gupta, (2015) studied the estimation of

phytochemical, nutritional and antioxidant activity of figs (*Ficus religiosa*) and formulated value added product (Hard Candy). Result showed that fig was used for the preparation of hard boiled candies was made with the incorporation of glucose syrup and lemon juice with dried powder of fig incorporated with flavoring and coloring agents. In sensory evaluation, it showed very good acceptability by the panelists. Khapre *et al.* (2015) studies the standardization of *Ficus carica* powder enriched cookies and its composition. In this study fig powder was incorporated in cookies at 0,6,12 and 18 per cent level for nutritional and sensory evaluation. Result showed that cookies were incorporated with 12 per cent fig powder showed that 3.1 per cent- dietary fiber, 6.9 per cent- protein content, 1.1per cent- potassium content and organoleptically accepted well.

Experimental design

Ficus carica have an antioxidant effect, which act as antibacterial, hypoglycemic effect, anti cancerous effect and hypotriglyceridaemic effects etc. (Wang *et al*., 2004). They are used as a source of traditional medicine (Jain *et al.*, 2013) to cure many health problems (Mahapatra *et al.*, 2012). The reports of different studies have shown that therapeutical used of fruits. Perez *et al.* (2000) studied the hypoglycemic effect of fig leaves to control sugar levels in rats and observed for 3 weeks. They selected four groups and each groups contained 13 rats. Result revealed that given aqueous extract was decreased the sugar levels in diabetic rats as compared to other groups. In conclusion, fig leaves proved beneficial for hypoglycemic effect. Shobaki *et al*. (2010) studied the effect of different level of fig leaves on diabetic rats. In this forty eight male rats were divided into two groups. Group first contained (n=6) which was fed on basal diet. Second group (n=46) was injected with 150 mg/kg body weight alloxan to induce hyperglycemia and further divided into seven equal subgroups. One subgroup (n=6) was fed on basal diet and other six subgroups (1-3) were fed on basal diet contained (5%,10%, 20%) levels of *Ficus carica* leaves groups (4-6) were also fed on basal diet contained (4%, 6%, 8%) levels of *Ficus carica* leaves, respectively. Result revealed that Ficus *carica* leaves act as antidiabetic effect. Choudhary *et al*. (2011) studied *Ficus religiosa* Linn effect on diabetes. In this study, the ethanolic extract of fruits was orally given to diabetic and normal rats. They measured of their blood glucose lowering activity. Rats were treated with higher dosages of 250 mg and lower dose of 100 mg according to body weight of rats. Result reported that ethanolic extract of fruits with

higher dose was proved effective for antidiabetic activity as compared to lower dose and showed no effect on the normal rats. Rashidi and Noureddini, (2011) studied the effect fig leaves on sugar levels of diabetic rats. Result showed that diabetic rats that were administered with 0.4 mg/dl of extract proved effective to decrease the blood glucose levels. Statin *et al.* (2012) studied effect of fig extract to control diabetes in diabetic rats. They administered methanolic *Ficus carica* extract dose of 100 mg and dose of 200 mg according to body weight of rats. In result, dose of 200 mg reduced more diabetes as compared to dose of 100 mg. Results indicated that, dose of fig proved to be very effective for antidiabetic activity. Ahmad *et al*. (2013) studied the effect of stem bark of fig to control diabetes. They administered orally prepared extract to diabetic induced rats. Study, concluded that stem bark showed effective results to control diabetes. Kanuur *et al.* (2014) found dried Ficus *carica* fruits were subjected to extraction using (90 %) ethanol and this extract was further evaluated for the adaptogenic activity in rats. In this study, they were analyzed sugar levels. In results, Ficus *carica* extract treated rats were proved effective to reduce sugar levels and act as antidiabetic activity. Ibrahmin *et al*. (2014) determined the effect of fig leaves to control diabetes in rabbits. They selected diabetic rabbits for the study. They have been started to given different selected dosages after seven days of alloxan injection and observed for 6 weeks. They had given 0.3gm fig leaves prepared extract to rats according to their body weight. Study concluded that, *Ficus carica* leaves aqueous extract proved very effective for the reduction of glucose level. It showed better effect by supplementing with insulin to cure diabetes. Jayakumar *et al*. (2014) studied the effect of leaves of *Ficus carica* to control diabetes. In this study, extract was orally given to diabetic rats with selected dosages 200 mg and 400 mg according to body weight of rats. Result mentioned that *Ficus carica* leaves extract proved beneficial to control over polyphagia.

2.3 *CARISSA SPINARUM (*KARONDA)

Karonda characteristics (Morphological, nutritional and phytochemical)

Carissa spinarum is an erect thorny shrub with forked branches (light brown to green colour) usually about 2-3 meter height. Fruits (ovoid berry) are blue in colour, 9 mm in length and 6mm in diameter. Seed has black colour, 5-6 mm in length and 4 mm in diameter (Fatima *et al.*, 2013). Karonda has 1.08 cm-length, 219.6 mg-fresh weight, 2.53 per cent- ash content, 16.0 per cent-

protein content and 16.0 per cent- calcium content (Mishra and Gupta, 2005). *Carissa spinarum* is proved to be an important source of nutrition for the poor people. It contained 73.2 per cent-moisture content, 12.43 per cent-carbohydrate, 3.64 per cent- protein content and 0.72 per cent-phenolic content (Mahapatra *et al.,* 2012). Fresh riped fruit contained (0.73g GAE/100gm) phenolic content, (2118 µM AEAC/g dry wt.) ferric reducing power assay and (1013 mg AEAC/100g dry wt.) DPPH antioxidant activity on dry basis as milligram of ascorbic acid equivalent per 100 grams of sample (Nayak and Basak, 2015).

Value added product development

Value added products played very important role to improve nutritional value and acceptance level of the products (Singh *et al*., 2009). Mentioned studies are explained the formation of many innovative value added products. Hanwate (2005) studied extracted *Carissa caranda* juice at different per cent level of milk along with suitable stabilizer gelatin (0.5%) were added. Result revealed that according to 9 point hedonic scale *Carissa caranda* 10 per cent juice and 7.5 per cent sugar were produced the flavoured milk which was accepted with the highest score of 7.60 amongst the nine different combinations. It was highly accepted in flavoured milk prepared with the use of 10 per cent *Carissa caranda* juice and 7.5 per cent sugar along with 0.5 per cent gelatin on the basis of overall acceptability. Yadav *et al*. (2005) explored the feasibility of the incorporation *Carissa caranda* pulp used as natural flavouring agent in ice-cream. In this study, (0%), (10%), (20%) and (30%) selected fruit pulp was used to prepared for different types of ice-cream. The sample which made with the incorporation of (20%) pulp had contained highest rating (49.15%) and overall acceptability was (7.515) as compared to control and other treatments. Result showed that the incorporation of fruit pulp in ice-cream as natural flavouring agent at 20 per cent was proved to be most desirable and acceptable. Wani *et al.* (2013) studied the shelf life of Karonda jams (*Carissa caranda*) under ambient temperature. The study was based on the variations of sugar and the 5 levels of addition of sugar (850 gm, 950gm, 1050 gm,1150 gm and 1250 gm) were mixed with 1.0 kg of fruit pulp .They were known as 1, 2, 3, 4 and 5 treatment, respectively to obtained data and analyzed it. Result showed that treatment 4 (1150 gm sugar) possessed an ideal value of moisture content, ascorbic acid and overall acceptability. Study concluded that treatment 4th was the best as compared to other treatment in

case of physical, chemical and sensory parameters of jam. Shaheel *et al*. (2015) evaluated the effect of blending of karonda (*Carissa caranda*) juice incorporated with guava, papaya and pineapple juice on its quality and organoleptic evaluation. They evaluated their physico-chemical properties and organoleptic evaluation. They incorporated 25 per cent karonda juice with 75 per cent pineapple juice. Result revealed that it was contained 10.35 per cent- total sugar, 6.96 per cent- reducing sugars and 7.42 - organoleptic score was followed by 50 per cent karonda juice with 50 per cent guava juice of 7.18.

2.3 (e) Experimental designs

Fruits are nutritionally beneficial for the people and play an important role to improve human health (Williams *et al*., 2002). Given studies are well explained, the effects of fruits effects to control diseases. Swami *et al.* (2010) studied *Carissa caranda* effect on diabetic rats. Different dosages (250, 500 and 1000 mg) were selected according to body weight of rats and given orally to rats for the examination of glucose level. The 500 mg and 1000 mg of extract was proved to be very effective to decrease the blood glucose levels after 4 hours, 8 hours and 24 hours in normoglycemic rats as compared to 250 mg/kg extract. In result it revealed that doses of extract proved beneficial to control sugar. Itankar *et al.* (2011) evaluated the unripe *Carissa caranda* fruits effect to control diabetes. They studied the effect of selected fruit effect in alloxan induced diabetic rats. In this study, 400mg according to body weight of rat's drug was orally given to diabetic rats. After that it was observed for 24 hours and decreased the blood glucose levels by 48 per cent and 64.5 per cent. Rahman *et al*. (2011) studied the antihyperglycemic effect of *Carissa caranda L*. leaves in swiss albino mice. Selected extract was administered orally to glucose-loaded mice at dosages 50 mg, 100 mg and 400 mg according to body weight of rats. Result revealed that serum glucose levels were found to be reduced by 15.6 per cent, 17.8 per cent, 20.0 per cent and 47.8 per cent. Present study, concluded that selected methanolic extract was proved very effective to diminished the glucose parameters and act as antidiabetic drug. Fatima *et al.* (2013) examined the effect of *Carissa spinarum* leaves to control sugar levels in alloxan-induced diabetic rats. The extract was given orally at dosages 200,400 and 600 according to body weight of rats. Result revealed that extract at higher dose was proved to be effective than lower dosages.

Influence of processing methods on fruits

Fresh fruits are classified as perishable commodities due to presence of higher moisture content (Orsat *et al.* 2006). Locally available fruits are very cheap, fresh but have short life span. Therefore, processing methods are used to enhance their shelf life. Nowadays, perishable crops are dried in the world (Grabowski *et al.* 2003).

Sun drying

Drying is a technique which is used mainly to dry agricultural products, storage and to extend shelf life. Drying method proved to be one of the oldest method for food preservation (Papu *et al.* 2014). The reports of different studies have shown the influence of drying on nutritional and phytochemical composition of fruits. Farsi *et al.* (2005) studied the comparison of fresh and dried date was grown in Oman for the phenolic content. Selected fruit sample was sun dried at temperature 50°C for 7-10 days. Result showed that after drying process phenolic content was increased and proved that sun dried dates have higher phenolic content as compared to fresh sample. Similar result were reported by Jung *et al*. (2005) for fresh and dried persimmon fruits for their phytochemicals and the antioxidant compounds. Result concluded that dried fruit contained higher amount of bioactive compounds as compared to fresh. Noutchogoue *et al*. (2005) studied the biochemical changes related to hardening phenomenon in Aiele fruit (*Canarium schweinfurthii Eng)*. Sample was collected from West Cameroon and kept for 7 days for the storage, given heat treatment at 45°C temperature for 40 minutes, 70°C for 40 minutes and room temperature at 22°C for a period of 7 days and fourth group was raw fruits. Result revealed that after storage and heating treatment was responsible to increase the lignin content and cellulose content as compared to controlled sample. Xu *et al*. (2007) evaluated the effect of heat treated citrus peel extract for their phenolic compounds and antioxidant capacity. Huyou fresh fruit sample was selected from a farm in China and dried by hot air at temperature 45 °C for 48 hours. After that it was again, oven dried at temperature 120 °C for 60 minutes and 90 minutes. Result revealed that there was found enhancement in antioxidant capacity and phenolic content. Dangcham *et al*. (2008) studied temperature effect on lignin content of mangosteen fruit (red-brown stage) at low storage temperature. Sample was collected from Thailand and stored at temperature 6 °C and 12 °C for 12 days. Result reported that lignin content was increased from

0.57 to 0.725 g/100kg and 0.587 to 0.643 g/100kg at storage temperature 6 °C and 12 °C from 0 to 12 days. Monica *et al*. (2009) evaluated the antioxidant activity of heat treated apricots. Selected sample was air dried at different temperature 55°C and 75°C. In this study they reported higher antioxidant activity at temperature 75°C as compared to 55°C. Wang *et al*. (2009) studied blueberry changes in the phenol and antioxidant capacity by the exposure of ultraviolet light (UV-C). Sample was collected from the orchards in Maryland and illuminated by UV-C device with different UV dosages (6.45 kJ/m^2) at temperature 20°C as compared to control. Result showed that after UV treatment increased phenol from 3.12 to 4.72 mg/100gm and antioxidant capacity from 30.5 to 34.6 µ mol gallic acid equivalent/gm. Patras *et al*. (2010) determined the effect of heat treatment on anthocyanin stability. Thermal processing was responsible for the reduction of anthocyanin pigment and caused major effect on the colour quality due to the presence of some conjugated bond in their structures, which absorbed light at 500 nm , on the basis of red, blue and purple colour in the fruits. In result, study concluded that heating played an important role for the degradation of the anthocyanin pigments. Slatnar *et al.* (2011) studied the impact of fig (*Ficus carica*) drying on the contents of organic acids and phenolic compounds. Selected fruits were processed under sun-drying and oven-drying method. Phenolic compounds of the samples were analyzed three times in a year by using high-performance liquid chromatography. Result mentioned that dried fruits contained higher source of organic acids and phenolic compounds as compared to fresh one. Zivkovic *et al*.(2011) estimated the temperature effect on physical changes in Plum (*Prunus domestica L*.) "Pozegaca variety". In this study selected fruits were dried at temperature 75°C . Result showed that physical characteristics (length and width) was decreased after drying as compared to fresh. Sharifian *et al*.(2012) studied the microwave drying effect on moisture content of fig fruit (*Ficus carica).* In this study weight and temperature of the sample was recorded at regular intervals of 10 seconds to investigate the moisture variation. The result reported that raised the temperature in the microwave proved better removal of the moisture content. Kamiloglu (2012) studied the effect of sun drying on polyphenols and in *vitro* bioavailability of "*Bursa Siyahi"* figs *(Ficus carica L.).* Sample was collected from orchards located in Turkey. Fruits were dried in the sunlight for 8 days at temperature 31°C to 34°C in day time. In this study, they estimated sun drying effect on moisture content, flavonoid content and anthocyanin content. Result revealed

that heating treatment was responsible to reduced the moisture content from 81.4 to 49.7 per cent and also showed reduction in the flavonoid content, anthocyanin content. Mithanka(2012) studied the polyphenol content of *Pseudolachinostylis Maprouneifolia Pax Var* Dikindtii. Fruit sample was selected from a village in Eastern Botswana from a city Gaborone. Fruit sample was sun dried for eight days and used for further analysis. Result showed that phenolic content of sun dried sample was higher (1240.3 mg gallic acid equivalents/l) as compared fresh (838.6 mg gallic acid equivalents/l) and flavonoid content was higher i.e. 159.9 mg quercetin equivalents/l for sun dried sample, 139.1 quercetin equivalents/l for fresh fruit. Amalina *et al*.(2013) evaluated the modification of oil palm mesocarp fiber characteristics using superheated treatment. Sample was collected from Malaysia and dried in the sun light and kept at temperatures 190°C, 210°C and 230°C to analyzed lignin content. Result showed that lignin content of oil palm mesocarp fiber was increased from 28.44 per cent, 45.19 per cent and 49.73 per cent at different temperatures 190°C, 210°C and 230°C. Garcia *et al*. (2013) studied the drying effect on functional properties of (*Ficus carica L.)* var mission. In this study, *Ficus carica* was dried at temperature 45℃ in a thin layer drying equipment for 24 hours. Result revealed that drying process was mainly contributed to increase the phenolic content, antioxidant activity and decreased the anthocyanin content. Moldovan and David, (2014) studied the effect of heat treatment on anthocyanin stability of "Cornelian" cherries. Sample was selected from a local market in Romania and studied its anthocyanin degradation at 2°C temp., 22°C temp. and 75° C temp. Result showed that highest degradation rate of anthocyanin content was at temperature 75°C as compared to 2°C and 22°C. Anantawat (2015) determined the antioxidant activity of gac fruit aril powder by the effect of spray drying condition. Fully riped fruit was used as a sample and dried in a spray dryer at temperature 120°C, 150°C and 170°C. Result revealed that antioxidant activity was increased with increased temperature and ranged from (2758.33, 2797.50 and 2808.33) μg Trolox equivalent/100 gm at temperature 120°C, 150°C and 170°C. Mrabet *et al*.(2015) studied the effect of hydrothermal treatments on date varieties (*Phoenix dactylifera L*.) Garen Gaze. This variety was selected from Southern Tunisia. Dates were treated with direct heating contact at temperature 190°C and analyzed their lignin content and cellulose content. Result showed that increased lignin was 50.38 per cent, 60.80 per cent and cellulose content was 14.36 per cent, 16.34 per cent at temperature 180 °C and 200°C.

Hussain *et al*.(2015) reported the effect of sun drying methods on dates. Sample was selected from Pakistan and dried for 6 to 8 days by direct exposure of sun light during the day time. They analyzed the total phenolic content with their antioxidant activity. Result revealed that, drying process was responsible to increase the total phenolic compounds from 166.80 to 181.50 mg gallic acid equivalent /100 gm and antioxidant activity from 32.35 to 51.31 per cent. Kamiloglu and Capanoglu, (2015) investigated the sun drying effect on anthocyanin content of *Ficus carica.* Samples were collected from Aydin and dried in the sunlight for 8 days at temperature 31 to 34 °C. In result, drying process helped to decrease the anthocyanin content. Sieminska *et al.* (2015) studied the content of phenol and antioxidant activity of wild "Yellow Wonder" strawberry fruits *(Fragaria vesca L.).* Sample was air dried at temperature 40°C till constant weight achieved. They analyzed the content of phenol and antioxidant activity, DPPH (diphenylpicrylhydrazine) in fresh and air died sample. Result revealed that after drying the phenolic content was increased from 1.64 to 4.483 mg/100gm and antioxidant content (DPPH) was also increased from 13.63 to 25.70 per cent.

2.4 (b) Microwave drying

Drying method played very important role for food preservation and to increase the shelf life of the product (Papu *et al.* 2014). Ariffin *et al*. (2000) studied the effect of heat treatment on cellulose content of oil palm empty fruit bunch fiber. Sample was selected from Selangor and dried by using thermal treatment. First sample was dried at temperature 121°C for 15 minutes and another sample was heated at temperature 240°C for 1 hours and 15 minutes. Result reported that heating temperature was responsible to increase the cellulose content. It showed that cellulose content was 51.49 per cent at heating temperature 121°C and increased 54.67 per cent with heating temperature 240°C. Pragati et *al*. (2003) evaluated the heat treatment on nutritional composition of aonla fruit *(Emblica officinalis Garten)* during storage. Fruit samples (riped) were dried by using different methods viz., direct solar and oven drying. Result showed that the level of tannin content was found to be lower in solar drying method (13.60 %) as compared to oven drying method (14.60 %) due to leaching process. Jeong *et al*. (2004) studied the phenolic content and antioxidant activity of citrus peels extract under heat treatment. 5 gm weighed sample was taken in a Pyrex petri dishes and heated at different increased heating temperature in

a pre heated muffle furnace. Result indicated that the antioxidant activities were increased with increased heating temperature. In case of selected sample total phenolic content was also increased from 84.4 to 204.9 mg/100gm and reducing power from 0.27 to 0.96 mg/100gm at temperature 150 °C for 60 min. Study mentioned that heating proved to be a major tool to increase the antioxidant activity. Laleh *et al.* (2006) studied the temperature effect on anthocyanin stability in *Berberis.* Sample was dried in a vacuum evaporator at different heating temperatures. Result reported that anthocyanin content degradation was increased with increased heating temperature. Anthocyanin content loss was observed 41.05 per cent at 5°C temperature, 52.09 per cent at 15°C temperature, 62.33 per cent at 25°C temperature and 89.42 per cent at temperature 35°C. Clary *et al.* (2007) determined the improving grape quality by using microwave vacuum drying. In this study, fresh seedless grapes were dried at temperature 66°C in the microwave. Result showed that microwave dried grapes contained higher nutritional composition. Pacco *et al.* (2007) studied the drying treatment influence on kinetics of 'Gigante de Valinhos' figs. Fig sample was selected from Brazil and dried at temperature 60 °C in an oven for 24 to 48 hours. Result showed that moisture content was decreased from 1.9 to 0.03 per cent with increased temperature and decreased relative humidity. Drying process was caused to increase the apparent density (1.025 to 1.186 gm/ml). Result showed that drying temperature proved effective for the maintance of quality products. Mori *et al*. (2007) studied the loss of anthocyanins in *Vitis vinifera* L. cv. *Cabernet Sauvignon* red- wine grape berries under high temperature. Sample was dried at (15°C, 25°C and 35 °C) temp. in an oven. Result revealed the concentration of anthocyanin (3-glucoside,3-acetylglucoside and3-p-coumaroylglucoside) content was decreased at higher temperature. Anthocyanin content was degraded more at temperature 35 °C as compared to 15°C and 25°C temperature. Data suggested that higher heating temperature was proved effective for the degradation of anthocyanin content due to the inhibition of mRNA transcription of the anthocyanin biosynthetic genes. Elhana (2008) determined microwave drying of apple. In this study, sample was dried in an oven at temperature 100 W and 200W to observe product drying time. Result showed that at 55 per cent of water was removed from the sample at temperature 100W. At 200W, drying constantly increased with the increased microwave output power. Study concluded that 35 per cent drying rate increase with relative increased of density power (W/g). Wojdylo *et al*. (2009) evaluated the influence of

microwaves heat (480 W) on strawberry fruits bioactive compounds. Whole fresh and dried fruits were determined for phenolics (anthocyanins, flavanols and flavonols). Result revealed that heating process affect the ellagic acid, caused degradation of the flavanols and anthocyanins content. Simonyan *et al.* (2009) studied the influence of water content on physical parameters of *Lablab purpureus* (L.) sweet seeds. Sample was oven dried at 130 ^{o}C temperature for 24 hours. They measured the density of the sweet seeds. Result showed that the bulk density was decreased with the improvement of the moisture content. Somsong *et al*. (2010) estimated the influence of preconditioning on dried blueberries. Selected mature fruits were dried at high temperature 70ºC and 90 ºC in a cabinet dryer. Result revealed that the anthocyanin content was decreased by heating process as compared to non heating process i.e. 14.5 mg/100gm-fresh (non heating), 4.9 mg/100gm- dried (at 70ºC) and 6.2 mg/100gm (at 90 ºC) heating temperature. Khanal *et al.* (2010) evaluated the effect of heating on grapes and blueberry pomace fruit anthocyanin content stability. These selected samples were heated in an oven. Result showed reduction in anthocyanin content. In result, total anthocyanin loss was highest at temperature of 105°C, 120°C as compared to temperature 40°C and 60°C. Musto and Satriano, (2010) studied the characteristics of heat- treated strawberry (*Fragaria xananassa*) cv. '*Candonga*' fruits. Selected sample was oven dried at temperature 45°C for 0 hour and 4 hours to analyzed the phenolic content and anthocyanin content. Result revealed that after heat treatment phenolic content was increased from (1.968 to 2.576) mg gallic acid equivalent/100 gm and anthocyanin content was decreased from (0.201 to 0.170) mg of pelargonidin-3-glucoside/ 100gm at temperature 45°C for 0 hour and 4 hours of heating treatment . Akhijahani and Khodaei, (2011) studied some physical properties of strawberry fruit (Kurdistan variety). Sample was selected from a local market in Iran (June, 2010). Fruit sample was oven dried at 75°C temperature for 24 hours. In this study, they determined the physical properties as a function of moisture content. Result revealed that length of the selected fruit was 18.22 mm, 19.54 mm and width was 11.01mm, 13.62 mm at moisture content 24.85 per cent and 66.33 per cent. Study concluded that physical properties (length and width) were improved as the moisture content was increased. Borchani *et al.* (2011) studied the influence of heat treatment on physical and chemical properties of date "Alligh" fiber concentrates. Sample was selected from Tunisia and dried by using sun dried and oven dried method for 48 hours at temperature 40 °C. In this study,

they analyzed the total dietary fiber. Result revealed that drying method contained significantly higher dietary fiber. Cheng (2011) studied the influence of heating treatment on citrus fruit peel phenolic content. They investigated the effects of different drying temperatures in an oven to analyzed the phenolic content and antioxidative activities. Result revealed that at lower temperature (50, 60) °C phenolic content was decreased and at higher temperature (70, 80, 90) °C and 100°C the phenolic content was increased. Jin *et al*. (2011) studied the influence of cultural and temperature on strawberries phenolic compounds and antioxidant activity. In this study, sample was selected from a United States Department of Agriculture (USDA), which was certified organic farm and stored at different temperature in a plastic trays in conventional cultural system. Result revealed that strawberry stored at higher temperature 10°C, had higher antioxidant activity and phenolic content as compared to less storage temperature 0°C and 5°C. Sunmola *et al*. (2011) analyzed the biochemical influence of processing treatment on under-utilized *Carissa papaya* seed. These seeds were dried in oven at temperature 50°C for 48 hours. Result revealed that mature riped fruit seed was contained 1.46 mg/100gm-tannin content and 0.18 mg/100gm- protein content. After processing the tannin content was found to be decreased (1.31 mg/100gm) and protein content was increased (0.41 mg/100gm). Nithiyanantham *et al*. (2012) investigated the differential effects of processing methods on antioxidant activity of species Solanum. Selected samples were dried at temperature 40°C. Result reported that raw fruit was contained 5.3 gm/100gm- tannin content and 7.2 mmol Fe(II) /micromol extract-FRAP (antioxidant activity). After drying tannin content (4.5 gm/100gm) was decreased and antioxidant activity was (28.9 2 mmol Fe (II) /micromol extract, ferric reducing scavenging activity) was increased. Johnson *et al.* (2012) studied the evaluation of anti-nutrient contents of watermelon *Citrullus lanatus.* In this study fresh sample was oven dried at temperature 50°C to measure the phenolic content and flavonoid content. Result revealed that drying process led to increase the phenolic content and decreased the flavonoid content. Sultana *et al*. (2012) analyzed the influence of drying techniques on phenolic content of fruits and their antioxidant activity. Fresh apricot was dried at ambient temperature 30°C for 7 days and oven dried at temperature 80°C for 2 days. Result revealed that after drying the phenolic content and DPPH scavenging capacity was increased from 0.59 to 0.72 gallic acid equivalent gm /100g and 58.7 to 60.8 per cent. Avil *et al*. (2012) studied the effect of different time duration of heat processing on

"Murtanr" berries fruit. Sample was selected from a local market of Poland and lyophilized for 48 hours and dried in an oven at temperature 100°C for different period of time as 10 minutes and 60 minutes. They analyzed the bioactive compounds (flavonoids, tannins and anthocyanins) of berries. Result showed that heat treatment affect the bioactive compounds i.e. flavonoid content was 11.47 mg catechin equivalent/gm and 5.99 47 mg catechin equivalent/gm, tannin content was 8.91 catechin equivalent/gm and 4.94 catechin equivalent/gm, anthocyanin content was 16.7 cyanidin-3-glucoside equivalent/gm and 9.9 cyanidin-3-glucoside equivalent/gm at heating period 10 minutes and 60 minutes. Liu *et al.* (2012) investigated the influence of heating time on citrus fruit (*Citrus sinensis* (L.) by products phenolic content. Sample was selected from Taiwan and orange extract was prepared with heating process. Samples were oven dried at temperature 50 ºC. After 40 hours, the dried by-products were heated again at temperature 100 ºC for (0, 30, 90 and 180) minutes and converted into a fine powder. Phenolic content was (21.65, 24.16, 26.59 and 27.99) mg gallic acid equivalents/100gm at (0, 30, 90 and 180) minutes heating time. Result reported that phenolic content was increased with increased heating temperature. Sharifian *et al.* (2012) reported the effects of microwave heat intensity and pulsing ratio on *Ficus carica* fruit drying process. Weighed sample at regular intervals of ten seconds. Result showed that at pulsing ratio of 1.5 W/g to 4 W/g the drying time of products 200 per cent was increased. And, at pulsing ratio 0.5 W/g to 2.5 W/g the drying time of product 500 per cent was decreased. Study concluded that microwave heat intensity resulted in the raised temperature was responsible for the better removal of moisture content. Wich *et al*. (2012) studied the effect of drying on *Carissa spinarum.* The sample was oven dried at different temperatures in an oven to reach the final moisture content (not more than 5 per cent). Selected fruits were dried at optimum condition, 60°C for 200 minutes. Result revealed that dried *Carissa spinarum* contained highest antioxidant properties and total phenolic content. Lopez *et al.* (2013) estimated the heating effect on phenols and antioxidant activity of goldenberry (*Physalis peruviana* L.). Sample was purchased from Chile and dried at temperature 90 ºC in a convective dryer to analyzed the phenols and antioxidant activity (FRAP). Result showed that heating process increased the phenolic content from 321.05 to 356.68 mg gallic acid/100 gm and antioxidant activity (FRAP) from 99.70 to 109.81 milimoles of Trolox equvivalents/100gm. Irondi *et al*. (2013) evaluated the influence of heat treatment on *Carica papaya* seed

phytochemical composition and antioxidant activities. Fresh sample was collected from Nigeria, June (2012). Sample was dried by two methods. First it was dried for 3 days under direct exposure of sunlight and second was oven dried. Result predicted that oven dried sample led highest phenolic content and antioxidant activity (FRAP) as compared to sun dried sample. Sarkis *et al*. (2013) studied the effects of electric heating on anthocyanin content degradation during the processing of blueberry pulp. Sample was purchased from Italbraz Company (Brazil) and dried by using the selected heating treatment at temperature 60 Hz. The anthocyanin content was studied by using high performance liquid chromatography. Result reported that degradation of anthocyanin content was noticed higher with increased voltage and also showed reduction with decreased voltage. Study, concluded that heating treatment was helped to decrease the anthocyanin content. Kamiloglu *et al.* (2013) estimated the polyphenol composition of black mulberry (*Morus nigra L.).* Sample was selected from a local market in Turkey and converted into fine powder for storage at temperature −80°C. They measured the flavonoid content and anthocyanins content by using Spectrophotometric method. Result showed that after drying flavonoid content and anthocyanin content was decreased from 768.0 to 380 mg catechin equivalent /100gm and 1221.0 to 61.3 mg cyanidin-3-O-glucoside equivalent /100 gm. Candrawinata *et al*. (2014) studied apple pomace fruit for its total phenolic content and antioxidant activity. Apple pomace was selected from a local commercial juice manufacturer (Australia). It was homogenized at temperature (20-90) °C for 5 - 60 minutes. Result revealed that the phenolic content and antioxidant activity was increased with increased heating temperature. Bernard *et al*. (2014) mentioned the influence of heating treatment on phytochemical composition of orange fruit peel. The fruit sample was sun dried at temperature 16.5°C and oven at temperature 50°C. Result reported that orange fruit peel sun dried sample was contained 0.72mg/100gm- tannin content and oven dried sample was contained (0.91 mg/100gm). Alkaloid content of sun dried sample - 0.81 mg/100gm and oven dried sample- 0.99 mg/100gm. Study concluded that tannin and alkaloid content was increased in oven dried sample as compared to sun dried sample. Alfaro *et al*. (2014) evaluated the effects of heating techniques on polyphenol and antioxidant activity of Murtilla (*Ugni molinae* Turcz) fruit. Sample was selected from an Agricultural Research Institute (INIA-Carillanca) and dried by using convective dryer at temperature 65 ºC. Result revealed that after drying the total polyphenolic content and

antioxidant (DPPH) activity was increased from 0.51 to 2.16 mg/100gm and 2111.1 to 3567.41µmol Trolox equivalent /100 g. Anthocyanin content was decreased from 0.106 to 0.012mg cyanidine-3-glucoside equivalent per 100 gram. Ertekin *et al*. (2014) studied the drying of strawberries. Fruit sample was selected from Turkey and oven dried at temperature 60°C, 70°C by infrared radiation (radiator). They evaluated the total phenolic content at different drying temperature. Result revealed that highest amount of total phenolic content of fruit sample were obtained at different drying temperature i.e. 4.44 mg gallic acid equivalent /100 gm – fresh, 11.03mg gallic acid equivalent /100 gm - at 60°C , and 13.96 mg gallic acid equivalent /100 gm - at 70°C temperature. Oancea *et al*. (2014) determined the effect of frozen storage and oven drying on the total anthocyanin content and antioxidant capacity of raspberries. Selected sample was freezed at temperature – 18 °C, oven dried at temperature 60°C. Result revealed that frozen sample was proved to be effective to maintained good anthocyanin content. In case of anthocyanin content, after drying it was decreased as compared to dried. Oven dried sample was also showed better retension of antioxidant activity. Lutz *et al*. (2015) studied the phenolics and antioxidant capacity of fresh and dry blackberry fruits. Fruits were oven dried at temperature 60°C in an oven for 36 hours. Result revealed that moisture content of fresh sample was 841.3 g/100 kg and after dehydration it was decreased 2.1g/100 kg. Drying process was increased the phenol content (22.1mg gallic acid equivalent/100gm –fresh and 126.3 mg gallic acid equivalent/100gm - dried). In case of antioxidant activity (DPPH) was 295.8 µ mol Trolox equivalent/100gm -fresh and after dehydration it was found to be increased by 1203.8 µ mol Trolox equivalent/100gm. In result, dehydrated food proved to be good as functional foods. Adiletta *et al*. (2015) studied the effect of abrasive pretreatment on hot dried goji berry. Fresh fruit sample was selected from Spa farm in Italy and oven dried at temperature 60 °C for 21 hours. In this study, they evaluated the antioxidant DPPH activity. They showed that after drying antioxidant activity was increased. In result, drying method proved to be very effective for the preservation of nutrients. Rabeta and Lin, (2015) studied the influence of different drying techniques on the antioxidant activities of berries fruit. In this study, sample was selected from Malaysia. Sample was oven dried at temperature 30°C for 2 to 3 days. Result revealed that drying method was increased the antioxidant DPPH activity and phenolic content in selected sample i.e. FRAP value 47.1 µmol Fe II/gm- fresh, 537.0 µmol Fe II/gm - dried, DPPH value

42.22 per cent-fresh, 89.64 per cent- dried, phenolic content was 2.9 gallic acid equivalent /100gm-fresh and 24.7 gallic acid equivalent /100gm - dried. Arslan (2015) evaluated the effects of degradation preventive agents on anthocyanins stability in sour cherry fruit. Sample was stored in a room at temperature 24°C (room temperature), oven dried at temperature 45 °C and refrigerated at temperature 4°C. They analyzed the anthocyanin content (cyanidin-3-glucosylrutinoside) in fruits. Result revealed that anthocyanin content was 77.0 mg/l at temperature 24°C, 63.0 mg/l at temperature 45 °C and 80 mg/l at 4°C (refrigerator). Study, concluded that heating process led anthocyanin content degradation. Zaidel *et al*. (2015) studied the anthocyanin stability of red dragon fruit (*Hylocereus polyrhizus*) by using microwave-assisted technique. Sample was dried in a microwave at different temperature 60°C and 80°C with different drying time 2 minutes and 3 minutes. Result showed that higher temperature was proved more effective for the degradation of anthocyanin content as compared to lower temperature. Anantawat (2015) determined the effect of spray drying on antioxidant activity of gac fruit aril powder. Fully riped fruit was dried in a spray dryer at temperature 120°C, 150°C and 170°C. Result revealed that antioxidant activity was increased with increased temperature, that was (2758.33, 2797.50 and 2808.33)µg Trolox equivalent/100 gm at temperature 120°C, 150°C and 170°C . Sharma and Gupta, (2013) determined the antioxidant activity and polyphenols of *Carissa spinarum* (non- edible parts). Sample was dried by microwave at temperature 300 W for 2 minutes. Antioxidant activity was evaluated by using Ferric reducing activity power (FRAP) assays. Results showed that Carissa *spinarum* contained highest antioxidant activity and polyphenols compounds. Nakilcioglu and Hisil, (2013) studied the research on the flavonoid compounds in Sarilop (*Ficus carica L.)* Fig variety. In this study, fruit sample was selected from Turkey, oven dried at temperature 65℃ in an oven till constant weight. Result revealed that fresh sample was contained 82.69 per cent- moisture content and 147.51 mg/ rutin equivalent/100gm – total flavonoid content. After drying these parameters were decreased i.e. 16.73 per cent- moisture content and 52.23 mg/ rutin equivalent /100gm – total flavonoid content. In result, flavonoid content was decreased after drying as compared to fresh. Reyes *et al.* (2013) investigated the inactivation (polyphenol oxidase) in loquat (*Eriobotrya Japonica)* fruit by microwave heat and its phenolic profile. Fresh and dried sample was selected for the study. Result showed that phenolic content was increased after drying as compared to fresh ones. Study

concluded that drying process proved very effective for the enhancement of phenolic content as compared to fresh sample. Garcia *et al.* (2013) studied the effect of heating temperature 45°C and 55°C (in a convective hair dryer) on functional properties figs (*Ficus carica* L., var. Mission). Result showed that after drying the total phenolic content was increased, 2.62 mg/100gm, 3.13 mg/100gm at temperature 45°C, 55°C. In case of anthocyanin content it was decreased, 1.20 mg/100gm and 1.12 mg/100gm at temperature 45°C and 55°C. Safy (2014) studied the density, phenolic content of loquat slices by using dehydration method. Riped fresh loquat (*Eriobotrya japonica*) fruit samples were obtained from local market in Egypt (May, 2012) and oven dried at temperature 80 °C and 90 °C for 50 minutes. Result revealed that density was increased from 0.846 to 0.861 gm/cm^3 and phenolic content was also increased from 312.66 to 320.31 mg/10gm was increased with the rising heating system from 80 to 90 °C. Ayadi *et al.* (2014) analyzed the influence of microwave and solar drying methods on physicochemical properties of kiwifruit. In this study sample was sun dried and microwave dried. They studied the effect of different drying methods on moisture content and total phenolic contents. Result showed that sun dried and microwave dried sample was contained less moisture content and higher phenolic content as compared to fresh. Duan *et al.* (2015) studied the microwave-assisted extraction of anthocyanin content (Cyanidin-3-O-glucose) of Chinese bayberry. Mature fruit sample was collected from China (June, 2013). Sample was heated in a microwave at temperature (800 W). They studied antioxidant activity and anthocyanin content. Result revealed that microwave heat was increased the antioxidant activity from 63.43 to 64.60 per cent at temperature 40°C and 80 °C for 15 minutes. And, anthocyanin content was decreased from 97.00 to 48.00 mg/100gm at temperature 40°C and 80 °C for 15 minutes. Mechlouch *et al.* (2015) evaluated the changes in the physico-chemical properties of palm date of 'Alligh' cultivar at different drying methods. Sample was dried by using different method i.e. sun drying, solar drying and microwave drying at different temperature 90 °C. Result revealed that after drying the polyphenol content was increased, 244.42 mg/100g - open air sun drying, 140.48 mg/100g - direct sun drying, 540.48 mg/100g - microwave drying and 77.37 mg/100g - fresh sample. In result, microwave heating was responsible to increase the antioxidant activity as compared to other methods. Udomkun *et al.* (2015) investigated the drying effect on sorption behavoiur of papayas fruit Sample was selected from Thailand and dried by convective dryer at

temperature 70°C. Result showed that fresh fruit sample was contained 7.74 kg/kg - moisture content, 0.968 gm/cm^3 - apparent density and 1.038 gm/cm^{3-} solid density. Result showed after drying moisture content was decreased 0.15 kg/kg, apparent density and solid density was found to be increased by 1.124 gm/cm^3 and 1.425 gm/$cm^{3.}$

2.4 (c) Freezing

Freezing is a process which help to reduce the temperature of food and help to increase its storage ability. The reports of different studies have shown the influence of freezing on nutritional and phytochemical composition of fruits. Ramaswamy and Tung, (1981) studied the thermophysical properties of apples in relation to freezing. Sample (Golden and Granny Smith apples) were selected for the study and stored at temperature (1-2) °C. In this study, the density was studied under freezing conditions. Result revealed that in unfrozen state, the density of the Golden apple and Granny apple was 8.45 kg/m^3 and 7.88 kg/m^3 but it was decreased, 829 kg/m^3 and 7.86 kg/m^3 respectively after freezing. Ancos *et al.* (2000) estimated the influence of frozen storage temperature on ellagic acid, total phenolic contents and radical scavenging capacity of raspberry fruit. In this study, the four raspberries from different cultivars were selected and quantified by using high performance liquid chromatography. Fresh, frozen and stored fruits were evaluated at temperature -20 °C for the duration of one year. Result showed that the frozen storage process slightly affect the ellagic acid and total phenolic content. Result showed that 12 months frozen sample (ellagic acid) found to be decreased from 14 per cent -21 per cent. Mullen *et al.* (2002) evaluated the effect of frozen storage red raspberries on phenolic, ellagitannins, flavonoids and antioxidant capacity. Result showed it was contained total flavonols content for fresh- 1.0 nmol/g , frozen- 0.8 nmol/g. Total anthocyanin content in fresh sample was 156 cyanidin-3-glucoside equivalents/100gm and 1049 cyanidin-3-glucoside equivalents /100 gm was in frozen sample. In case of fresh sample total phenolic content was 3383 nmole/gallic equivalent and frozen sample was contained 3321 nmole/gallic equivalent. In result, freezing process proved effective to improve the flavonols and anthocyanin content and caused degradation in phenolic content. Zavala *et al.* (2004) studied the influence of storage temperature on anthocyanin content and aroma compounds in strawberry fruit. Fruit sample was selected from Butler,s Orchards (USA) and stored at different temperature in a cold room. Result

revealed that sample which was stored at higher frozen temperature showed higher anthocyanin content as compared lower frozen storage temperature. Lohachoompol *et al*. (2004) estimated drying and freezing effect on anthocyanins and their antioxidant effect of blueberries. Fresh sample was stored for two weeks at temperature 5°C and frozen sample was stored at 0°C for three months and in another treatment fruit was dried in a cabinet dryer. Result revealed that total anthocyanin content was 7.2 mg/100gm- fresh, 5.7 mg/100gm - fresh (2 weeks storage), 4.3 mg/100gm- dried and 7.9 mg/100gm –frozen (1 month storage), 7.9 mg/100gm - frozen (3 months storage). Study, concluded that drying process was helped to decrease and freezing caused improvement in the anthocyanin content. Skupien (2006) studied the chemical composition of fresh and frozen stored blueberry fruit *(Vaccinium corymbosu L.).*In this study samples were stored for 6 months at temperature -25°C. They analyzed the phenolic content. Result revealed that after frozen storage, phenolic content was decreased from 258.8 to 236.4 mg/100gm. Rickman *et al*. (2007) evaluated the phenolic compounds difference in fresh and frozen stored fruits. These samples were stored at temperature -20°C for one year. Result revealed that frozen product lose fewer nutrients. In case of raspberry and blackberries, freezing caused reduction in the phenolic compounds. It contained phenolic compounds was 0.576 gm gallic acid equivalents/kg – fresh and in frozen state it was decreased 0.565 gm gallic acid equivalents/kg. In case of blackberries phenolic content was 9.777 gm gallic acid equivalents/kg (fresh) and 9.036 gm gallic acid equivalents/kg (frozen) sample. The findings indicated that frozen fruits were contained less phenolic content as compared to fresh. Scibisz *et al. (*2007) studied the influence of long-term frozen storage on antioxidant activity of blueberries (*Vaccinium corymbosum L*.). Selected samples were stored for six months at frozen temperature -18°C for the determination of anthocyanin content and phenolic content. Result revealed that sample contained phenolic content was 427.8 mg/100gm- fresh, 427.0 mg/100gm- freezing (at temperature -18°C). Anthocyanin content was 137.6 mg/100gm - fresh, 140.6 mg/100gm - freezing (at -18°C). Study, concluded freezing process caused reduction in the phenolic content and increased the anthocyanin content. Wetwitayaklung et *al*. (2008) studied fresh and preserved fruits of *Ellaeocarpus hygrophilus Kurz*. for their phenolic content and antioxidant activity. Sample was selected from a local market in Nakhon- Pathom province. The fruits were stored at frozen temperature -4°C for 6 months. Result revealed that after freezing the phenolic content

was decreased and antioxidant activity was also low. Poiana *et al*. (2010) examined the effect of freezing method on antioxidant activity of fruits. They selected strawberry as a sample and refrigerated at temperature 5 °C (for 12 hours) and stored for ten months at temperature -18°C. Result revealed that after freezing phenolic content was decreased, 109.212 mg gallic acid equivalent/100gm as compared to fresh 177.43 mg gallic acid equivalent /100gm. Antioxidant activity of fresh sample was 24.37 mM F^{e2}+/kg, after freezing it was decreased (14.22 mM F^{e2}+/kg). Study, concluded that after freezing phenolic content was decreased upto 28 per cent to 47 per cent and caused small losses in the antioxidant activity was recorded. Zheng and Fujan, (2010) studied the fresh *Ficus carica* by treating it with different methods of cold-shock treatment at temperature 0 ℃ for 1.5 hours. Result showed that the effect of the treatment with cold shock at 0 ℃ for 1.5 hours was significantly better to save fruit quality. Study concluded that the fresh keeping effect of cold shock treatment for 1.5 hours was the best, easy and simple way to handle the fruits and not influenced the quality of the *Ficus carica*. Mohammadian *et al*. (2011) determined the bioactive compounds and antioxidant capacities of two citrus cultivars *Citrus sinensis* 'Siavaraz' and *Citrus limon* 'Lisbon'. Fresh sample was collected from Iran and stored at different temperature i.e. (15, 3, 0, -3 and -6) ºC for ten hours to analyze the total flavonoids content and antioxidant capacity. Result reported that freezing temperature was increased the flavonoids content and decreased the antioxidant capacity for both the cultivars. Leong *et al*. (2012) studied the effects of processing on anthocyanins in summer fruits. In this study, they evaluated the effect of freezing at temperature -20°C. Cherries were selected as a sample from Otago region. Result revealed that after processing it was contained anthocyanin content i.e. 207.00 mg/100gm- fresh and 570.08 mg/100gm- freezed. In conclusion, freezing enhanced the release of membrane bound anthocyanins, resulted processing was increased the anthocyanin content as compared to fresh sample. Jan and Rab, (2012) examined the effect of storage period on physical and chemical differences changes in apple fruit. Mature apple was selected as a sample and stored in a cold room for 0, 30, 60, 90, 120 and 150 days. In this study physico-chemical changes were observed in 30 days intervals. Result showed that fruit density was decreased with increased storage period, it was (0.82g/cm^3- at 0 days storage, 0.81 g/cm^3- 30 days storage,0.80 g/cm^3 - 60 days storage, 0.78 g/cm^3 - 90 days storage,0.78 g/cm^3 – 120 days storage, 0.05 g/cm^3 - 150 days storage). Chaparzadesh and Yavari, (2013) evaluated the

antioxidant activity of Golden delicious apple under frozen storage conditions. Sample was selected from orchards in Iran and stored at temperature 1°C for 45 days, 90 days and 135 days in a cold house. Result revealed that during cold storage the content of phenol and antioxidant activity diphenylpicrylhydrazine radical (DPPH) was decreased as storage time increased. Sikora *et al.* (2013) examined chemical composition of fresh and frozen storage blackthorn fruits (*Prunus Spinosa L.).* Fresh sample was collected from a mountain village, in South and frozen at temperature of -18°C. In this study, fresh blackthorn fruit was contained 0.8 gm/100gm- protein content, 0.37 gm/100gm- fat content, 396.19 mg/100gm- anthocyanin content. After freezing it was contained, 0.34 gm/100gm- protein content, 0.33 gm/100gm-fat content, 415.04 mg/100gm-anthocyanin content. In result, due to frozen storage the protein content, fat content was decreased and anthocyanin content was increased.

3. OBJECTIVES OF THE STUDY

1. To evaluate proximate, nutritional, physical and phytochemical composition of fresh fig and Karonda fruits.
2. To assess the influence of processing methods viz. sun drying, microwave drying and freezing on physicochemical, nutritional and phytochemical composition of selected fruits.
3. To evaluate the effect of fruit extract of *Ficus carica* and *Carissa spinarum* on blood glucose level of normoglycemic and diabetic wistar rats
4. To develop various value added products from the selected fruits and analyze their nutritional composition during 6 months of storage.

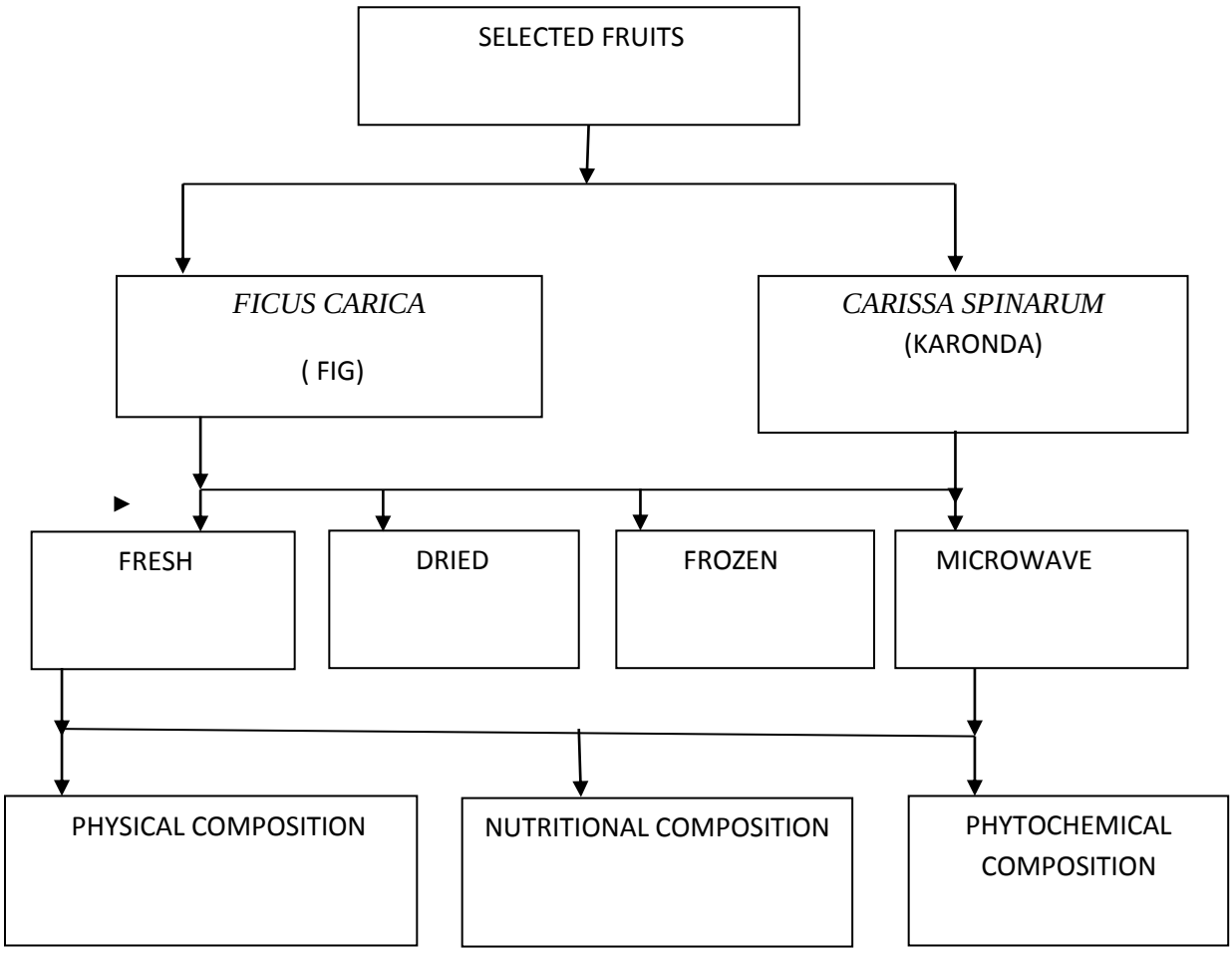

Fig. 4. 1 Flow chart for processing methods

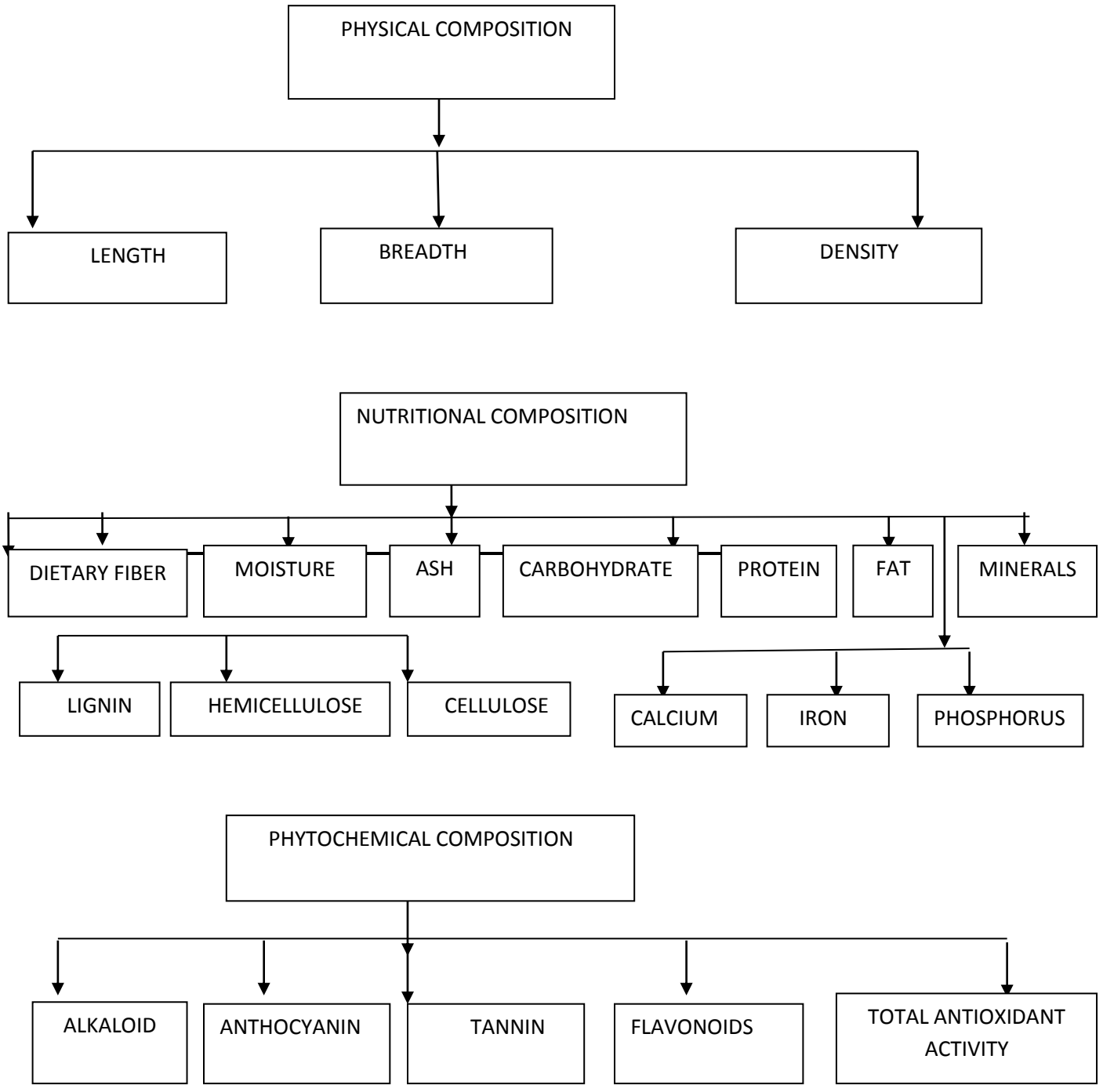

Fig. 4. 1 Flow chart for processing methods

4. RESEARCH METHODOLOGY

The present study was carried out in the Department of Food Technology and Nutrition, School of Agriculture and Food Technology, Lovely Professional University, Phagwara, Punjab. The research methodology and procedures to achieve the set objectives have been described under the following subheads:

4.1 Sample selection

4.2 Sample preparation

4.2 (a) Drying techniques

4.2 (b) Sorting

4.2 (c) Washing

4.2.(d) Sun drying

4.2 (e) Freezing

4.2 (f) Microwave drying

4.3 Physical composition

4.3 (a) Length and width

4.3 (b) Density

4.4 Nutritional composition

4.4 (a) Moisture content

4.4 (b) Ash content

4.4 (c) Carbohydrate content

4.4 (d) Fat content

4.4 (e) Protein content

4.4 (f) Dietary fiber

4.4 (g) Hemicellulose

4.4 (h) Neutral detergent fiber

4.4 (i) Acid detergent fiber

4.4 (j) Cellulose content

4.4 (k) Lignin content

4.5 Extraction preparation

4.5 (a) Total phenolic content

4.5 (b) Total flavonoid content

4.6 Antioxidant activity

4.6 (a) DPPH assay

4.6 (b) FRAP assay

4.7 Tannin content

4.8 Alkaloid content

4.9 Anthocyanin content

4.10 Mineral composition

4.11 Experimental design

4.11 (a) Experimental animals

4.11 (b) Preparation of extracts

4.11 (c) Method for acute toxicity test

4.11 (d) Preparation of interventions

4.11 (e) Animals and induction of diabetes mellitus

4.11 (f) Multiple dose of hypoglycemic study

4.11 (g) Experimental plan

4.12 Value added product development

4.12 (a) Procurement for raw materials

4.12 (b) Fruit powder preparation

4.12 (c) Experimental plan

4.12 (d) Organoleptic evaluation

4.13 Statistical analysis

4.1 Sample selection

Ripened whole fresh *Ficus carica* and *Carissa spinarum* were collected from orchard of a local cultivar from Bilaspur, Himachal Pradesh, (India) during 2014 - 2015.

4.2 Sample Preparation

4.2 (a) Sorting

Fresh, non insected fruits were selected for the study purpose. Discolored fruits were removed before washing.

4.2 (b) Washing

Selected fruits were washed by using distilled water and cleaned properly to remove dust particles. These fruits were dried properly and weighed accurately to and divide into four equal slots. First slot was for fresh (without any treatment), second slot (sun dried), third slot (freezing) and fourth slot was (microwave dried).

4.1 (c) Drying methods

Fruits were exposed to the methods given below:

4.2 (d) Sun drying

Fruits were distributed separately, on the stainless steel trays and dried under direct sunlight for 5 days between 15 July to 20 July, 2015 and stored in cellophane bag for further use.

4.2 (e) Frozen storage

In frozen, the selected whole fresh fruits were packed in polyethylene bags, sealed and safely collected in a freezer at -20°C for 20 days.

4.2 (f) Microwave drying

Selected fresh fruits were placed in a Pyrex petri dish in a single layer and heated for 3 minutes and 15 seconds by using microwave (Sharp R-248e; 800W). Dried fruits were cooled normal temperature. After that again weight was taken to measured the weight loss. After the treatment of different processing methods, selected fruits were used for further analysis.

4.3 Physical composition

4.3 (a) Length and Width

Ten fruits were randomly selected for the measurement of length by using a vernier calliper with 0.01 mm reading accuracy (Mohsenin,1970).

4.3 (b) Density

Randomly ten fruits were selected for mass and measured accurately by using an accurate (0.01) electrical balance (Balasubramanian, 2001). For the measurement of density fruit was weighed and toluene was used to dropped them. The density was calculated by using displacement method. Toluene was used to measure the density of fruits instead of water (Mohsenin, 1986; Gezer *et al.* 2002). Bulk density was calculated with a definite volume beaker. The fruits were poured from 15 cm height into a beaker and excess fruits were discarded. Weighed when it was filled. The bulk density explained as the ratio mass and total volume of the sample (Aydin, 2002).

4.4 Nutritional composition

4.4 (a) Moisture content (AOAC, 2010)

Procedure The moisture content was determined by using oven dried method. 3 gram fruit sample was weighed and taken in a pre heated petri dish. Dried petri dish was kept in oven at temperature 45°C for 3 hrs. It was taken out from pre heated oven then kept in a dessicator for 30 minutes to cool and attained constant weight. Samples were weighed again with petri dish after cooling. Weight loss was represented the moisture content.

Calculation

weight (g) of fruit sample before drying (W1)

weight (g) of fruit sample after drying (W2)

$$\text{Moisture}(\%) = \frac{(W1 - W2)}{W1} X\ 100$$

4.4 (b) Ash content (AOAC, 2010)

Total 3 gm fruit sample was weighed and put in previously pre dried silica crucible. Placed the crucible with lid in the furnance at heating temperature at 550 °C overnight to burn off all

impurities, which were presented on the surface of crucible. After that ashed sample were taken out from the muffle furnance and cooled in a dessicator for 2 hrs. Cooled samples were weighed again and calculated the per cent of ash content given below.

Calculation

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of fruit sample}} X\ 100$$

4.4 (c) Carbohydrate (Hedge and Hofreiter, 1962)

Reagents

5ml of 2 N HCL

Anthrone reagent: Dissolved 200 mg anthrone in 100 ml of ice-cold 95% H_2SO_4.

Standard glucose: Stock- Dissolved 100 mg in 100 ml water.

Working standard: 10 ml of stock diluted to 100 ml with distilled water. Added few drops of toluene and stored in a refrigerator.

Procedure

Take a boiling tube and weighed 100 mg fruit sample in it. Tubes were boiled for three hours in a boiling water bath with 5 ml of 2.5 N HCl. Wait for some time to cooled them at normal temperature. Neutralized it by using sodium carbonate powder until the froth ceases. Made up the volume to 100 ml and centrifuged these tubes. Supernatant was easily collected and taken 0.5, 1 ml aliquots and used it for further analysis. Prepared standards by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of standard solution '0' serves as blank. Made up the volume to 1 ml with distilled water. Anthrone reagent (4 ml) was added and heat them in a boiling water bath for eight minutes. Absorbance was taken at 630 nm. Drawn a standard graph on the X-axis versus absorbance on the Y-axis. From the graph calculated the total carbohydrate present in the sample tube.

Calculation $x = \frac{\text{mg of glucose}}{\text{vol.of fruit sample}}\ X\ 100$

4.4 (d) Fat (AOAC, 2010)

Reagent

Petroleum ether – 250 ml

Procedure

Soxhlet extraction method was used for the fat determination. Bottle was placed with the lid in the incubator at temperature 105 °C overnight. Weighed about 3gm of fruit sample into wraped paper filter. Fruit sample was wrapped in a extraction thimble and transferd into a soxhlet. Filled 250 ml of petroleum ether into the bolltle and fixed it with heating mantle. Connected the soxhlet apparatus and turned on the water to cool them and heated the sample for 14hrs by switched on the heating mantle. Evaporated solvent by using the vacum condenser. Bottle was dried completely at temperature 80°C - 90 °C to evaporate the solvent. Cooled it in a dessicator, after drying. Dried content was weighed with the bottle.

Calculation

$$\text{Fat (\%)} = \frac{\text{Weight of fat}}{\text{weight of fruit sample}} X\ 100$$

4.4 (e) Protein (AOAC, 2010)

Reagents

Kjedahl catalyst- Mixed 1 part of coppersulphate and 9 part of potassium sulphate

Conc.sulphuric acid – 200 ml

NaOH - 40%

HCl - 0.2 N

H_3BO_3 - 4%

Indicator solution- Mixed 200 ml of 0.2 % bromocresol green (in 95% ethanol) in 100 ml of 0.1% methyl red (in 95% ethanol)

Procedure

1gm weight sample was taken in a digestion flask. Then added 200ml of conc. sulphuric acid and 5gm Kjedhal catalyst in it. Prepared a tube which contained heated above mentioned chemical except sample as blank. Inclined position was used for the flask to heat it gently unit frothing ceases. Boiled contineously till solution was cleared. Then, 60 ml of distilled water was added in it and cooled it. Flask was connected immediately to the digestion bulb on condenser

and condenser tip was immersed in the standard acid. Mixed few indicator drops in a receiver. Flask was shaked to mix all contents properly untill, NH_3 was distilled. Removed receiver and washed the tip of condenser. Titratration was done by using the excess standard acid distilled with standard NaOH solution.

Calculation

$$\text{Protein (\%)} = \frac{(\text{A}-\text{B})XNX1.400\ 7X6.25}{\text{W}}$$

Where, A= Vol. (ml) of 0.2 N HCl used sample titration

B = Vol. (ml) of 0.2 N HCl used blank titration

N= Normality of HCl

W= Weight (g) of sample

14.007= Atomic weight of nitrogen

4.4 (f) Dietary fiber content (Van and Robertson, 1977)

4.4 (g) Hemicellulose = NDF-ADF

4.4 (h) Neutral detergent fiber (NDF)

Reagents

Neutral detergent solution
Sodium borate decahydrate -6.81g
Disodium ethylene diamine neutral -18.61 g
Sodium lauryl sulfate neutral – 30g
2- ethoxyethanol – 10 ml
Disodium phosphate anhydrous – 4.5g

Procedure

Dried sample was grinded well to pass through 1 mm screen. Weighed 1 gm of grinded sample in a crucible. Mixed solution of neutral detergent 100 ml into 0.5 gm of sodium sulfite in a crucible at normal temperature. Mixed few drops of n-octanol. After heat treatment refluxed it for 60 minutes from onset of boiling. Filtered properly, boiling water used to wash it three times. After that again wash it with cold acetone. Then, dried for 8 hours at heating

temperature 105 °C. Then kept in a dessicator to cool and weighed. Made ash in a muffle at temperature 550 °C for 2 hours. Cooled it in a dessicator and weighed.

Calculation

$$\text{NDF}\ (\%) = \frac{(\text{weight of crucible} + \text{weight of residue}) - \text{weight of crucible}}{\text{weight of sample}} \text{X}100$$

4.4 (i) Acid detergent fiber (ADF) (AOAC, 1975)

Reagents

Acid detergent solution- 75 ml

Buffer solution (P^H 1.5-2.0): 0.2M HCl -260 ml

0.2 M KCL - 1000ml

Hexadecyltrimethylammonium bromide-20gm dissolved in 1 liter of buffer solution.

Procedure

Dried sample was fine grinded and passed through 1mm screen. Weighed 1 gm of grinded sample. Added 75 ml of acid detergent solution into a Berzelius beaker and heated the sample on a hot plate for 5 minutes. Covered gently with the condenser and refluxed for 1 hour. Beaker was removed for refluxing apparatus and vacuum-filtered hot solution through tared gooch crucible by using 50-60ml hot water with 30 ml acetone. Vacuum has been used to dry fiber by sucking. Then crucible and fibre was dried overnight at temperature 110°C in oven. Percentage of fiber was calculated at dry basis.

Calculations

$$\text{ADF}\ \% = \frac{(\text{weight of crucible} + \text{weight of residue}) - \text{weight of crucible}}{\text{weight of sample}}\ \text{X}100$$

Cellulose= Neutral detergent fiber – Acid detergent fiber

4.4 (j) Cellulose content (Updegroff, 1969)

Reagents

Nitric reagent - Mixed 150 ml (80% acetic acid) and 15 ml (conc. nitric acid)

Anthrone reagent- Dissolved 200 mg anthrone in 100 ml conc. sulphuric acid.

Prepared fresh and chilled for 2 hours before use.

Sulphuric acid- 67%

Procedure

Taken a test tube with 1gm weighed sample. Added 3 ml of nitric acid and mixed in a vortex mixer. After that test tube was heated in a hot water-bath at temperature 100°C for half an hour. Cooled them and centrifuged for 20 minutes and supernatant was removed. Washed residue with distilled water. Mixed 10 ml (67% sulphuric acid) and allowed to stand for 1 hour. After that 1 ml of above solution was taken and diluted it to 100 ml. Then, 1 ml from that dilute solution was also taken and further added 10 ml of anthrone reagent in it. Boiling water bath was used to heat the tubes for ten minutes. Cooled and absorbance was taken at 630 nm. Anthrone reagent and distilled water was used as a blank. Weighed 100 mg cellulose and proceeded was taken in a test tube and all above mentioned steps for standard. Instead of just taken 1 ml of the diluted solution mentioned above taken a series of volumes and colour developed.

Calculation

Drawn the standard graph and cellulose sample was calculated.

4.4 (k) Lignin content (Burke *et al.* 2000)

Reagents

Acid detergent solution-75 ml

Buffer solution (P^H 1.5-2.0): 0.2M HCl -260 ml

0.2 M KCL - 1000ml

Hexadecyltrimethylammonium bromide-20gm dissolved in 1 liter of buffer solution.

Procedure

Dried sample was grinded fine to pass through 1mm screen. Weighed 1 gm of grinded sample . Berzelius beaker was used for the mixing of acid detergent solution and heated the sample on a hot plate for 5 minutes. Beaker was covered with the condenser and refluxed gently for 1 hours. Beaker was removed for refluxing apparatus and through tared gooch crucible was used to vacuum filter with 50-60ml hot water and with 30 ml acetone. Fiber has been sucked dried by using the vacuum. After that crucible and fiber was dried overnight at temperature 110°C in oven. Mixed 1.5 ml of 12 M H_2SO4 to all tubes contained residue fiber and digested at temperature 30°C for 30 minutes. After digestion the acid – insoluble residue was collected by using whatman filter paper with Buckner funnel (45mm) by filteration. Then, washed with water and two times with acetone and sample was dried at temperature 100 °C overnight. Weighed the filter and residue. Made ash at heating temperature 450°C for 6 hours. Weighed again after ashing . Lignin content was determined by the difference in the weight of the residue before and after ashing.

4.5 Extraction preparation

Methanol was used for the extraction of solvent. Taken a conical flask (covered it with aluminum foil) and filled it with 1 gm of weighed sample with 80 per cent methanol. After that agitated it in a orbital shaker at 50°C with 200rpm for two hours (Heidolph Unimax 1010, Schwabach, Germany). Mixture was filtered through a whatman filter paper No.4. Cleared solution was taken for the analysis (Emmy *et al.* 2009).

4.5 (a) Total phenolic content (Thimmaiah, 1999)

Reagents

Fruit powder juice (extract) -0.5 ml

Distilled water- 2.5 ml

Folin- Ciocalteu reagent- 0.5 ml

Sodium carbonate- 2ml

Conc. tannic acid -1000 µg/ml

Procedure

Folin –Ciocalteu (F- C) reagent was used to determine the phenolic content. Mixed 0.5 ml fruit extract in a beaker contained 2.5 ml of distilled water. Added 0.5 ml of Folin -Ciocalteau reagent (1:1) in it and incubated for 3 minutes. After that 2 ml (20% sodium carbonate) was mixed to each tube and kept for 1 minute in a hot boiling water bath. Wait to cool the tubes and taken absorbance at 650 nm. Tannic acid was used as standard. Graph was plotted by using different concentration of standard and absorbance therefore concentration of unknown was intercepted from graph.

4.5 (b) Total flavonoid content (Olajire and Azeez, 2011)

Reagents

Sample extracted - 1ml

Distilled water- 4 ml

Aluminum chloride – 0.3 ml of 10 %

Sodium nitrite- 0.3 ml of 5 %

Sodium hydroxide- 2ml of 1 M

Procedure

Total 1ml of extract solution was mixed in 4 ml (distilled water) and 0.3ml (5% sodium nitrite). Left it for 5 minutes and then mixed with 0.3ml 10% aluminum chloride in all mixture. Added 2ml of 1M NaOH in it after 6 minutes and volume make up to 10 ml with distilled water. After that absorbance was taken at 510 nm. Quercetin was used as a standard and graph was plotted against different concentration of standard and absorbance therefore concentration of unknown was intercepts from graph.

4.6 Antioxidant activity

4.6 (a) DPPH assay (Blois , 1958)

Reagents

DPPH solution- 50 µg/ml

Methanol- 50 µg/ml

Procedure

Antioxidant activity was determined by DPPH radical scavenging method. Extract was taken 50 μg/ml by pipette into DPPH solution conc. 50 μg/ml (1:1) for the initiation of reaction. Incubated it after 30 minutes and taken absorbance at 516 nm. DPPH solution 50 μg/ml was for standard and methanol was used for blank. The experiment was replicated with three independent assay.

Calculation

$$\text{Scavenging activity (\%)} = \frac{(Ac - As)}{Ac} X100$$

Where, Ac = Absorbance of the control

As=Absorbance of the sample

4.6 (b) Antioxidant activity

FRAP assay (Oyaizu,1986)

Reagents

Phosphate buffer- 1 ml

Potassium ferricyanide-1.0 ml

Trichloroacetic acid – 1.0 ml

Ferric chloride- 0.1 ml

Procedure

The antioxidant activity was determined by using (FRAP) ferric reducing assay. In this method 1 ml potassium ferricyanide (1.0 ml, 10 mg/ml) and phosphate buffer (1 ml, 0.2 M, pH 6.6) was mixed together and incubated for 20 minutes at temperature 50 °C. Mixed trichloroacetic acid (1.0 ml,100 mg/ml) with mixture and centrifuged for 5 minutes. Supernatant (1.0 ml) was mixed well by using distilled water (1.0 ml) and ferric chloride (0.1 ml, 1.0 mg/ml). Absorbance was taken at 700 nm.

Calculation

Scavenging activity (%) = $\frac{(A - B)}{A} X100$

4.7 Tannin content (Price *et al*. 1978).

Reagents

Concentrate HCL- 10 ml

Methanol- (1 %)

Vanillin reagent- (0.5% , 5 ml)

Catechin – 1 mg/ml

Procedure

Weighed 200 mg sample was taken in a test tubes. And extraction was done by using 10 ml (1% concentrated HCl) in methanol for 20 minutes. Mixed vanillin reagent (0.5%, 5 ml) to 1 ml extract and left it for 20 minutes at temperature 30°C. Then, taken absorbance at 500nm and result was expressed in catechin equivalents i.e. catechin (mg/100gm) which has been given a colour intensity equivalent to tannins after corrected the blank. Calculation of tannin content was done and results were expressed in mg/ 100 gm.

4.8 Alkaloid content (Herborne, 1973)

Reagents

Acetic acid – 100ml of 10 %

Ethanol – 100 ml

Conc. ammonium hydroxide- drop wise

Procedure

Weighed 5 gm of sample and kept into a 250 ml of beaker. Mixed 100 ml (10% acetic acid and ethanol). Beaker was covered tightly and left it for 4 hours. Filtered it properly and

concentrated it up to one-fourth of its original volume by using a boiling water bath. Concentrated ammonium hydroxide mixed dropwise in this extract till precipitation was completed. After settled down the whole solution, the precipitate was collected. Washed it with diluted ammonium hydroxide. Alkaloid was contained from the left residue after filteration. Dried it properly and weighed.

4.9 Anthocyanin content (Giusti and Wrolstad, 2001)

Reagents

Sample- 1ml

Potassium chloride-5ml

Sodium acetate-5 ml

Procedure

Anthocyanin quantification was done by using P^H- differential method. Taken extract was diluted in a solution of (1.0 M HCL,25 Mm KCL) P^H 1.0 and in a solution (0.4 M CH_3COONa) P^H 4.5. Absorbance was taken against distilled water at 510 nm and 700 nm.

Calculation

Diluted sample absorbance (A) as follows:

$A = (A_{510} – A_{700})$ pH 1.0 – $(A_{510} – A_{700})$ pH 4.5

Monomeric anthocyanin pigment (mg/L) = $x = \frac{(AXMWXDFX1000)}{\varepsilon X1}$

Where,

The molecular weight(MW)

The dilution factor (DF)

The molar absorptivity(ε)

Cyanidin-3-glucoside (pigment content) where MW = 449.2 and ε= 26,900

4.10 Mineral composition (AYUSH, 2008)

Calcium, Iron and Phosphorus

Reagents

Nitric acid- 10 ml

Procedure

Weighed 0.5 gm of coarse fruit sample in a casparian flask and mixed with 10 ml nitric acid. Covered it properly and left for overnight. After that, heated on a electric hot plate till the solution become cleared and transparent . Heat continuously till the solution became light yellow colour and white smoke dispersed. The solution was cooled and then transferred into 50 ml volumetric flask and diluted with the same solvent to the volume and mixed it properly. Prepared reagent blank solution with explained method. The mineral content was carried out from the cleared solution by Inductively coupled plasma- optical emission spectrometry (ICP-OES).

4.11 Experimental Design

4.11 (a) Experimental animals

Healthy male albino rats were 200gm -250gm body weight were mainly used for the study purpose. The rats were acclimatized in the animal house environment for seven days before starting the research work. The study was approved by Animals Ethics Committee in University (Regd. No. 954/PO/AC/06/CPCSEA).

4.11 (b) Preparation of extracts

Microwave dried fruits were selected for the study and converted into fine powder. Petroleum ether was used to remove fat from the powder material. Methanol and water mixture of 1:1 was used for the 72 hours extraction. Filtered extract was concentrated by rotary evaporator and vacuum dessicator was used to keep it. The calculated yield for the extract of *Ficus carica*

extract was 29 per cent and *Carissa spinarum* was 31.6 per cent and with respect to dried powder (Rout *et al.*2013).

4.11 (c) Method for acute toxicity test

Male rats (wistar albino) were fasted overnight and separated into two groups (n=3). Two groups were orally fed with the extract of *Ficus carica* and *Carissa spinarum* separately, in increasing dose of 1000 mg, 2500 mg and 5000 mg according to body weight of rats. And rats were observed continuously for 2 days for change noticed in their behaviour, neurologically, any toxicity sign and mortality. If any, so they were again observed for the next 7 days for any changes in their behavoiur and death. One- tenth and one fifth of the maximum safe dose of the extract were selected for the experiment which was used for acute toxicity (Rout *et al.*2013).

4.11 (d) Preparation of interventions

Selected fruit extract dosage according to body weight of rats i.e. 500 mg. Mixed it with distilled water by using Tween 20 at 25 per cent level. Tween 20 was used as suspending agent. The Metformin dose (50 mg/kg body weight) was also made by same method The sample used for test, solvent and Metformin drug were given orally to rats based on their level of dose according to their body weight (Rout *et al.*2013).

4.11 (e) Animals and induction of diabetes mellitus

Overnight fasted rats were administered (35mg/kg body weight) of single injection of Streptozotocin (STZ) interaperitoneally for the induction of diabetes (Gupta *et al*.2004). STZ solution was prepared by dissolving it into 0.9 per cent of ice cold saline instantly before use. Fasting blood sugar levels were observed (FBG>250 mg/dl)to be diabetic after a week of STZ administration and further used for the experiment (Sachin *et al*.2009).

4.11 (f) Multiple dose hypoglycemic study

Rats were divided into seven groups and each group contained six rats. Every group was either received solvent (2.5 ml), selected fruit extract doses and Metformin 50 mg/kg body weight of everyday 30 minutes before food throughout experimental period. All rats were continuously observed and blood sample was collected on 0,7 14 and 21 days. Blood sample was collected for the measurement of fasting blood sugar level (Ngueguim *et al.* 2007; Kar *et al.* 2006).

4.11 (g) Experimental plan

Seven groups of rats each group contained six rats and conducted a study for 21 days:

Group 1 Rats treated with basal diets (control group)

Group 2- Diabetic control group treated with drug streptozotocin, negative control group (Diabetic+ Streptozotocin)

Group 3- Diabetic rats treated with antidiabetic drugs i.e. metformin and supplemented with basal diet, positive control group (Diabetic + Metformin)

Group 4- Diabetic rats treated with 500 mg extract of *Ficus carica* according to body weight of rats supplemented with basal diet

Group 5- Diabetic rats treated with 500 mg extract of *Carissa spinarum* according to body weight of rats and supplemented with basal diet

Group 6- Normal rats treated with 500 mg extract of *Ficus carica* according to body weight of rats and supplemented with basal diet

Group 7- Normal rats treated with 500 mg extract of *Carissa spinarum* according to body weight of rats and supplemented with basal diet

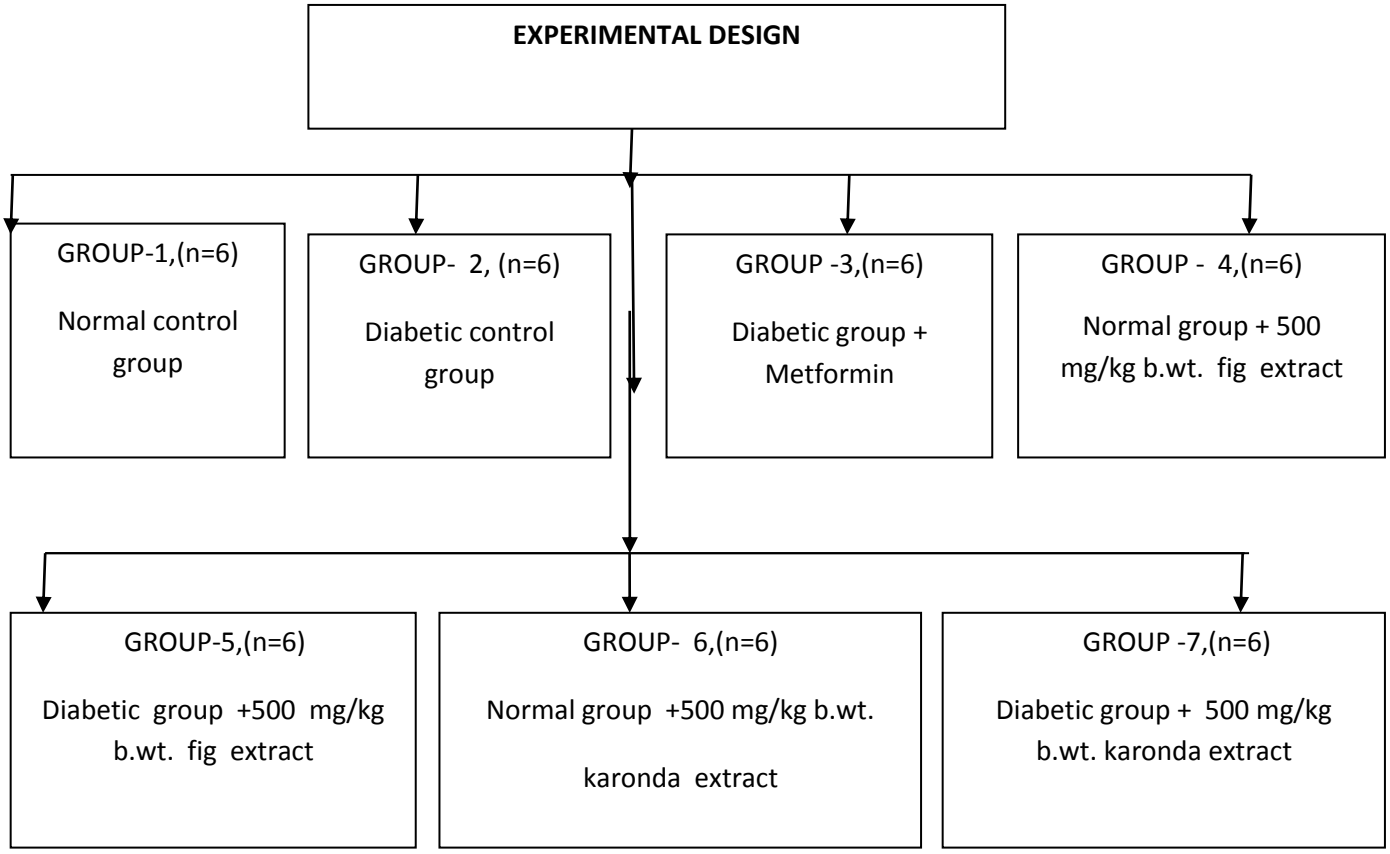

Fig. 4.2 Flow chart for value experimental design

4.12 Value added products development

4.12 (a) Procurement for raw materials

In order to develop (bun ,muffin, noodles and nuggets) value added products, the required materials were purchased from a local market in Jalandhar (wheat flour, R. oil, skimmed milk, honey, baking powder) etc.

4.12 (b) Fruit powder preparation

Fresh fruits were collected and spoiled fruits were removed before washing. Distilled water was used to wash these fruits three times to remove unwanted dirt particles then weighed and divided equally. Selected fruits were dried and distributed separately on the stainless steel trays and microwave dried for 3 minutes and 15 seconds (800W). Dried fruits were grounded fine in a grinding machine and sieved through 1mm sieve. All prepared mixture was stored in airtight container at room temperature and used for further analysis.

4.12 (c) Experiment design

The experimental design for the present research is depicted in **Table 4.1** and **Table 4.1.1** showed the different incorporation of fruits. In **Table 4.1.2** the different ingredients were used in making the buns were given in gm and **Fig 4.1** showed the flowchart for the preparation of buns.

Table 4.1 Experimental plan for bun

S. No.	Parameter	Level	Description
1.	Product	1	Bun
2.	Ingredient	5	Wheat flour, whole fresh fruit, R.oil, yeast powder and salt
3	Samples	8	B1, B2, B3, B4, T1, T2, T3 and T4 (Bun)
4.	Analysis	3	Nutritional analysis, Mineral analysis, sensory analysis

Table 4.2 Treatment description. Different combination of wheat flour, fresh fruit , R.oil, yeast powder and salt were used for the development of bun

Treatment	**Wheat Flour (WF), %**	***Ficus carica* (FC), %**	***Carissa spinarum* (CS), %**
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Where, B1 (Standard) =100% wheat flour bun, B2 = 15% *Carisssa spinarum*, B3= 30% *Carisssa spinarum*, B4= 45% *Carisssa spinarum*), T1= 100 % wheat flour bun , T2 = 15% *Ficus carica*, T3 = 30% *Ficus carica*, T4 = 45% *Ficus carica*

Table 4.3 Ingredients were used in the preparation of bun (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Wheat flour	100	85	70	55	100	85	70	55
2.	Fresh sample	0	15	30	45	0	15	30	45
3.	R.oil	1	1	1	1	1	1	1	1
4.	Yeast powder	2	2	2	2	2	2	2	2
5.	Salt	2	2	2	2	2	2	2	2

Bun Development (Alam *et al.* 2013)

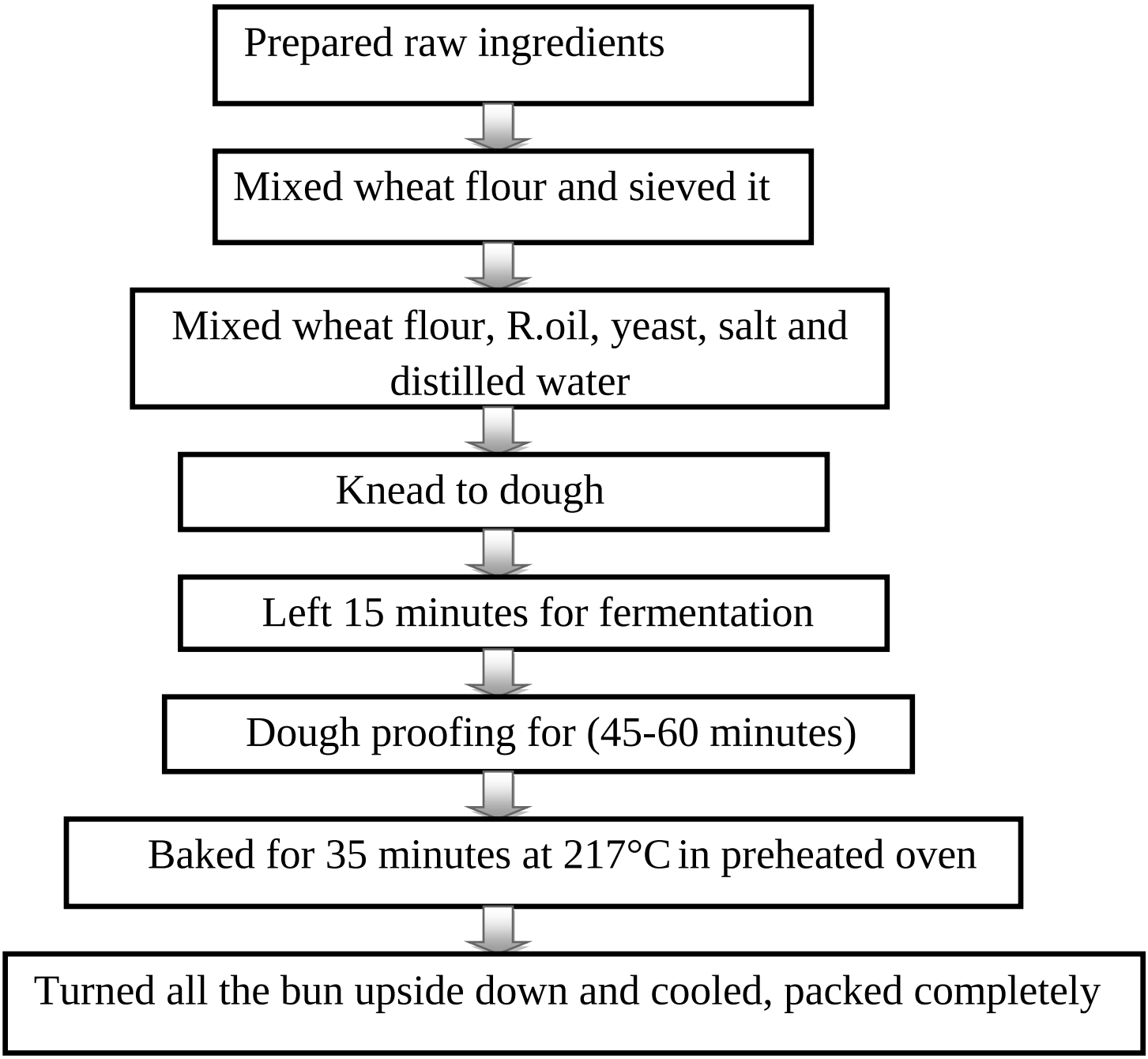

Fig. 4.3 Flow chart for the preparation of bun

Table 4.4 Experimental plan for muffin

S. No.	Parameter	Level	Description
1.	Product	2	Muffin
2.	Ingredient	6	Refined wheat flour, fresh fruit, R.oil, skimmed milk, honey, baking powder
3	Samples	8	B1, B2, B3, B4, T1, T2,T3and T4 (Muffin)
4.	Analysis	3	Nutritional analysis, Mineral analysis, sensory analysis

Table 4.5 Treatment description. Different combination of refined wheat flour, fresh fruit, R.oil, skimmed milk, honey, baking powder were used for the development of muffin

Treatment	**Wheat Flour (WF), %**	***Ficus carica* (FC), %**	***Carissa spinarum*(CS) %**
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Table 4.6 Ingredients were used in the preparation of muffin (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Refined wheat flour	100	85	70	55	100	85	70	55
2.	Sample/fruit powder	0	15	30	45	0	15	30	45
3.	R. oil	15	15	15	15	15	15	15	15
4.	Skimmed milk	25	25	25	25	25	25	25	25
5.	Honey	9	9	9	9	9	9	9	9
6.	Baking powder	1	1	1	1	1	1	1	1

Muffin Development (Uchenna *et al.* 2013)

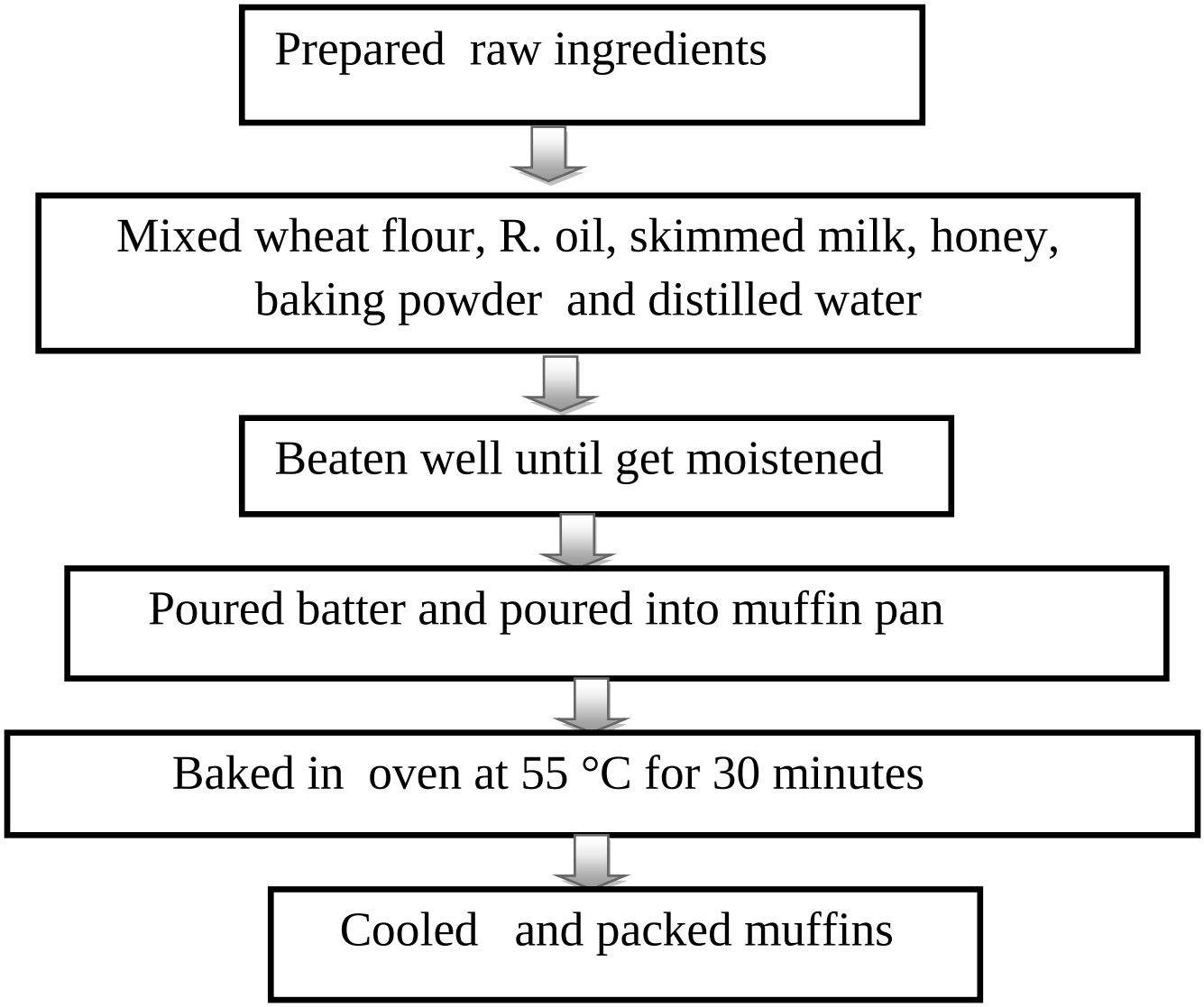

Fig. 4.4 Flow chart for the preparation of muffin

Table 4.7 Experimental plan for noodles

S. No.	Parameter	Level	Description
1.	Product	3	Noodles
2.	Ingredient	2	Wheatflour,fruit powder
3	Samples	8	B1, B2, B3, B4, T1, T2, T3 andT4 (Noodles)
4.	Analysis	2	Nutritional analysis, Mineral analysis

Table 4.8 Treatment description. Different combination of wheat flour, fruit powder was used for the development of noodles

Treatment	Wheat Flour (WF), %	*Ficus carica* (FC), %	*Carissa spinarum* (CS), %
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Table 4.9 Ingredients were used in the preparation of noodles (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Wheat flour	`100	85	70	55	`100	85	70	55
2.	Sample/fruit powder	0	15	30	45	0	15	30	45

Noodles Development (Ibitoye *et al.* 2013)

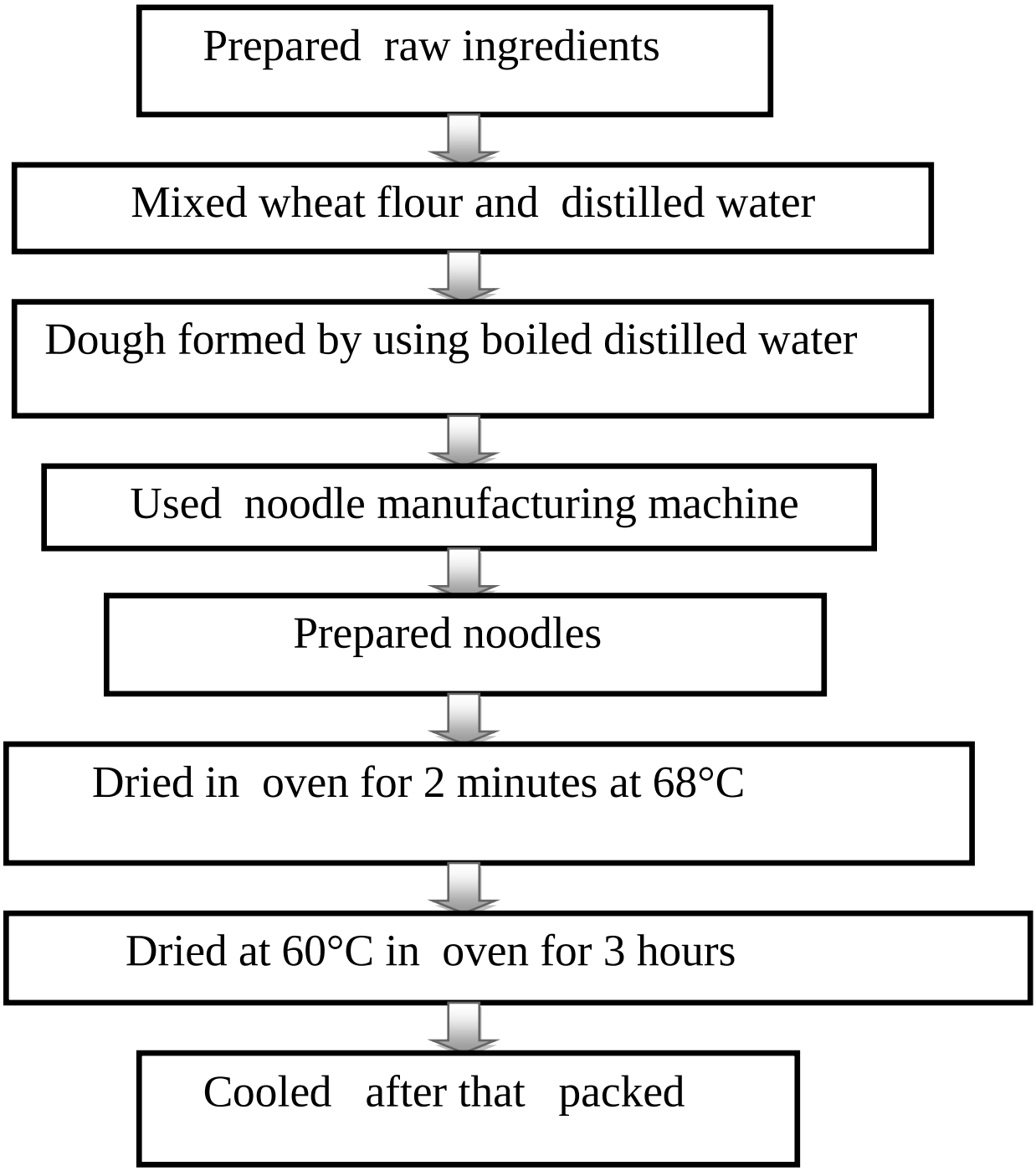

Fig. 4.5 Flow chart for the preparation of noodles

Table 4.10 Experimental plan for nuggets

S. No.	Parameter	Level	Description
1.	Product	4	Nuggets
2.	Ingredient	2	Moong flour, fruit powder
3	Samples	8	B1, B2, B3, B4, T1,T2,T3andT4 (Nuggets)
4.	Analysis	2	Nutritional analysis, Mineral analysis

Table 4.11 Treatment description. Different combination of moong flour, fruit powder was used for development of nuggets

Treatment	**Wheat Flour (WF), %**	***Ficus carica* (FC), %**	***Carissa spinarum* (CS), %**
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Table 4.12 Ingredients used in the preparation of nuggets (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Moong flour	100	85	70	55	100	85	70	55
2.	Sample/fruit powder	0	15	30	45	0	15	30	45

Nugget Development (Pandey *et al.* 2012)

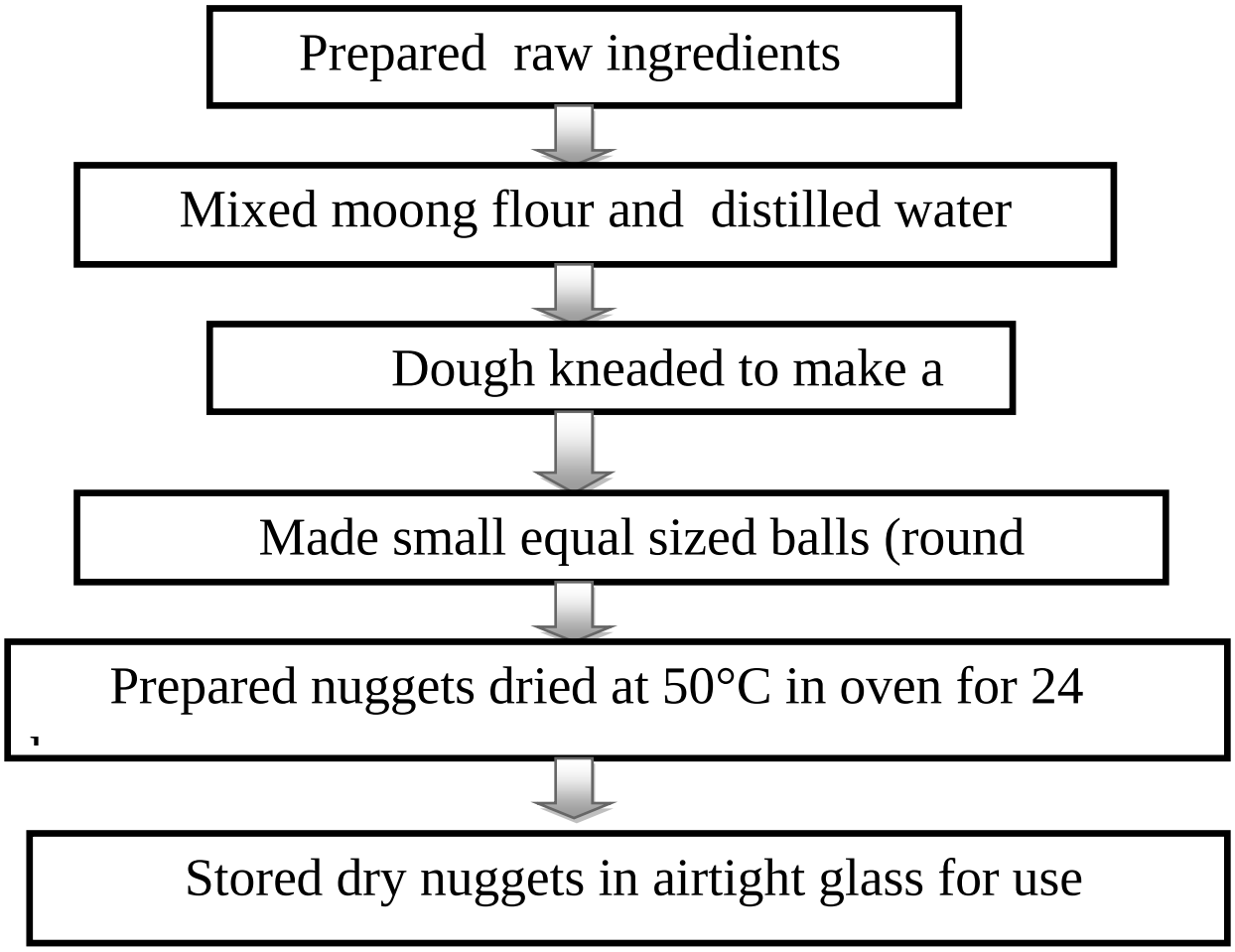

Fig. 4.6 Flow chart for the preparation of nuggets

4.12 (d) Organoleptic evaluation

Bun and muffin samples were evaluated for the appearance, colour, texture, flavor and overall acceptability by using 9 – point hedonic scale (Schutz and Cardello, 2001).

4.13 Statistical analysis

Experiments were performed in triplicates. These results were analyzed by using Graph pad prism 5 software for ANOVA (one-way analysis of variance) with Tukey's test for the determination of significant difference between the mean at 5 per cent level and statistically measured at significant level ($p < 0.05$).

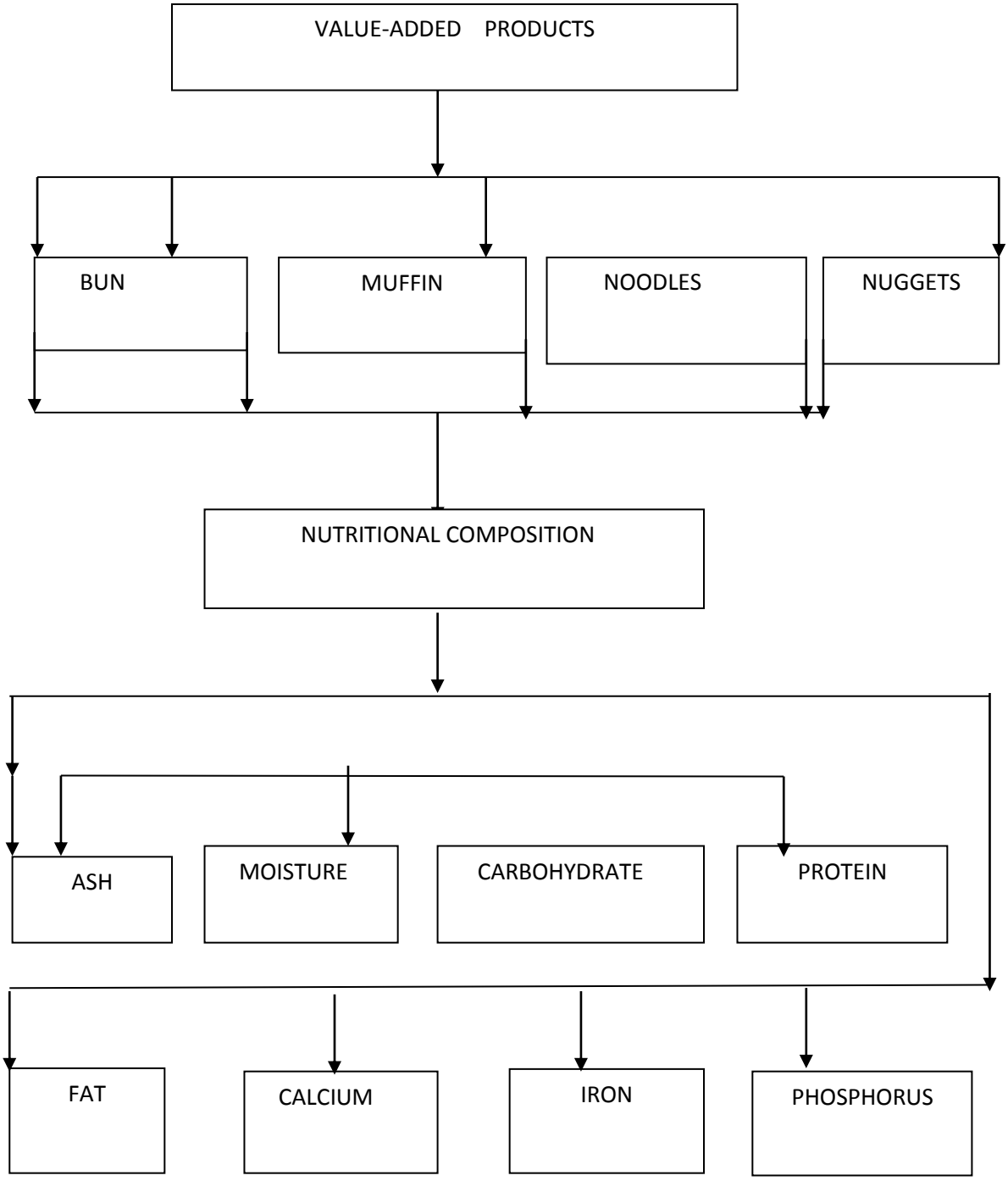

Fig. 4.7 Flow chart for value added products

5. RESULTS AND DISCUSSION

The present study was carried out in the Department of Food Technology and Nutrition, School of Agriculture and Food Technology, Lovely Professional University, Phagwara, Punjab during the year 2012- 2016. The results are discussed in the following subheads:

5.1 Analysis of *Ficus carica* (fig)

5.1 (a) Physical properties of fig

5.1 (b) Nutritional composition of fig

5.1 (c) Dietary composition of fig

5.1 (d) Phytochemical composition of *Ficus carica* (Total phenolic content)

5.1 (e) The total flavonoid content of fig

5.1 (f) Antioxidant activity (DPPH) of fig

5.1 (g) Antioxidant activity (FRAP) of fig

5.1 (h) Anti- nutritional content and anthocyanin content of fig

5.1 (i) Mineral composition of fig

5.2 Analysis of *Carissa spinarum* (Karonda)

5.2 (a) Physical properties of Karonda

5.2 (b) Nutritional composition of Karonda

5.2 (c) Dietary composition of Karonda

5.2 (d) Phytochemical composition of *Carissa spinarum* (Total phenolic content)

5.2 (e) The total flavonoid content of Karonda

5.2 (f) Antioxidant activity (DPPH) of Karonda

5.2 (g) Antioxidant activity (FRAP) of Karonda

5.2 (h) Anti- nutritional content and anthocyanin content of Karonda

5.2 (i) Mineral composition of Karonda

5.3 Experimental design

5.3 (a) Effect of fig (*Ficus carica*) methanolic extract on fasting blood glucose level in diabetic and non diabetic rats

5.3 (b) Effect of fig (*Ficus carica*) methanolic extract on body weight in diabetic and non diabetic rats

5.4 Experimental design

5.4 (a) Effect of Karonda (*Carissa spinarum*) methanolic extract on fasting blood glucose level in diabetic and non diabetic rats

5.4 (b) Effect of Karonda (*Carissa spinarum*) methanolic extract on body weight in diabetic and non diabetic rats

5.5 Formulation of value added product with substitution of fig

5.5 (a) Bun

5.5 (b) Nutritional composition

5.5 (c) Dietary fiber

5.5 (d) Mineral composition

5.5 (e) Organoleptic analysis

5.6 Muffin

5.6 (a) Nutritional composition

5.6 (b) Dietary fiber

5.6 (c) Mineral composition

5.6 (d) Organoleptic analysis

5.7 Noodles

5.7 (a) Nutritional composition

5.7 (b) Dietary fiber

5.7 (c) Mineral composition

5.7 (d) Organoleptic analysis

5.8 Noodles

5.8 (a) Nutritional composition

5.8 (b) Dietary fiber

5.8 (c) Mineral composition

5.8 (d) Organoleptic analysis

5.9 Formulation of value added product with substitution of Karonda

5.9 (a) Bun

5.9 (b) Nutritional composition

5.9 (c) Dietary fiber

5.9 (d) Mineral composition

5.9 (e) Organoleptic analysis

5.10 Muffin

5.10 (a) Nutritional composition

5.10 (b) Dietary fiber

5.10 (c) Mineral composition

5.10 (d) Organoleptic analysis

5.11 Noodles

5.11 (a) Nutritional composition

5.11 (b) Dietary fiber

5.11 (c) Mineral composition

5.11 (d) Organoleptic analysis

5.12 Noodles

5.12 (a) Nutritional composition

5.12 (b) Dietary fiber

5.12 (c) Mineral composition

5.12 (d) Organoleptic analysis

5.1 Analysis of *Ficus carica* (fig)

5.1 (a) Physical properties of fig

The effect of processing methods on the physical properties of fig is depicted in Table 6.1. The length of fresh fig was found to be 15.46 mm. Similar results, i.e. 20 mm to 36 mm were reported by Darjazi *et al*. (2011) in fresh fig fruit. A statistically significant increase ($p< 0.05$) in length was observed in fresh fig sample, the increasing order being MDS<SD <FRS<FS.

Table 5.1 Effect of processing methods on physical properties of fig

Drying methods	FS	SD	FRS	MDS
Length(mm)	15.46 ± 0.05^{a}	14.26 ± 0.05^{b}	14.46 ± 0.05^{c}	14.16 ± 0.05^{bd}
Width(mm)	18.14 ± 0.00^{a}	17.46 ± 0.05^{b}	17.86 ± 0.05^{c}	17.16 ± 0.05^{cd}
Density(gm/cc)	0.95 ± 0.00^{a}	0.93 ± 0.02^{a}	0.94 ± 0.01^{a}	0.91 ± 0.00^{ab}

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample

Length of sun dried fig was found to be 14.26 mm. Length decreased by 7.76 %, in sun dried fig as compared to fresh ones. Length of microwave dried fig was found to be 14.16 mm. Length decreased by 8.40 %, in microwave dried fig as compared to fresh ones. Similar results have been reported by Hazbavi *et al.* (2014), wherein they reported 3.06 % decrease in length in date palm fruit by thermal processing. Similar decrease in length has been reported by Zivcovic *et al*. (2011) in thermal dried plum. This may be attributed to the fact that thermal process leads to decrease in length of fruits as moisture content is reduced (Kashaninejad *et al*.2006) and also due to the shrinkage of fruits (Jha *et al*.2006).

Length of frozen fig was found to be 14.46mm. Length decreased by 6.46 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 4.80 % decrease in length in frozen dates. This decrease in length by frozen storage might be due to the period of cold storage (Al- Yahayai and Al- Kharusi,2012).

The width of fresh fig was found to be 18.14 mm. Similar results, i.e. 21mm to 48 mm was reported by Darjazi *et al*. (2011) in fresh fig fruit. A statistically significant increase ($p<0.05$) in width was observed in fresh fig sample, the increasing order being MDS<SD <FRS<FS.

Width of sun dried fig was found to be 17.46 mm. Width decreased by 3.74 % in sun dried fig as compared to fresh ones. Width of microwave dried fig was found to be 17.16 mm. Width decreased by 5.40 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Hazbavi *et al.*(2014), where they found 1.45 % decrease in width in thermal processed date palm fruit. Similar decrease in width has been reported by Zivcovic *et al*. (2011) in heat treated plum. This decrease in width by thermal process might be due to the reduction of moisture content (Kashaninejad *etal.*2006) and also due to the shrinkage of fruits (Jha *et al.*2006; Hazbavi *et al*, 2014). Width of frozen fig was found to be 17.86 mm. Width decreased by 1.54 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), wherein they reported 7.69 % decrease in width in frozen dates. This decrease in width by frozen storage might be due to the period of cold storage (Al- Yahayai and Al- Kharusi, 2012).

The density of fresh fig was found to be 0.95 gm/cc. Similar results, i.e. 1.46 gm/cc was reported by Razavi *et al*. (2010) in fresh fig fruit. A statistically significant increase ($p<0.05$) in density was observed in fresh sample, the increasing order being MDS<SD <FRS<FS. Density increased in fresh due to higher moisture content that leads to increase volume (Garmakhany *et al.* 2013). Density of sun dried fig was found to be 0.93 gm/cc. Density decreased by 2.10 % in sun dried fig as compared to fresh ones. Density of microwave dried fig was found to be 0.91 gm/cc. Density decreased by 4.21 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Pacco and Menegalli (2004), where they reported decrease in density in thermal dried fig fruit. This is may be attributed to the fact that thermal processing fig becomes more porous.

Density of frozen fig was found to be 0.94 gm/cc. Density decreased by 1.05 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Ramaswamy and Tung (1981), wherein they reported decrease in density by 6.74 % in frozen storage "Golden" apple.

5.1 (b) Nutritional composition of fig

The moisture content of fig fruit is depicted in Table 5.2. Moisture content of fresh fig was found to be 80.2 per cent. Similar results, i.e. 80.61 per cent was reported by Nakilcioglu and Hisil, (2013) in "Sarilop" fresh fig variety. The moisture content increased significantly ($p<0.05$) in frozen fig sample, the increasing order being MDS<SD<FS<FRS.

Table 5.2 Effect of processing methods on nutritional properties of fig

Drying methods	FS	SD	FRS	MDS
Moisture (%)	80.2 ± 0.00^{a}	25.86 ± 2.48^{b}	81.0 ± 1.97^{ac}	25.43 ± 3.23^{bc}
Ash (%)	4.00 ± 0.34^{a}	4.42 ± 0.19^{a}	4.20 ± 0.08^{a}	4.30 ± 0.23^{a}
Carbohydrate (%)	16.3 ± 0.18^{a}	65.15 ± 0.20^{b}	16.0 ± 0.03^{ac}	65.18 ± 0.08^{cd}
Fat (%)	0.53 ± 0.08^{a}	0.56 ± 0.00^{a}	0.51 ± 0.07^{a}	0.59 ± 0.03^{a}
Protein (%)	0.53 ± 0.15^{a}	3.01 ± 0.09^{a}	2.71 ± 0.32^{a}	3.18 ± 0.07^{a}

The moisture content of sun dried fig was found to be 25.85 per cent. Moisture content decreased by 67.75 % in sun dried fig as compared to fresh ones. Similar results have been reported by Siriwattananon and Maneerate (2016), in guava where they found 89.08% decrease in moisture content in sun dried fruit. Moisture content of microwave dried fig was found to be 25.43 per cent. Moisture content decreased by 68.29 % in microwave dried fig as compared to

fresh ones. Similar results have been reported by Nakilcioglu and Hisil (2013), wherein they reported 79.76% decrease in moisture content in fig fruit after thermal process. Similar decrease in moisture content (99.75%) has been reported by Lutz *et al.* (2015) in heat treated blackberry. Kshetrimayum *et al*. (2015), also reported 92.86 % reduction in moisture content in microwave dried guava slices. This reduction in moisture content by thermal process might be due to the rapid water loss (Mechlouch *et al.* 2015), heating temperature (Brooker, 1974) and higher absorption power (Meda *et al.* 2008).

Moisture content of frozen fig was found to be 81.0 per cent. Moisture content increased by 0.99 % in frozen fig as compared to fresh ones. Similar results have been reported by Aleid *et al*. (2014), where they reported 10.51% increase in moisture content in date during frozen storage and Damini *et al*.(2013), wherein they reported 2.45 % increase in the moisture content in frozen marolo pulp. Similar increase in moisture content (1.0 %) has been reported by Boca *et al.* (2014) in frozen strawberry puree. This may be attributed to the fact that frozen storage leads to increase in moisture content of fruits as destruction of cellular structure by syneresis (Sae-Kang and Suphantharika, 2006) that leads to release of intracellular water (Chefteh and Besancon, 1989) which is migrated out of the cell (Damiani *et al*.2013).

The ash content of fig fruit is depicted in Table 5.2. Ash content of fresh fig was found to be 4.00 per cent . Similar results, i.e. 5.74 per cent was reported by Chawla *et al*. (2012) in fresh fig fruit. Ash content increased non significantly ($p>0.05$) in all fig dried samples and the increasing order being FS<FRS<MDS<SD. The ash content of sun dried fig was found to be 4.42 per cent. Ash content increased by 10.5 % in sun dried fig as compared to fresh ones. Ash content of microwave dried fig was found to be 4.30 per cent. Ash content increased by 7.5 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Nordin *et al*. (2013), wherein they reported 12.53 % increase in ash content in palm during thermal process. This increase in ash content by thermal process might be due to the removal of moisture content (Lisa, 1997).

Ash content of frozen fig was found to be 4.20 per cent. Ash content increased by 5.0 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Zolfaghari *et al*. (2010), where they reported 8.3 % increase in ash content in kiwi fruit during frozen storage.

Similar increase in ash content 20 % has been reported by Ogunobanwo *et al*.(2013) in frozen water melon juice. This increase in ash content by frozen storage might be due to the presence of products which has chemical stability (Raji *et al.* 2016).

Fat content of fig fruit is depicted in Table 5.2. Fat content of fresh fig was found to be 0.53 per cent. Similar results, i.e. 0.34 per cent was reported by Mahmoud *et al*. (2013) in fresh fig fruit. A statistically non significant increase ($p<0.05$) in fat content in all dried fig samples and the increasing order being FRS<FS<SD<MDS.

The fat content of sun dried fig was found to be 0.56 per cent. Fat content increased by 5.66 % in sun dried fig as compared to fresh ones. Fat content of microwave dried fig was found to be 0.59 per cent. Fat content increased by 11.32 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Nwaigwe and Adejumo (2015), in African bread fruit where they found 2.10 % increase in fat content during thermal process. This may be attributed to the fact that thermal process leads to increase in fat content of fruits along with removal of moisture content (Morris *et al.* 2004). Fat content of frozen fig was found to be 0.51 per cent. Fat content decreased by 3.77 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 10.81 % decrease in fat content in frozen blackthorn fruit. This decrease in fat content by frozen storage might be due to oxidation (Ryder *et al*.1993) that leads to release oxidative enzymes from various rupture cellular organelles (Boonsumrej *et al.* 2007).

Carbohydrate content of fresh fig was found to be 16.3 per cent. Similar results, i.e. 17.1 per cent was reported by Guvenc *et al*. (2009) in fresh fig fruit. Significant difference ($p<0.05$) increased in carbohydrate content in all fig dried samples and the increasing order being FRS<FS<SD<MDS. The carbohydrate content of sun dried fig was found to be 65.15 per cent. Carbohydrate content increased by 299.69% in sun dried fig as compared to fresh ones. Carbohydrate content of microwave dried fig was found to be 65.18 per cent. Carbohydrate content increased by 299.87% in microwave dried fig as compared to fresh ones. Similar results have been reported by Guvenc *et al*. (2009) in fig fruit where they found 240.39 % increase in carbohydrate content during heat treatment and Clary *et al*. (2007), wherein they reported 265. 27% increase in carbohydrate content in microwave dried grapes. Similar increase in

carbohydrate content (13.15 %) has been reported by Nwaigwe and Adejumo (2015) in thermal treated African bread fruit. This increase in carbohydrate content by thermal process might be due to hydrolytic effect of carbohydrate stored in fruits (Akinhanmi *et al.* 2008).

Carbohydrate content of frozen fig was found to be 65.15 per cent. Carbohydrate content decreased by 1.84 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Galoburda *et al.* (2014), where they reported 55.2% decrease in the carbohydrate content in strawberry puree during frozen storage. Damiani *et al*. (2013), wherein they reported 16.11% decrease in carbohydrate content in frozen marolo pulp. Similar decrease in carbohydrate content (25.78%) has been reported by Zolfaghari *et al*. (2010), in frozen kiwi fruit. This may be attributed to the fact that frozen storage leads to decrease in carbohydrate content of fruits as increase in carbon consumption which is required for fruit respiration (Holland *et al*. 2002) and also due to the breakdown of cell structure during frozen storage (Cheftel and Besancon,1989).

The protein content of fig fruit is depicted in Table 5.2. Protein content of fresh fig was found to be 2.98 per cent. Similar results, i.e.1.30 per cent was reported by Guvenc *et al*. (2009) in fresh fig fruit. Protein content non significantly increased ($p>0.05$) in all fig dried samples and the increasing order being FRS<FS<SD<MDS. The protein content of sun dried fig was found to be 3.01 per cent. Protein content increased by 467.92 % in sun dried fig as compared to fresh ones. Protein content of microwave dried fig was found to be 3.18 per cent. Protein content increased by 500.00 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mahmoud *et al*.(2013) in fig fruit where they found 288.23 % increase in protein content during thermal process and Clary *et al*. (2007), wherein they reported 236.11 % increase in protein content in grapes during heat treatment. Similar increase in protein content (14.28 %) has been reported by Nwaigwe and Adejumo (2015) in African bread fruit during thermal process. This increase in protein content by thermal process might be due to the enhancement in dry matter contents by the concentration of soluble solids (Eze and Akubor, 2012).

Protein content of frozen fig was found to be 2.71 per cent. Protein content decreased by 411.32 % in frozen storage fig as compared to fresh ones. Similar results have been reported by

Sikora *et al.* (2013), where they reported 57.51% decrease in protein content in blackthorn fruit during frozen storage. Similar decrease in protein content (7.79 %) has been reported by Damiani *et al*. (2013) in frozen marolo pulp. This may be attributed to the fact that frozen storage decrease in protein content of fruits as reduction in proteins which are water and salt soluble (Chomnawang *etal.*2007), denaturation of proteins (Ryder *et al.* 1993) and destruction caused by enzymatic activity (Hultman and Rustard, 2004).

5.1 (c) Dietary composition of fig

The neutral detergent fiber (NDF) of fig fruit is depicted in Table 5.3. Neutral detergent fiber of fresh fig was found to be 12.73 per cent. Similar results, i.e. 12.49 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. A statistically significant ($p<0.05$) increase in NDF in all fig dried samples, the increasing order being FRS<FS<SD<MDS

Table 5.3 Effect of processing methods on dietary composition of fig

Drying methods	FS	SD	FRS	MDS
NDF (%)	12.73 ± 0.05^{a}	12.83 ± 0.05^{a}	12.53 ± 0.11^{b}	12.86 ± 0.05^{ac}
ADF (%)	0.40 ± 0.10^{a}	0.56 ± 0.11^{a}	0.38 ± 0.07^{a}	0.60 ± 0.05^{a}
Hemicellulose (%)	12.26 ± 0.05^{a}	12.30 ± 2.17^{a}	12.16 ± 0.05^{a}	12.33 ± 0.11^{a}
Cellulose (%)	15.91 ± 0.05^{a}	16.11 ± 0.07^{a}	15.90 ± 0.40^{a}	16.68 ± 0.05^{b}
Lignin (%)	1.72 ± 0.01^{a}	1.73 ± 0.01^{a}	1.70 ± 0.00^{a}	1.74 ± 0.01^{ab}

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The neutral detergent fiber of sun dried fig was found to be 12.83 per cent. NDF increased by 0.78 % in sun dried fig as compared to fresh ones. NDF in microwave dried fig was found to be 12.86 per cent. NDF increased by 1.02 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Clary *et al*. (2007), where they reported 58 % increase in dietary fiber content in microwave dried grapes. This increase in dietary fiber by thermal process might be due to the formation of Maillard reaction product (Chang and Morris, 1990; Vidal and Frias, 1991) and also due to the reduction in moisture content (Fennema, 1976), by leaching of soluble components to the solution that leads to form the heat resistant complexes between polysaccharides and other mechanism i.e. protein and phenolic content (Caprez *et al.* 1986; Rodriguez *et al.* 2006). Dietary fiber (hemicellulose, cellulose and lignin) also increased (Vasishtha *et al.* 2013) due to releasing of enzymatic fiber components from insoluble cell wall matrix (Hakkinen *et al.*2003).

Neutral detergent fiber of frozen fig was found to be 12.53 per cent. The NDF decreased by 1.57% in frozen storage fig as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 18.13 % decrease in dietary fiber in frozen blackthorn fruit and Salgado *et al.* (1999), wherein they reported reduction in dietary fiber in frozen tropical fruits. This decrease in NDF by frozen storage might be due to the reduction in of cell wall polysaccharides tissues that leads declined dietary fiber (Khan and Vincent, 1996).

Acid detergent fiber (ADF) of fig fruit is depicted in Table 5.3. Acid detergent fiber of fresh fig was found to be 0.40 per cent. Similar results, i.e. 0.74 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. The ADF increased non significantly ($p>0.05$) in dried fig samples, the increasing order being FRS<FS<SD<MDS. The acid detergent fiber of sun dried fig was found to be 0.56 per cent. ADF increased by 40 % in sun dried fig as compared to fresh ones. ADF in microwave dried fig was found to be 0.60 per cent. ADF increased by 50 % in microwave dried fig as compared to fresh ones. Acid detergent fiber in frozen fig was found to be 0.38 per cent. The ADF decreased by 5.0 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Mohajer *et al.* (2016), where they reported 32.66 % decrease in ADF in frozen sainfoin seed.

Hemicellulose content of fresh fig was found to be 12.26 per cent. Similar results, i.e. 12.09 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. A statistically non significant increase ($p>0.05$) in hemicellulose content in fresh fig samples, the increasing order being FRS<FR<SD<MDS. The hemicellulose content of sun dried fig was found to be 12.30 per cent. Hemicellulose content increased by 0.32 % in sun dried fig as compared to fresh ones. Hemicellulose content in microwave dried fig was found to be 12.33 per cent. Hemicellulose content increased by 0.57 % in microwave dried fig. Similar results have been reported by Komolka *et al*. (2012), where they reported 5 % increase in hemicellulose content in common cabbage by thermal processing. Hemicellulose content in frozen fig was found to be 12.16 per cent. The hemicellulose content decreased by 0.06 % in frozen storage fig.

Cellulose content of fig fruit is depicted in Table 5.3. Cellulose content of fresh fig was found to be 15.91 per cent. Similar results, i.e. 22.20 per cent was reported by Nzidda (2010) in " *Ficus polita*" a variety of fig fruit. The cellulose content increased significantly ($p<0.05$) in dried fig samples, the increasing order being FRS<FS<SD<MDS. The cellulose content of sun dried fig was found to be 16.11 per cent. Cellulose content increased by 1.25 % in sun dried fig as compared to fresh ones. Cellulose content in microwave dried fig was found to be 16.68 per cent. Cellulose content increased by 4.83 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015), where they reported 13.7% increase in cellulose content in date fruit during thermal process and Nordin *et al*. (2013), wherein they reported 3.31% increase in oil palm fruit during heat treatment. Cellulose content in frozen fig was found to be 15.90 per cent. The cellulose content decreased by 0.06 % in frozen storage fig as compared to fresh ones.

Lignin content of fresh fig was found to be 1.72 per cent. Similar results, i.e. 2.53 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. The lignin content increased significantly ($p<0.05$) in dried fig samples, the increasing order being FRS<FS<SD<MDS. The lignin content of sun dried fig was found to be 1.73 per cent. Lignin content increased by 0.58 % in sun dried fig as compared to fresh ones. Lignin content in microwave dried fig was found to be 1.74 per cent. Lignin content increased by 1.16 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015) in date fruit where they

found 20.68 % increase in lignin content during thermal process. Similar increase in lignin content (38.79 %) has been reported by Nordin *et al*. (2013) in thermal processed oil palm fruit. This increase in lignin content by thermal process might be due to increase the activity of lignin synthesis enzymes i.e. phenylalanine ammonia lyase (Yun *et al*.2013). Hosseinaei *et al.* (2012) also reported that due to heat, complex structure of lignin is formed which makes it difficult for degradation. Lignin content in frozen fig was found to be 1.70 per cent. The lignin content decreased by 1.16 % in frozen fig as compared to fresh ones. Similar results have been reported by Dangcham *et al*. (2008), where they reported 65.07 % decrease in lignin content in mangosteen fruit at low temperature storage.

5.1 (d) Phytochemical composition of fig (Total Phenolic content)

Processing methods caused remarkable changes in the total phenolic content of fig fruit is depicted in **Figure 5.1**. Total phenolic content (TPC) of fresh fig was found to be 4.58 mg TAE/100gm. Similar results, i.e. 1.15 mg GAE/100gm to 6.98 mg GAE/100gm were reported by Nakilcioglu and Hisil, (2013) in "Sarilop" fresh fig varieties.

A statistically significant increase ($p<0.05$) in TPC was observed in all dried fig samples, the increasing order being FRS<FS <SD<MDS. Total phenolic content of sun dried fig was found to be 4.92 mg TAE/100gm. TPC increased by 7.42 %, in sun dried fig as compared to fresh ones. Al-Farsi *et al.* (2005), reported 22.5 % increase in TPC in dates after sun drying. Total phenolic content of microwave dried fig was found to be 4.94 mg TAE/100gm. TPC increased by 7.86 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Reyes *et al.* (2013) in loquat where they found 10.52 % increase in TPC in microwave dried fruit as compared to fresh ones and Hayat *et al*. (2010), wherein they reported increase from 4.3% to 45.61% in microwave dried pomace. This increase in TPC by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (HMP) by Maillard reaction (Donovan *et al.* 1998) and also due to the breakdown of cellular structure of cells, which makes the phenolic content more extractable (Van *et al.* 2000). Singleton *et al.* (1999) mentioned enhancement in phenolic content may be due to the formation of aglycons by reacting with Folin-Ciocalteau reagent.

Total phenolic content of frozen fig was found to be 4.52 mg TAE/100gm. Frozen stored fig fruits exhibited 1.31 % decrease in total phenolic content as compared to fresh ones. Similar results have been reported by Mullen *et al.* (2002), where they reported 21 to 28 % decrease in the TPC in raspberries during frozen storage as compared to fresh ones. Similar decrease in TPC (0.81%) has been reported by Scibisz and Mitek (2007) in frozen blueberries. This may be attributed to the fact that frozen storage leads to decrease in total phenolic content of fruits as polyphenol oxidase enzymes (PPO) are released by breaking cells and that leads to oxidation of polyphenolics to quinines (De Ancos *et al*. 2000a).

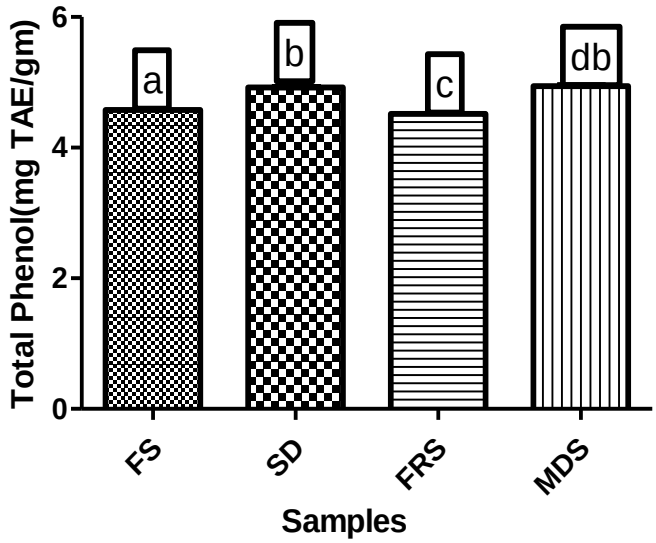

Fig. 5.1 Total Phenolic content of fig

Values are expressed in triplicates (mean ± SD)

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample

5.2 (e) Total Flavonoid content of fig

Flavonoid content of fig fruit is depicted in **Figure 5.2.** Total flavonoid content of fresh fig was found to be 0.21 mg QE/100gm. Similar results, i.e. 1.6 mg catechin equivalent/ 100gm

to 2.3 mg catechin equivalent /100gm were reported by Solomon *et al*. (2006) in "Brunswick " fresh fig varieties.

The total flavonoid content increased significantly ($p<0.05$) in fresh fig sample, the increasing order being SD<MDS<FS<FRS. The flavonoid content of sun dried fig was found to be 0.19 mg QE/100gm. Flavonoid content decreased by 9.52 % in sun dried fig as compared to fresh ones. Similar results have been reported by Wang *et al.* (2016) in jujube fruit where they found 26.75 % decrease in flavonoid content in sun dried fruit. Flavonoid content of microwave dried fig was found to be 0.20 mg QE/100gm. Flavonoid content decreased by 4.76 % in microwave dried fig as compared to fresh ones. Similarly reduction in total flavonoid content (33.3%) has been reported by Salim *et al.* (2014) in microwave dried pepper and Planinic *et al.* (2015), wherein they reported 15.3% reduction in flavonoid content in microwave dried grape fruit. Similar results have been reported by Macias *et al* .(2013), where they reported 23.13 % decrease in flavonoid content in strawberry fruit during thermal process. This decrease in flavonoid content by thermal process (Crozier *et al.* 1995; Price and Rhodes, 1997) might be due to the breakdown of some phytochemicals, which affects cell wall integrity and that leads to migration of some flavonoid components (Davey *et al.* 2000). Ioannou *et al.* (2012) also mentioned that heating process caused degradation might be due to parameters such as pH, oxygen, light, activity of polyphenoleoxidase enzymes and by hydrolysis of C- glycosides bonds, which are presented in flavonoids (Manach *et al.*2004). Flavonoid content of frozen fig was found to be 0.23 mg QE/100gm.

Flavonoid content increased by 9.52 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Mohammadian *et al*.(2011), where they reported 52.11% increase in flavonoid content in "*Citrus limon*" during frozen storage. This may be attributed to the fact that frozen storage leads to increase in flavonoid content of fruits as increase in quercetin derivatives during cold storage (Omer and Canan, 2014) that increases quercetin hydrolysis (Hakkinen *et al*.2000).

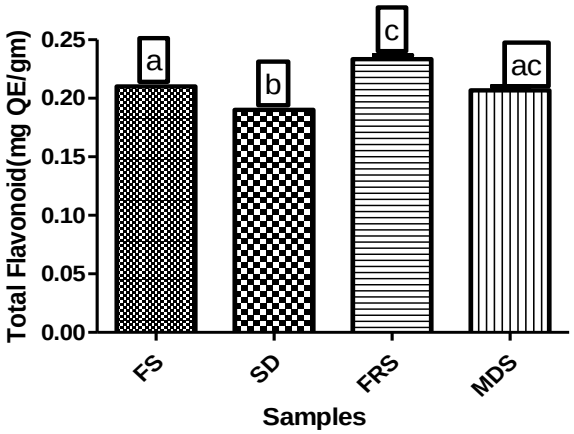

Fig. 5.2 Total Flavonoid content of fig

Values are expressed in triplicates (mean ± SD)

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.1 (f) Antioxidant activity of fig

Processing methods caused remarkable changes in antioxidant activity of fig fruit is depicted in **Figure 5.3.** Antioxidant activity of fresh fig was found to be 73.42 per cent. Similar results, i.e. 75.16 per cent was reported by Wilson *et al*. (2016) in " *Ficus religiosa*" a variety fig fruit.

Antioxidant activity significantly ($p<0.05$) increased in all dried fig sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity of sun dried fig was found to be 75.36 per cent. Antioxidant activity increased by 2.64 % in sun dried fig as compared to fresh ones. Antioxidant activity of microwave dried fig was found to be 75.84 per cent. Antioxidant activity increased by 3.29 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mechlouch *et al.* (2015), where they found 95.32 % increase in antioxidant activity (DPPH) in microwave dried palm date and Juhaimi *et al*.(2015), wherein they reported 280.33 % increase in DPPH antioxidant activity in microwave dried apple. Similar increase in antioxidant activity from 0.27 % to 0.96 % has been reported by Jeong et al.(2004) in heat treated citrus peel extract. This increase in antioxidant activity (DPPH) by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (Raupp *et al*.2011), presence of

naturally occurring compounds such as Maillard reaction products (Yin and Chang,1998; Piga *et al*. 2003;Lee *et al*.2003), released of a free phenolic fraction (Yamaguchi *et al*. 2001), due to oxidative and hydrolytic enzyme (Farsi *et al*.2005), disruption of cell wall that leads to release and enhances antioxidant activity (Chumyan *et al*.2013).

Antioxidant activity of frozen fig was found to be 71.66 per cent. Antioxidant activity (DPPH) decreased by 2.39 % in frozen storage fig as compared to fresh ones. Similar results have been reported by De Ancos *et al.* (2000), where they reported 12 % decrease in antioxidant activity (DPPH) in frozen raspberry fruit and Pimia *et al*.(2003), wherein they reported 20 % decrease in antioxidant activity in frozen peas. Similar decrease in antioxidant activity (1.64 %) has been reported by Mohammadian *et al.*(2011) in frozen "*Citrus limon*. This may be attributed to the fact that frozen storage leads to decrease in antioxidant activity of fruits as disruption of cell structure (Sikora *etal*.2013) and cell wall that leads to release of the oxidative and hydrolytic enzymes that can destroy antioxidant in fruits (Chism,1996).

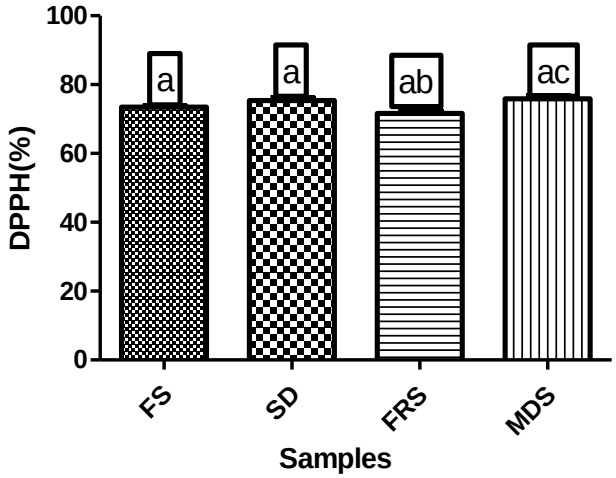

Fig. 5.3 Antioxidant activity (DPPH) of fig

Different superscripts in the same row are significantly different ($p<0.05$).

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.1 (g) Antioxidant activity of fig

Ferric reducing scavenging activity (FRAP) is depicted in **Figure 5.4.** Antioxidant activity of fresh fig was found to be 76.22 per cent. Shivasharanappa and Londonkar, (2014) reported lower antioxidant activity in"*Ficus glomerata*" variety of fig fruit, i.e. 29 per cent to 70 per cent as compared to our results. This difference might be due to many parameters such as fruit colour (Bey and Louaileche, 2015), extraction methods, solvent (Musa *et al.*2011), difference in cultivation (Wand *et al*. 2002; Hakkinen and Torronen, 2000), ripening period (Raffo *et al.* 2012), environmental factor (Wu *etal*.2014). Antioxidant activity non significantly ($p > 0.05$) increased in all dried fig sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity (FRAP) of sun dried fig was found to be 76.55 per cent. Antioxidant activity (FRAP) increased by 0.43 % in sun dried fig as compared to fresh ones. Antioxidant activity of microwave dried fig was found to be 78.54 per cent. Antioxidant activity increased by 3.04 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Piga *et al.* (2003), where they reported increase in antioxidant activity (FRAP) in plum fruit during thermal process. Higher antioxidant activity might be due to relative increase of FRAP value which determined the capacity of plant extract for the donation and acceptance of electrons (Yan *et al.* 2006). This increase in antioxidant activity by thermal process may be due to reduction in moisture content(Abou El-Hana, 2008), inhibition of oxidative enzymes and cell wall destruction which releases antioxidant compounds (Yamaguchi *et al.* 2001).

Antioxidant activity of frozen fig was found to be 75.76 per cent. Antioxidant activity (FRAP) decreased by 0.60 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Poiana *et al*.(2010), where they reported decrease from 6.5% to 12% in frozen strawberry fruit and Nilsson *et al.* (2004), wherein they reported decrease in antioxidant activity (FRAP) in frozen peas.

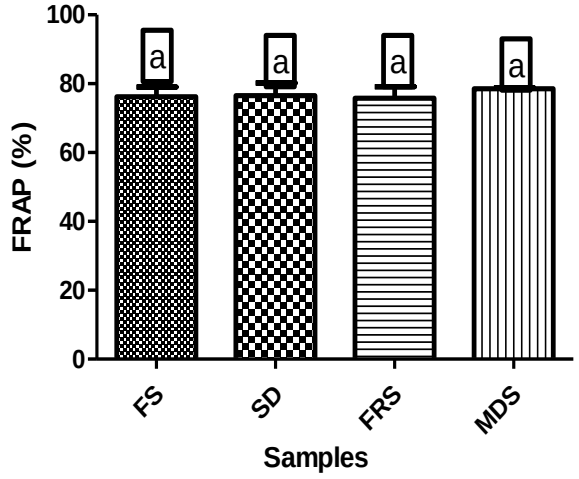

Fig. 5.4 Antioxidant activity (FRAP) of fig

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample

5.1 (h) Anti - nutritional content and anthocyanin content of fig

Tannin content of fresh fig was found to be 0.67 gm/100gm and depicted in Table 5.4. Similar results, i.e. 1.88 gm/100 gm was reported by Noonan and Savage (1999) in "*Ficus Benghalensis* " a variety of fig fruit. Tannin content increased significantly ($p<0.05$) in fresh fig samples, the increasing order being FRS<SD<MDS<FS.

Sun dried fig tannin content was found to be 0.61 gm /100gm. Tannin content decreased by 8.95 % in sun dried fig as compared to fresh ones. Tannin content of microwave dried fig was found to be 0.62 gm /100gm. Tannin content decreased by 7.46 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Pragati *et al.* (2003) in aonla fruit where they found 31.50% decrease in tannin content during thermal process and Nwaigwe and Adejumo (2015), wherein they reported 92.56 % decrease in tannin content in African bread fruit heat treatment. Similar decrease in tannin content (10.58 %) has been reported by Sunmola *et al.* (2011) in *Carica papaya* seed during thermal process. This decrease in tannin content by thermal process might be due to the oxidation of bioactive compounds (Yoshioka *etal.* 1990) and also due to the breakdown of cell structure which migrates the components that

are creating loss by leakage in the presence of oxygen and light (Scheieber *et al*.2001) and also due to various chemical reaction involving enzymes (polyphenoleoxidase) which are responsible to convert tannins into other products (Pragati *et al.* 2003; Mehta,1995).

Table 5.4 Effect of processing methods on anti - nutritional and anthocyanin content of fig

Drying methods	FS	SD	FRS	MDS
Tannin- (gm/100g)	0.67 ± 0.00^{a}	0.61 ± 0.00^{b}	0.60 ± 0.00^{bc}	0.62 ± 0.00^{bd}
Alkaloid- (gm/100g)	7.80 ± 0.04^{a}	7.76 ± 0.02^{a}	7.60 ± 0.1^{b}	7.79 ± 0.04^{ac}
Anthocyanin- (mg/100g)	4.78 ± 0.19^{a}	4.67 ± 0.00^{a}	4.89 ± 0.19^{a}	4.56 ± 0.50^{a}

Tannin content of frozen fig was found to be 0.60 gm /100gm. Tannin content decreased by 10.44 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 33.33 % reduction in tannin content in frozen dates. Similar decrease in tannin content in persimmons fruit has been reported by Nakamura (1961) during frozen storage. This decrease in tannin content by frozen storage might be due to the non-enzymatic activity in fruits (Al-Ogadi and Mutlak, 1986; Abu-Goukh *et al*. 2003), change occurs in chemical properties of tannin (Nakamura ,1961) that leads to coagulate soluble tannin into insoluble (Brackmann *et al.*1997; Matsu and Itoo,1978).

Alkaloid content of fig fruit is depicted in Table 5.4. Total alkaloid content of fresh fig was found to be 7.80 gm /100gm. Similar results, i.e. 9.6 gm/100gm was reported by Soni *et al*. (2014) in fig fruit. A statistically significant increase ($p<0.05$) in alkaloid content was observed in fresh fig samples, the increasing order being FRS<SD<MDS<FS. The alkaloid content of sun dried fig was found to be 7.76 gm /100gm. Alkaloid content decreased by 0.51 % in sun dried fig as compared to fresh ones. Alkaloid content of microwave dried fig was found to be 7.79 gm /100gm. Alkaloid content decreased by 0.12 % in microwave dried fig as compared

to fresh ones. Similar results have been reported by Nwaigwe and Adejumo (2015) in African bread fruit they found 20.75 % decrease in alkaloid content during heat treatment and Irondi *et al*. (2010), wherein they reported decrease in alkaloid content in *Carica papaya* by thermal process. This decrease in alkaloid content by thermal process might be due to the breakdown of cell structure which results migration of components, that leads to loss by various chemical reactions i.e. involving enzymes, light and heat (Atlabachew *et al*. 2013). Alkaloid content of frozen fig was found to be 7.60 gm /100gm. Alkaloid content decreased by 2.56 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Atlabachew *et al*. (2013), where they reported 56 % decrease in alkaloid content (cathinone) in frozen (*Catha Edulis* Forsk) leaves.

The anthocyanin content of fig fruit is depicted in Table 5.4. Total anthocyanin content of fresh fig was found to be 4.78 mg cyanidin-3-glucoside equivalents/100gm. Similar results, i.e. 0.1 mg cynide-3-glucose/100gm to 27.3 mg cynidin-3-glucoside equivalent /100gm were reported by Solomon *et al*. (2006) in "Mission" fresh fig varieties. Anthocyanin content increased non significantly ($p > 0.05$) in frozen fig samples, the increasing order being MDS<SD<FS<FRS.

The anthocyanin content of sun dried fig was found to be 4.67 mg cyanidin-3-glucoside equivalents/100gm. Anthocyanin content decreased by 2.30 % in sun dried fig as compared to fresh ones. Anthocyanin content of microwave dried fig was found to be 4.5 mg /100gm. Anthocyanin content decreased by 2.30 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Wojdylo *et al.* (2009) in strawberry where they found 12.9 % decrease in anthocyanin content in microwave dried fruit. Similar decrease in anthocyanin content (35.69 %) has been reported by Wojdylo *et al*. (2014) in microwave dried sour cherries. This decrease in anthocyanin content by thermal process (Juan *et al*.2013) might be due to different factors i.e. heat, oxygen, metal ion, co-pigmentation and pH (Mishra and Yang, 2008), polyphenol oxidase enzymes activity (Kwok *et al.*2004) and browning reaction (Wrolstad *et al.* 2004).

Total anthocyanin content of frozen fig was found to be 4.89 mg cyanidin-3-glucoside equivalents/100gm. Anthocyanin content increased by 4.60 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Scibisz and Mitek (2007), where they

reported 1.30 % increase in anthocyanin content in frozen blueberries. Similar increase in anthocyanin content (2.16 %) has been reported by Mullen *et al.* (2002) in frozen red raspberries. This increase in anthocyanin content might be due to ice crystal formation that favours to reallocation of water molecules in cell structure, that leads to enhance the release of membrane bound anthocyanin (Szczesniak, 1998; Leong and Oey, 2012) and also due to the cellular disruption in fruits (Skrede, 1996) which contributes to increase the cyanidin -3-galactoside content in fruits (Scibisz and Mitek, 2007).

5.1 (i) Mineral composition of fig

The mineral composition of fig fruit as depicted in Table 5.5. Calcium content of fresh fig was found to be 80.76 mg /100gm. Similar results, i.e.78 mg/100gm was reported by Khan *et al*. (2011) in fresh fig fruit.

Table 5.5 Effect of processing methods on mineral composition of fig

Drying methods	FS	SD	FRS	MDS
Calcium- (mg/100g)	80.6± 0.01 ^{a}	285.23±0.01 ^{b}	80.76± 0.01 ^{c}	302.86± 0.01^{cd}
Iron- (mg/100g)	12.01±0.01^{a}	12.66± 0.01 ^{b}	11.51 ±0.01^{c}	13.20 ±0.01^{dc}
Phosphorus- (mg/100g)	17.66± 0.01^{a}	106.16 ± 0.01^{cd}	17.41± 0.01^{c}	123.13± 0.01 ^{cd}

Calcium content increased significantly ($p<0.05$) in microwave dried fig sample, the increasing order being FS<FRS<SD<MDS. Mineral composition might be increased or decreased by different processing methods (Rickman *et al.* 2007). The calcium content of sun dried fig was found to be 285.23 mg /100gm. Calcium content increased by 253.18% in sun dried fig as compared to fresh ones. Calcium content of microwave dried fig was found to be 302.86 mg /100gm . Calcium content increased by 275.01 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Clary *et al.* (2007) in grapes where they found

157.81 % increase in mineral content in microwave dried fruit and Incedayi *et al.* (2016), wherein they reported 70.93 % increase in calcium content in microwave dried apricot fruit. This increase in calcium content by thermal process might be due to increasing of dry matter content. Ozcan *etal.* (2004) also reported that changes in the concentration of minerals are also depending on the method and the drying temperature used (Ozcan *et al.* 2004).

Calcium content of frozen fig was found to be 80.76 mg /100gm. Calcium content increased by 0.198 % in frozen storage fig as compared to fresh ones. Similar results were reported by Zolfaghari *et al*.(2010), where they reported 13.42 % increase in calcium content in frozen kiwi fruit of "Abbot" cultivar. Similar increase in calcium content (6.25%) has been reported by Bouzari *et al*.(2015) in frozen carrot.

Iron content of fresh fig was found to be 12.01 mg /100gm. Similar results, i.e. 10.09 mg/100gm was reported by Khan *et al*. (2011) in fresh fig. Iron content increased significantly ($p<0.05$)in microwave dried fig sample, the increasing order being FRS<FS<SD<MDS. The iron content of sun dried fig was found to be 12.66 mg /100gm . Iron content increased by 5.41% in sun dried fig as compared to fresh ones. Iron content of microwave dried fig was found to be 13.20 mg /100gm. Iron content increased by 9.90 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Clary *et al*. (2007) in grapes where they found 35.29 % increase in iron content during thermal process. Similar increase in iron content (395.06%) has been reported by Jung *et al*. (2005) in microwave dried persimmon fruit. Iron content of frozen fig was found to be 11.51 mg /100gm. Iron content decreased by 4.16 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Zolfaghari *et al*.(2010) in kiwi fruit where they found 13.80 % decrease in iron content in frozen storage.

Phosphorus content of fresh fig was found to be 17.66 mg /100gm. Guvenc *et al*. (2009) was reported higher phosphorus content in fresh fig fruit i.e. 22 mg/100gm as compared to our results. This differences might be due variation in cultivars, storage period and genetic factor (Zolfaghari *et al.* 2010). Phosphorus content increased significantly ($p<0.05$) in microwave dried fig sample, the increasing order being FRS<FS<SD<MDS. The phosphorus content of sun dried fig was found to be 106.16 mg /100gm. Phosphorus content increased by 501.13 % in sun dried fig as compared to fresh ones. Phosphorus content of microwave dried fig was found

to be 123.13 mg /100gm. Phosphorus content increased by 597.22 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Ozcan and Arslan, (2011) in tomato where they found 250% increase in phosphorus content during heat treatment . Phosphorus content of frozen fig was found to be 17.41 mg /100gm. Phosphorus content decreased by 1.42 % in frozen storage fig as compared to fresh ones. Similar decrease in phosphorus content 14.53 % has been reported by Zolfaghari *et al*.(2010) in frozen kiwi fruit and Ogbadoyi and Musa (2013), wherein they reported reduction in mineral content in frozen storage "*Amaranthus cruentus".* This may be attributed to the fact that frozen storage leads to decrease in iron content of fruits as high moisture content that leads to form ice crystals and causes leakage from the cell membranes (Baker and Gawish, 1997) that leads to reduction in mineral elements (Hui *et al*., 2004; McDonald *et al.,* 2006).

5.2 Analysis of *Carissa spinarum* (Karonda)

5.2 (a) Physical properties of karonda

The length of fresh karonda was found to be 7.46 mm. Similar results, i.e. 6 mm length was reported by Amreen *et al.* (2013) in fresh *Carissa spinarum* fruit. A statistically significant increase ($p<0.05$) in length was observed in fresh karonda sample, the increasing order being MDS<SD <FRS<FS.

Table 5.6 Effect of processing methods on physical properties of karonda

Drying methods	FS	SD	FRS	MDS
Length(mm)	7.46 ± 0.05^{a}	6.06 ± 0.05^{b}	6.36 ± 0.05^{c}	5.96 ± 0.05^{db}
Width(mm)	4.54±0.00a	3.76 ± 0.05^{b}	3.86 ± 0.05^{c}	3.26 ± 0.05^{cd}
Density(gm/cc)	0.64 ± 0.01^{a}	0.61 ± 0.00^{a}	0.62 ± 0.00^{ab}	0.60 ± 0.00^{a}

Where, Fresh- FS, Sun drying-SD, Freezed -FRS, Microwave drying-MDS

Length of sun dried karonda was found to be 6.06 mm. Length was decreased by 20.10 %, in sun dried karonda as compared to fresh ones. Length of microwave dried karonda was found to be 5.96 mm. Length decreased by 20.10 %, in microwave dried karonda as compared to fresh ones. Similar results have been reported by Oztekin *et al.* (2011), wherein they reported 0.70 % decrease in length in berry fruit by thermal processing. Similar decrease in length has been reported by Zivcovic *et al*. (2011) in thermal dried plum.

This may be attributed to the fact that thermal process leads to decrease in length due to the shrinkage of fruits (Hazbavi *etal*. 2014). Length of frozen karonda was found to be 6.36 mm. Length decreased by 14.74 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 4.80 % decrease in length in frozen dates. This decrease in length by frozen storage might be due to the period of cold

storage (Al- Yahayai and Al- Kharusi,2012). The width of fresh karonda was found to be 4.54 mm. Similar results, i.e. 6 mm width was reported by Amreen *et al.(*2013) in fresh *Carissa spinarum* fruit. A statistically significant increase ($p<0.05$) in width was observed in fresh karonda sample, the increasing order being MDS<SD <FRS<FS.

Width of sun dried karonda was found to be 3.76 mm. Width decreased by 17.18 % in sun dried karonda as compared to fresh ones. Width of microwave dried karonda was found to be 3.26 mm. Width decreased by 28.19 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Oztekin *et al.* (2011), wherein they reported 6.79 % decrease in width in berry fruit by thermal processing. Similar decrease in width has been reported by Zivcovic *et al*. (2011) in heat treated plum. This decrease in width by thermal process might be due to the reduction of moisture content (Kashaninejad *et al.*2006) and also due to the shrinkage of fruits (Jha *et al.*2006; Hazbavi *et al*, 2014). Width of frozen karonda was found to be 3.86 mm. Width decreased by 14.97 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), wherein they reported 7.69 % decrease in width in frozen dates. This decrease in width by frozen storage might be due to the period of cold storage (Al- Yahayai and Al- Kharusi, 2012).

The density of fresh karonda was found to be 0.64 gm/cc. Similar results, i.e. 0.82 gm/cc was reported by Din (2008) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically significant increase ($p<0.05$) in density was observed in all dried karonda samples, the increasing order being MDS<SD<FRS<FS. Density increased in fresh fruits due to higher moisture content that leads to increase volume (Garmakhany *et al.* 2013). Density of sun dried karonda was found to be 0.61 gm/cc. Density decreased by 4.68 % in sun dried karonda as compared to fresh ones. Density of microwave dried karonda was found to be 0.60 gm/cc. Density decreased by 6.25 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Pacco and Menegalli (2004), where they reported decreased density in thermal dried fruit. This may be attributed to the fact that fruit becomes more porous due to heating process.

Density of frozen karonda was found to be 0.62 gm/cc. Density decreased by 3.12 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Ramaswamy

and Tung (1981), wherein they reported decrease in density by 6.74 % in frozen storage "Golden" apple.

5.2 (b) Nutritional composition of karonda

The moisture content of karonda fruit is depicted in Table 5.7. Moisture content of fresh karonda was found to be 81.05 per cent. Similar results, i.e. 83.17 per cent was reported by (Morton, 1987) in "*Carissa carandas"* a variety of karonda. The moisture content increased significantly ($p<0.05$) in frozen karonda sample, the increasing order being MDS<SD<FS<FRS.

Table 5.7 Effect of processing methods on nutritional composition of karonda

Drying methods	FS	SD	FRS	MDS
Moisture(%)	81.05 ± 1.97^{a}	16.86 ± 0.75^{b}	82.06 ± 2.19^{ac}	16.83 ± 0.40^{bc}
Ash (%)	2.46 ± 0.06^{a}	2.51 ± 0.05^{a}	2.48 ± 0.07^{a}	2.50 ± 0.06^{a}
Carbohydrate (%)	18.66 ± 0.25^{a}	60.51 ± 0.00^{b}	18.16 ± 0.59^{ac}	61.81 ± 0.01^{cd}
Fat (%)	1.30 ± 0.01^{a}	1.50 ± 0.03^{b}	1.29 ± 0.02^{ac}	1.51 ± 0.01^{bc}
Protein (%)	2.07 ± 0.04^{a}	2.41 ± 0.33^{a}	2.04 ± 0.04^{a}	2.51 ± 0.33^{a}

The moisture content of sun dried karonda was found to be 16.86 per cent. Moisture content decreased by 79.19 % in sun dried karonda as compared to fresh ones. Similar results have been reported by Kamiloglu and Capanoglu (2015), in fig where they found 76% decrease in moisture content in sun dried fruit. Moisture content of microwave dried karonda was found to be 16.83 per cent. Moisture content decreased by 79.23 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015), wherein they reported 88.88% decrease in moisture content in okra after thermal process.

Similar decrease in moisture content (70.32 %) has been reported by Guvenc *et al.* (2009) in heat treated fig. Udomkun *et al*.(2015), also reported 98.06 % reduction in moisture content in thermal dried papaya. This reduction in moisture content by thermal process might be due to the rapid water loss (Mechlouch *et al.* 2015), heating temperature (Brooker, 1974) and higher absorption power (Meda *et al.* 2008).

Moisture content of frozen karonda was found to be 82.06 per cent. Moisture content increased by 1.24 % in frozen karonda as compared to fresh ones. Similar results have been reported by Aleid *et al*. (2014), where they reported 10.51% increase in moisture content in date during frozen storage and Damini *et al*.(2013), wherein they reported 2.45 % increase in the moisture content in frozen marolo pulp. Similar increase in moisture content (1.0 %) has been reported by Boca *et al.* (2014) in frozen strawberry puree. This may be attributed to the fact that frozen storage leads to increase in moisture content of fruits as destruction of cellular structure by syneresis (Sae-Kang and Suphantharika, 2006) that leads to release of intracellular water (Chefteh and Besancon, 1989) which is migrated out of the cell (Damiani *et al*.2013).

The ash content of karonda fruit is depicted in Table 5.7. Ash content of fresh karonda was found to be 2.46 per cent. Similar results, i.e. 2.53 per cent was reported by Mishra and Gupta (2005), in fresh *Carissa spinarum*. The result of ash content non significantly ($p>0.05$) increased in all karonda dried samples and the increasing order being FS<FRS<MDS<SD. The ash content of sun dried karonda was found to be 2.51 per cent. Ash content increased by 2.03 % in sun dried karonda as compared to fresh ones. Ash content of microwave dried karonda was found to be 2.50 per cent. Ash content increased by 1.62 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Guvenc *et al*. (2009), wherein they reported 379.16 % increase in ash content in fig during thermal process. Similar increase 1.48 % ash content in fig fruit during heat treatment has been reported by Mahmoud *et al.* (2013). This increase in ash content by thermal process might be due to the removal of moisture content (Morris *et al.* 2004).

Ash content of frozen karonda was found to be 2.48 per cent. Ash content increased by 0.81 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Zolfaghari *et al*. (2010), where they reported 8.3 % increase in ash content in kiwi fruit during

frozen storage. Similar increase in ash content (20 %) has been reported by Ogunobanwo *et al*.(2013) in frozen water melon juice. This increase in ash content by frozen storage might be due to the presence of products which has chemical stability (Raji *et al.* 2016).

Fat content of karonda fruit is depicted in Table 5.7. Fat content of fresh karonda was found to be 1.30 per cent. Similar results, i.e. 2.57 per cent was reported by Morton (1987) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically significant increase ($p<0.05$) in fat content in all dried karonda samples and the increasing order being FRS<FS<SD<MDS.

The fat content of sun dried karonda was found to be 1.50 per cent. Fat content increased by 15.38 % in sun dried karonda as compared to fresh ones. Fat content of microwave dried karonda was found to be 1.51 per cent. Fat content increased by 16.15% in microwave dried karonda as compared to fresh ones. Similar results have been reported by Mrabet *et al.* (2015), in date where they found 7.64 % increase in fat content during thermal process. This may be attributed to the fact that thermal process leads to increase in fat content of fruits along with removal of moisture content (Morris *et al.* 2004). Fat content of frozen karonda was found to be 1.29 per cent. Fat content decreased by 0.76 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Ogunbanwo *et al.* (2013), where they reported 50 % decrease in fat content in water melon juice and Raji *et al*. (2016) reported decrease 0.95% fat content in *Ewedu* soups during frozen storage. This decrease in fat content by frozen storage might be due to oxidation (Ryder *et al*.1993) that leads to release oxidative enzymes from various rupture cellular organelles (Boonsumrej *et al.* 2007).

Carbohydrate content of fresh karonda was found to be 18.66 per cent. Similar results, i.e. 15.16 per cent was reported by Ara *et al*. (2014) in fresh "*Carissa carandas"* a variety of karonda fruit. The carbohydrate content was significantly ($p<0.05$) increased in all karonda dried samples and the increasing order being FRS<FS<SD<MDS. The carbohydrate content of sun dried karonda was found to be 60.51 per cent. Carbohydrate content increased by 224.27% in sun dried karonda as compared to fresh ones.

Carbohydrate content of microwave dried karonda was found to be 61.81 per cent. Carbohydrate content increased by 231.24 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Guvenc *et al*. (2009) in fig fruit where they

found 240.39 % increase in carbohydrate content during heat treatment and Famurewa and Olumofin,(2015),wherein they reported 141.30 % increase in carbohydrate content in microwave dried okra. Similar increase in carbohydrate content (325.47 %) has been reported by Mahmoud *et al.* (2013) in thermal treated sycamore fruit. This increase in carbohydrate content by thermal process might be due to hydrolytic effect of carbohydrate stored in fruits (Akinhanmi *et al.* 2008).

Carbohydrate content of frozen karonda was found to be 18.16 per cent. Carbohydrate content decreased by 2.67 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Galoburda *et al.* (2014), where they reported 55.2% decrease in the carbohydrate content in strawberry puree during frozen storage. Damiani *et al*. (2013) also reported 16.11 % decrease in carbohydrate content in frozen marolo pulp. Similar decrease in carbohydrate content (25.78%) has been reported by Zolfaghari *et al*.(2010), in frozen kiwi fruit. This may be attributed to the fact that frozen storage leads to decrease in carbohydrate content of fruits due to the breakdown of cell structure during frozen storage (Cheftel and Besancon, 1989).

The protein content of karonda fruit is depicted in Table 5.7. Protein content of fresh karonda was found to be 2.07 per cent. Similar results, i.e. 3.64 per cent was reported by Mahapatra *et al*. (2012) in fresh " *Carissa spinarum"* fruit. The protein content increased non significantly ($p>0.05$) in all karonda dried samples and the increasing order being FRS<FS<SD<MDS. The protein content of sun dried karonda was found to be 2.41 per cent. Protein content increased by 16.42 % in sun dried karonda as compared to fresh ones. Protein content of microwave dried karonda was found to be 2.51 per cent. Protein content increased by 21.25 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Fedha *et al*.(2010) in pumpkin where they found 2.5 % increase in protein content during thermal process and Clary *et al*. (2007), wherein they reported 236.11 % increase in protein content in grapes during heat treatment.

Similar increase in protein content (258.55%) has been reported by Guvenc *et al*. (2009) in fig fruit during thermal process. This increase in protein content by thermal process might be due to

the enhancement in dry matter contents by the concentration of soluble solids (Eze and Akubor, 2012).

Protein content of frozen karonda was found to be 2.04 per cent. Protein content decreased by 1.44% in frozen storage karonda as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 57.51% decrease in protein content in blackthorn fruit during frozen storage. Similar decrease in protein content (4.22 %) has been reported by Ogunbanwo *et al*. (2013) in frozen water melon juice and Raji *et al*. (2016) reported decrease 3.83% protein content in *Ewedu* soups during frozen storage. This may be attributed to the fact that frozen storage decrease in protein content of fruits as reduction in proteins which are water and salt soluble (Chomnawang *et al.*2007), denaturation of proteins (Ryder *et al.* 1993) and destruction caused by enzymatic activity (Hultman and Rustard, 2004).

5.2 (c) Dietary composition of karonda

The neutral detergent fiber (NDF) of karonda fruit is depicted in Table 5.8. Neutral detergent fiber of fresh karonda was found to be 25.43 per cent. Similar results, i.e. 27.27 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit.

NDF was significantly ($p<0.05$) higher in all karonda dried samples, the increasing order being FRS<FS<SD<MDS. The neutral detergent fiber of sun dried karonda was found to be 25.56 per cent. NDF increased by 0.51 % in sun dried karonda as compared to fresh ones. NDF in microwave dried karonda was found to be 26.23 per cent. NDF increased by 3.14 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015), where they reported 6.54 % increase in dietary fiber content in microwave dried okra. Similar increase 102.2 % dietary fiber in *Musa paradisaca* during oven drying has been mentioned by Agoreyo *et al.* (2011) and Mahmoud *et al.* (2013) reported increase 1.48 % ash content in fig fruit during heat treatment. This increase in dietary fiber by thermal process might be due to the formation of Maillard reaction product (Chang and Morris, 1990; Vidal and Frias, 1991) and also due to the reduction in moisture content (Fennema, 1976), by leaching of soluble components to the solution that leads to form the heat resistant complexes between polysaccharides and other mechanism i.e. protein and phenolic content components (Caprez *et al.* 1986; Rodriguez *et al.* 2006). Dietary fiber (hemicellulose,

cellulose and lignin) also increased (Vasishtha *et al.* 2013) due to releasing of enzymatic fiber components from insoluble cell wall matrix (Hakkinen *et al.*2003).

Table 5.8 Effect of processing methods on dietary composition of karonda

Drying methods	FS	SD	FRS	MDS
NDF(%)	25.43± 0.05^{a}	25.56± 0.66^{a}	25.26±0.05^{b}	26.23± 0.05^{ac}
ADF(%)	16.03± 0.11^{a}	16.13± 0.66^{a}	15.96±0.49^{a}	16.50± 0.00^{a}
Hemicellulose (%)	9.40± 0.51^{a}	9.43±0.98^{a}	9.20±0.10^{a}	9.66±0.15^{a}
Cellulose(%)	14.05±0.13^{a}	14.67±0.54^{a}	12.97±0.00^{a}	14.89 ± 0.09^{b}
Lignin (%)	3.10± 0.05^{a}	3.20± 0.05^{a}	3.00± 0.10^{a}	3.33±0.05^{ab}

Neutral detergent fiber of frozen karonda was found to be 25.26 per cent. The NDF decreased by 0.66 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 18.13 % decrease in dietary fiber in frozen blackthorn fruit and Salgado *et al.* (1999), wherein they reported reduction in dietary fiber in frozen tropical fruits and Raji *et al*. (2016) reported decrease 0.92% dietary fiber in *Ewedu* soups during frozen storage. This decrease in NDF by frozen storage might be due to the reduction in of cell wall polysaccharides tissues that leads declined dietary fiber (Khan and Vincent, 1996).

The acid detergent fiber (ADF) of karonda fruit is depicted in Table 5.8. Acid detergent fiber of fresh karonda was found to be 16.03 per cent. Similar results, i.e. 18.03 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. The ADF was non significantly ($p>0.05$) increased in dried karonda samples, the increasing order being

FRS<FS<SD<MDS. The acid detergent fiber of sun dried karonda was found to be 16.13 per cent. ADF increased by 0.62 % in sun dried karonda as compared to fresh ones. ADF in microwave dried karonda was found to be 16.50 per cent. ADF increased by 1.24% in microwave dried karonda as compared to fresh ones. Acid detergent fiber in frozen karonda was found to be 15.96 per cent. The ADF decreased by 4.80 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Mohajer *et al.* (2016), where they reported 32.66 % decrease in ADF in frozen sainfoin seed.

Hemicellulose content of fresh karonda was found to be 9.40 per cent. Similar results, i.e. 9.24 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically non significant increase ($p>0.05$) in hemicellulose content in fresh karonda samples, the increasing order being FRS<FS<SD<MDS. The hemicellulose content of sun dried karonda was found to be 9.43 per cent. Hemicellulose content increased by 0.31 % in sun dried karonda as compared to fresh ones. Hemicellulose content in microwave dried karonda was found to be 9.66 per cent. Hemicellulose content increased by 2.76 % in microwave dried karonda as compared to fresh ones. This increase in hemicellulose content by thermal process. Similar results have been reported by Komolka *et al*. (2012), where they reported 5 % increase in hemicellulose content in common cabbage by thermal processing. Hemicellulose content in frozen karonda was found to be 9.20 per cent. The hemicellulose content decreased by 2.12 % in frozen storage karonda.

Cellulose content of karonda fruit is depicted in Table 5.8. Cellulose content of fresh karonda was found to be 14.05 per cent. Similar results, i.e. 11.64 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. The cellulose content increased significantly ($p<0.05$) in dried karonda samples, the increasing order being FRS<FS<SD<MDS. The cellulose content of sun dried karonda was found to be 14.67 per cent. Cellulose content increased by 4.41% in sun dried karonda as compared to fresh ones. Cellulose content in microwave dried karonda was found to be 14.89 per cent . Cellulose content increased by 5.97 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015), where they reported 13.7% increase in cellulose content in date fruit during thermal process and Nordin *et al*. (2013), wherein they

reported 3.31% increase in oil palm fruit during heat treatment. Cellulose content in frozen karonda was found to be 7.68 per cent. The cellulose content decreased by 7.68 % in frozen storage karonda as compared to fresh ones.

Lignin content of fresh karonda was found to be 3.10 per cent. Similar results i.e. 6.39 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. The lignin content increased significantly($p<0.05$) in dried karonda samples, the increasing order being FRS<FS<SD<MDS. The lignin content of sun dried karonda was found to be 3.20 per cent. Lignin content increased by 3.22 % in sun dried karonda as compared to fresh ones. Lignin content in microwave dried karonda was found to be 3.33 per cent. Lignin content increased by 7.41 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015) in date fruit where they found 20.68 % increase in lignin content during thermal process. Similar increase in lignin content (38.79 %) has been reported by Nordin *et al*. (2013) in thermal processed oil palm fruit. This increase in lignin content by thermal process might be due to increase the activity of lignin synthesis enzymes i.e. phenylalanine ammonia lyase (Yun *et al*. 2013). Hosseinaei *et al.* (2012) also reported that due to heat, complex structure of lignin is formed which makes it difficult for degradation. Lignin content in frozen karonda was found to be 3.00 per cent. The lignin content decreased by 3.23 % in frozen karonda as compared to fresh ones. Similar results have been reported by Dangcham *et al*. (2008), where they reported 65.07 % decrease in lignin content in mangosteen fruit at low temperature storage.

5.2 (d) Phytochemical composition of *Carissa spinarum* (Total phenolic content)

Processing methods caused remarkable changes in the total phenolic content of karonda fruit is depicted in Figure 5.5. Total phenolic content (TPC) of fresh karonda was found to be 5.31 mg TAE/100gm. Similar results i.e. 4.67 mg GAE/100gm was reported by Pewlong *et al.* (2014) in "*Carissa carandas"* a variety of karonda fruit .

A statistically significant increase ($p<0.05$) in TPC was observed in all dried karonda samples, the increasing order being FRS<FS <SD<MDS. Total phenolic content of sun dried karonda was found to be 5.50 mg TAE/100gm. TPC increased by 3.57 %, in sun dried karonda as compared to fresh ones. Sangeeta and Mahanta (2013), reported 30.18 % increase in TPC in tomato after

microwave drying. Total phenolic content of microwave dried karonda was found to be 5.74 mg TAE/100gm. TPC increased by 8.09 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Chumyam *et al.* (2013) in purple skin eggplants where they found 155.42 % increase in TPC in microwave dried fruit as compared to fresh ones and Turkmen *et al.*(2005), wherein they reported 126 % increase TPC in microwave dried pepper. Similar increase 85.12% TPC in pear by thermal treatment has been reported by Oboh *et al.*(2015). This increase in TPC by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (HMP) by Maillard reaction (Donovan *et al.* 1998) and also due to the breakdown of cellular structure of cells, which makes the phenolic content more extractable (Van *et al.* 2000). Singleton *et al.* (1999) mentioned enhancement in phenolic content may be due to the formation of aglycons by reacting with Folin-Ciocalteau reagent.

Phenolic content of frozen karonda was found to be 5.11 mg TAE/100gm. Frozen stored karonda fruits exhibited 3.76 % decrease in total phenolic content as compared to fresh ones. Similar results have been reported by Mullen *et al.* (2002), where they reported 21 to 28 % decrease in the TPC in raspberries during frozen storage as compared to fresh ones. Similar decrease in TPC (0.81%) has been reported by Scibisz and Mitek (2007) in frozen blueberries. This may be attributed to the fact that frozen storage leads to decrease in total phenolic content of fruits as polyphenol oxidase enzymes (PPO) are released by breaking cells and that leads to oxidation of polyphenolics to quinines (De Ancos *et al*. 2000a).

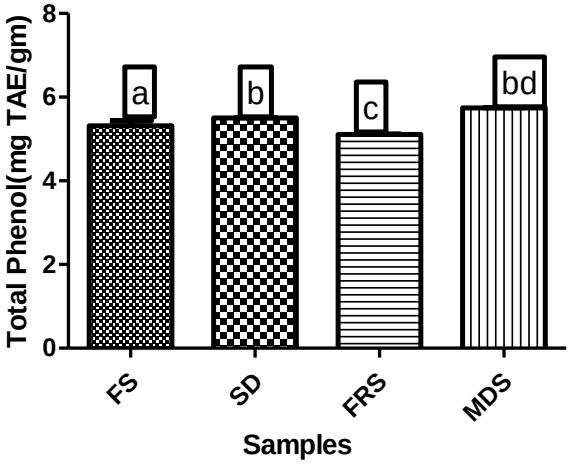

Fig. 5.5 Total Phenolic content of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS= Freezed sample, MDS=Microwave dried sample.

5.2 (e) Total flavonoid content of karonda

Flavonoid content of karonda fruit is depicted in Figure 5.6. Total flavonoid content of fresh karonda was found to be 0.44 mg QE/100gm. Similar results, i.e. 1.53 mg (rutin equivalent /100gm) was reported by Itankar *et al*.(2011) in "*Carissa carandas"* a variety of karonda. The total flavonoid content increased significantly ($p<0.05$) in fresh karonda sample, the increasing order being SD<MDS<FS<FRS. The flavonoid content of sun dried karonda was found to be 0.31 mg QE/100gm. Flavonoid content decreased by 29.54 % in sun dried karonda as compared to fresh ones. Similar results have been reported by Wang *et al.* (2016) in jujube fruit where they found 26.75% decrease in flavonoid content in sun dried fruit. Flavonoid content of microwave dried karonda was found to be 0.32 mg QE/100gm. Flavonoid content decreased by 27.27 % in microwave dried karonda as compared to fresh ones. Similar reduction in total flavonoid content (23.74%) has been reported by Sangeeta and Mahanta (2013) in microwave banana blossom and Planinic *et al.* (2015), wherein they reported 15.3% reduction in flavonoid content in microwave dried grape fruit. Similar results have been reported by Macias *et al* .(2013), where they reported 23.13 % decrease in flavonoid content in strawberry fruit during thermal process. This decrease in flavonoid content by thermal process (Crozier *et al.* 1995;

Price and Rhodes, 1997) might be due to the breakdown of some phytochemicals, which affects cell wall integrity and that leads to migration of some flavonoid components (Davey *et al.* 2000). Ioannou *et al.* (2012) also mentioned that heating process caused degradation might be due to parameters such as pH, oxygen, light, activity of polyphenoleoxidase enzymes and by hydrolysis of C- glycosides bonds, which are presented in flavonoids (Manach *et al.*2004).

Flavonoid content of frozen karonda was found to be 0.52 mg QE/100gm. Flavonoid content increased by 18.18 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Mullen *et al*. (2002), where they reported 21.07 % increase in flavonoid content in red raspberries during frozen storage. This may be attributed to the fact that frozen storage leads to increase in flavonoid content of fruits as increase in quercetin derivatives during cold storage (Omer and Canan, 2014) that increases quercetin hydrolysis (Hakkinen *et al*.2000).

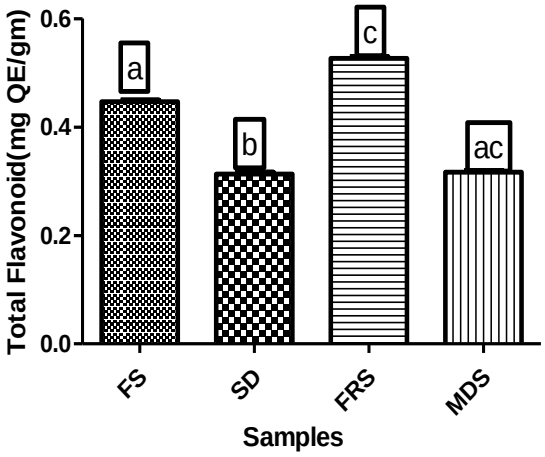

Fig. 5.6 Total Flavonoid content of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.2 (f) Antioxidant activity of karonda

Processing methods caused remarkable changes in antioxidant activity of karonda fruit is depicted in **Figure 5.7.** Antioxidant activity of fresh karonda was found to be 34.45 per cent. Similar results, i.e. 39.1 per cent was reported by Prakash *et al*. (2011) in "*Carissa carandas"* a variety of karonda fruit.

Antioxidant activity significantly ($p<0.05$) increased in all dried karonda sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity of sun dried karonda was found to be 34.47 per cent. Antioxidant activity increased by 0.05 % in sun dried karonda as compared to fresh ones. Antioxidant activity of microwave dried karonda was found to be 34.48 per cent. Antioxidant activity increased by 0.08 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Wojdylo *et al.* (2007), where they found 4.68 % increase in antioxidant activity (DPPH) in thermal dried apple and Chumyan *et al*. (2013), wherein they reported 266.12 % increase in DPPH antioxidant activity in microwave dried eggplants. Similar increase in antioxidant activity 138 % has been reported by Turkmen *et al*. (2005) in microwave heat treated pepper. Similar increase antioxidant activity 112.31% in berries has been reported by Rabeta and Lin (2015) and Sultana *et al.* (2012) also reported increase 3.57 % DPPH antioxidant activity in oven dried apricot. This increase in antioxidant activity (DPPH) by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (Raupp *et al*.2011), presence of naturally occurring compounds such as Maillard reaction products (Yin and Chang,1998; Piga *et al*. 2003; Lee *et al*.2003), released of a free phenolic fraction (Yamaguchi *et al*. 2001), due to oxidative and hydrolytic enzyme (Farsi *et al*.2005), disruption of cell wall that leads to release and enhances antioxidant activity (Chumyan *et al*.2013).

Antioxidant activity of frozen karonda was found to be 30.83 per cent. Antioxidant activity (DPPH) decreased by 10.50 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by De Ancos *et al.* (2000), where they reported 12 % decrease in antioxidant activity (DPPH) in frozen raspberry fruit and Pimia *et al*. (2003), wherein they reported 20 % decrease in antioxidant activity in frozen peas. Similar decrease in antioxidant activity (1.64 %) has been reported by Mohammadian *et al.* (2011) in frozen "*Citrus limon*" .

This may be attributed to the fact that frozen storage leads to decrease in antioxidant activity of fruits as disruption of cell structure (Sikora *etal*.2013).

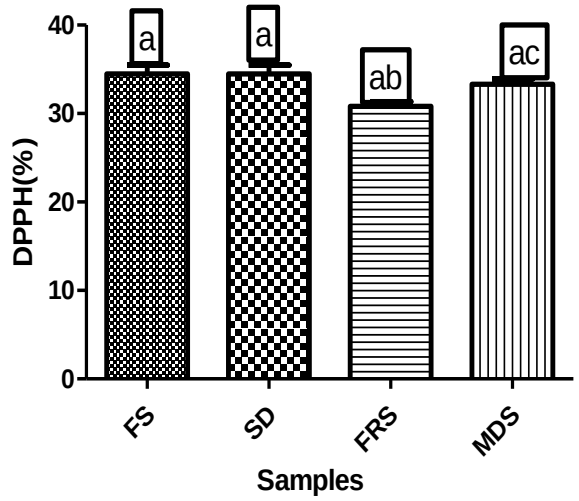

Fig. 5.7 Antioxidant activity (DPPH) of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.2 (g) Antioxidant activity of karonda

Antioxidant activity of karonda fruit is depicted in **Figure 5.8.** Antioxidant activity of fresh karonda was found to be 58.63 per cent. Prakash *et al.* (2011) reported lower antioxidant activity (48.2 %) in "*Carissa carandas*" a variety of karonda fruit as compared to our results. This difference might be due to many parameters such as fruit colour (Bey and Louaileche, 2015), extraction methods, solvent (Musa *et al.* 2011), cultivation location (Wand *et al.* 2002; Hakkinen and Torronen, 2000), ripening stage (Raffo *et al.* 2012), harvested condition and season (Wu *et al* .2014). Antioxidant activity increased non significantly ($p > 0.05$) in all dried karonda sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity (FRAP) of sun dried karonda was found to be 58.68 per cent. Antioxidant activity (FRAP) increased by 0.08 % in sun dried karonda as compared to fresh ones. Antioxidant activity of microwave dried karonda was found to be 58.79 per cent. Antioxidant activity increased by 0.27 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by

Rabeta and Lin (2015), where they reported increase 1040.12% antioxidant activity (FRAP) in berries during thermal process. Higher antioxidant activity might be due to relative increase of FRAP value which determined the capacity of plant extract for the donation and acceptance of electrons (Yan *et al.* 2006). This increase in antioxidant activity by thermal process may be due to reduction in moisture content(Abou El-Hana, 2008), inhibition of oxidative enzymes and cell wall destruction which releases antioxidant compounds (Yamaguchi *et al.* 2001).

Antioxidant activity of frozen karonda was found to be 55.36 per cent. Antioxidant activity (FRAP) decreased by 5.57 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Poiana *et al.*(2010), where they reported decrease from 6.5% to 12% in frozen strawberry fruit and Nilsson *et al.* (2004), wherein they reported decrease in antioxidant activity (FRAP) in frozen peas.

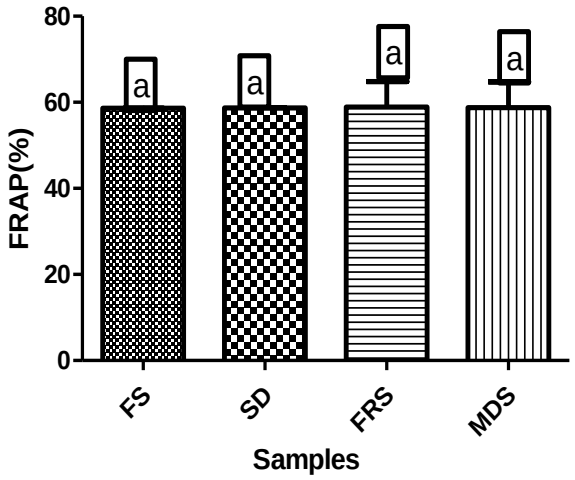

Fig. 5.8 Antioxidant activity (FRAP) of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.2 (h) Anti-nutritional content and anthocyanin content of karonda

Tannin content of fresh karonda was found to be 0.98 gm/100gm. Similar results, i.e. 1.02 gm/100gm was reported by Gupta *et al*. (2014) in "*Carissa carandas"* a variety of karonda fruit. Tannin content increased non significantly ($p>0.05$) increased in fresh karonda samples, the increasing order being FRS<SD<MDS<FS.

Table 5.9 Effect of processing methods on anti-nutritional and anthocyanin content of karonda

Drying methods	FS	SD	FRS	MDS
Tannin- (g/100g)	0.98± 0.01[a]	0.96± 0.01[a]	0.95±0.02 [a]	0.97± 0.00 [a]
Alkaloid- (g/100g)	1.94± 0.00 [a]	1.92±0 .01[a]	1.90±0.00[b]	1.92 ±0 .00[ac]
Anthocyanin- (mg/100g)	54.03± 0.00 [a]	53.43± 0.00[a]	55.20± 2.48 [a]	53.39± 5.02[a]

The tannin content of sun dried karonda was found to be 0.96 gm /100gm. Tannin content decreased by 2.04% in sun dried karonda as compared to fresh ones. Tannin content of microwave dried karonda was found to be 0.97 gm /100gm. Tannin content decreased by 1.02 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Chinyere and Obasi (2013) in leafy vegetable where they found 8.82 % decrease in tannin content during thermal process and Embaby (2011), wherein they reported 15.7 % decrease in tannin content in peanut seed during heat treatment. Similar decrease in tannin content (5.88 %) has been reported by Yusuf and Obiegbuna (2011) in *Vernonia amygdalina* leaf during thermal process. This decrease in tannin content by thermal process might be due to the oxidation of bioactive compounds (Yoshioka *et al.* 1990) and also due to the breakdown of cell structure which migrates the components that are creating loss by leakage in the presence of oxygen and light (Scheieber *et al*. 2001) and also due to various chemical reaction involving

enzymes (polyphenoleoxidase) which are responsible to convert tannins into other products (Pragati *et al.* 2003; Mehta,1995).

Tannin content of frozen karonda was found to be 0.95 gm /100gm. Tannin content decreased by 3.06 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 33.33 % reduction in tannin content in frozen dates. Similar decrease in tannin content in persimmons fruit has been reported by Nakamura (1961) during frozen storage. This decrease in tannin content by frozen storage might be due to the non-enzymatic activity in fruits (Al-Ogadi and Mutlak, 1986; Abu-Goukh *et al*. 2003), change occurs in chemical properties of tannin (Nakamura ,1961) that leads to coagulate soluble tannin into insoluble (Brackmann *et al.*1997; Matsu and Itoo,1978).

Alkaloid content of karonda fruit is depicted in Table 5.9. Total alkaloid content of fresh karonda was found to be 1.94 gm /100gm. Similar results, i.e. 1.96 gm/100gm was reported by Gupta *et al*. (2014) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically significant increase ($p<0.05$) in alkaloid content was observed in fresh karonda samples, the increasing order being FRS<SD<MDS<FS. The alkaloid content of sun dried karonda was found to be 1.92 gm /100gm. Alkaloid content decreased by 1.03 % in sun dried karonda as compared to fresh ones. Alkaloid content of microwave dried karonda was found to be 1.92 gm /100gm. Alkaloid content decreased by 1.03 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Chinyere and Obasi (2013) in leafy vegetable they found 22.83 % decrease in alkaloid content during heat treatment and Yusuf and Obiegbuna (2011), wherein they reported decrease 68.12% alkaloid content in *Vernonia amygdalina* by thermal process. This decrease in alkaloid content by thermal process might be due to the breakdown of cell structure which results migration of components that leads to loss by various chemical reactions i.e. involving enzymes, light and heat (Atlabachew *et al*. 2013). Alkaloid content of frozen karonda was found to be 1.90 gm /100gm. Alkaloid content decreased by 2.06 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Atlabachew *et al*. (2007), where they reported 56 % decrease in alkaloid content (cathinone) in frozen (*Catha Edulis* Forsk) leaves.

The anthocyanin content of karonda fruit is depicted in Table 5.9. Total anthocyanin content of fresh karonda was found to be 54.03 mg cyanidin-3-glucoside equivalents/100gm. Similar results, i.e. 54 mg/100gm was reported by Pewlong *et al*. (2014) in "*Carissa carandas"* a variety of karonda fruit.

Anthocyanin content increased non significantly ($p>0.05$) in frozen karonda samples, the increasing order being MDS<SD<FS<FRS. The anthocyanin content of sun dried karonda was found to be 53.43 mg /100gm. Anthocyanin content decreased by 1.11 % in sun dried karonda as compared to fresh ones. Anthocyanin content of microwave dried karonda was found to be 53.39 mg /100gm. Anthocyanin content decreased by 1.18 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Wojdylo *et al.* (2009) in strawberry where they found 12.9 % decrease in anthocyanin content in microwave dried fruit. Similar decrease in anthocyanin content (35.69 %) has been reported by Wojdylo *et al*. (2014) in microwave dried sour cherries. This decrease in anthocyanin content by thermal process (Juan *et al*.2013) might be due to different factors i.e. heat, oxygen, metal ion, co-pigmentation and pH (Mishra and Yang, 2008), polyphenol oxidase enzymes activity (Kwok *et al*.2004) and browning reaction (Wrolstad *et al.* 2004).

Anthocyanin content of frozen karonda was found to be 55.20 mg /100gm. Anthocyanin content increased by 2.16 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Scibisz and Mitek (2007), where they reported 1.30 % increase in anthocyanin content in frozen blueberries. Similar increase in anthocyanin content (2.16%) has been reported by Mullen *et al.* (2002) in frozen red raspberries. This increase in anthocyanin content might be due to ice crystal formation that favours to reallocation of water molecules in cell structure, that leads to enhance the release of membrane bound anthocyanin (Szczesniak, 1998; Leong and Oey, 2012) and also due to the cellular disruption in fruits (Skrede, 1996) which contributes to increase the cyanidin -3-galactoside content in fruits (Scibisz and Mitek, 2007).

5.2 (i) Mineral composition of karonda

The mineral composition of karonda fruit is depicted in Table 5.10. Calcium content of fresh karonda was found to be 29.00 mg /100gm. Similar results, i.e. 28.89 mg/100gm was reported

by Ara *et al*. (2014) in "*Carissa carandas"* a variety of karonda fruit. Calcium content increased significantly ($p<0.05$) in microwave dried karonda sample, the increasing order being FRS<FS<SD<MDS.

Table 5.10 Effect of processing methods on mineral composition of karonda

Drying methods	FS	SD	FRS	MDS
Calcium- (mg/100g)	29.00 ± 0.57^{a}	275.67 ± 0.00^{b}	28.9 ± 0.05^{c}	286.35 ± 0.00^{cd}
Iron- (mg/100g)	3.45 ± 0.00^{a}	12.43 ± 0.00^{b}	3.40 ± 0.05^{c}	12.82 ± 0.00^{cd}
Phosphorus- (mg/100g)	32.10 ± 0.05^{a}	106.20 ± 0.00^{b}	31.90 ± 0.05^{c}	$108.50\pm .00^{cd}$

Mineral composition might be increased or decreased by different processing methods (Rickman *et al.* 2007). The calcium content of sun dried karonda was found to be 275.67 mg /100gm. Calcium content increased by 850.6 % in sun dried karonda as compared to fresh ones. Calcium content of microwave dried karonda was found to be 286.35 mg /100gm. Calcium content increased by 887.44 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015), where they found 1028.09 % increase calcium content in microwave dried okra and Incedayi *et al.* (2016), wherein they reported 70.93 % increase in calcium content in microwave dried apricot fruit. This increase in calcium content by thermal process might be due to increasing of dry matter content. Ozcan *et al.* (2004) also reported that changes in the concentration of minerals are also depending on the method and the drying temperature used (Ozcan *et al.* 2004).

Calcium content of frozen karonda was found to be 28.9 mg /100gm. Calcium content decreased by 0.34 % in frozen storage karonda as compared to fresh ones. Similar results were reported by Zolfaghari *et al*. (2010), where they reported 1.53 % decrease in calcium content

in frozen kiwi fruit of "Monty" cultivar. Similar decrease in calcium content (5.23%) has been reported by Bouzari *et al*.(2014) in frozen strawberries.

Iron content of fresh karonda was found to be 3.45 mg /100gm. Similar results, i.e. 6.24 mg/100gm was reported by Dalal *et al*. (2010) in fresh "*Carissa carandas"* a variety of karonda fruit. Iron content increased significantly ($p<0.05$) in microwave dried karonda sample, the increasing order being FRS<FS<SD<MDS. The iron content of sun dried karonda was found to be 12.43 mg /100gm. Iron content increased by 260.28 % in sun dried karonda as compared to fresh ones. Iron content of microwave dried karonda was found to be 12.82 mg /100gm. Iron content increased by 271.59 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015) in okra where they found 963.75 % increase in iron content during thermal process. Similar increase in iron content (395.06%) has been reported by Jung *et al*. (2005) in microwave dried persimmon fruit. Iron content of frozen karonda was found to be 3.40 mg /100gm. Iron content decreased by 1.44 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Musa (2013) in *Amaranthus cruentus* leaf where they found 33.19 % decrease in iron content in frozen storage.

Phosphorus content of fresh karonda was found to be 32.10 mg /100gm. Similar results, i.e. 38 mg/100gm was reported by "CSIR NEW DELHI" (1950) in "*Carissa carandas"* a variety of karonda fruit. Phosphorus content increased significantly ($p<0.05$) in microwave dried karonda sample, the increasing order being FRS<FS<MDS<SD. The phosphorus content of sun dried karonda was found to be 106.20 mg /100gm. Phosphorus content increased by 230.85 % in sun dried karonda as compared to fresh ones. Phosphorus content of microwave dried karonda was found to be 108.50 mg/100gm. Phosphorus content increased by 238.01 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015) in okra where they found 811.45 % increase in phosphorus content during microwave heat treatment. Phosphorus content of frozen karonda was found to be 31.90 mg /100gm. Phosphorus content decreased by 1.42 % in frozen storage karonda as compared to fresh ones. Similar decrease in phosphorus content (0.62 %) has been reported by Zolfaghari *et al*.(2010) in frozen kiwi fruit and Ogbadoyi and Musa (2013), wherein they reported reduction in mineral content in frozen storage "*Amaranthus cruentus".* This may be attributed to the fact

that frozen storage leads to decrease in iron content of fruits as high moisture content that leads to form ice crystals and causes leakage from the cell membranes (Baker and Gawish, 1997) that leads reduction in mineral elements (Hui *et al*. 2004; McDonald *et al.* 2006).

5.3 Experimental Design

5.3 (a) Effect of fig (*Ficus carica)* methanolic extract on fasting blood glucose (FBG) level on diabetic and normoglycemic rats

The aim of the present study is to explored the scientific basis of the utility of fig (*Ficus carica*) fruit methanolic extract to improve FBG level in selected group of rats. The calculated percentage yield of methanolic extract of fig fruit was 31.6 per cent. Acute toxicity test revealed non toxic nature of fig fruit methanolic extract on rats. There was no lethality and toxic reactions at any dose.

The effect of fig methanolic fruit extract on fasting blood glucose level in rats is depicted in **Table 5.11**. FBG level was found highest on 21th day (277.45 mg/dl) and lowest on 0 day (259.35 mg/dl). FBG level in normal control group ranged from 95.61 to 97.27 mg/dl. The FBG level were increased in diabetic rats whose having streptozotocin intraperitoneal injection, ranged from 259.35 to 277.45 mg/dl. FBG level significantly ($p<0.05$) increased (171.25%) on starting 0 day in diabetic control group as compared to normal group. And, on 7th day (1.98 %), 14th day (5.20 %) and 21th day (6.97%), FBG level increased after 3 days of streptozotocin intraperitoneal injection to rats as compared to 0 day. FBG level was highest on 21 th day (277.45 mg/dl) and lowest on 0 day before the start of treatment (259.35 mg/dl). The increase in fasting blood glucose level might be due to streptozotocin injection which causes death of β-cells that leads insufficient production of insulin and elevates blood glucose level (Shen *et al.* 2010).

Metformin treated diabetic rats fasting glucose level ranged from 266.27 to 90.34 mg/dl. FBG level significantly ($p<0.05$) reduced on 7 th day (59.06 %), 14th day (63.62 %) and 21th day (66.07 %) with repeated oral dose administration of metformin (50 mg/kg b.wt.) as compared to 0 day. This decrease in fasting blood glucose level might be due to metformin suppress hepatic glucose production (Stumvoll *et al.*1995) and improved the insulin sensitivity that leads enhancement in binding of insulin to its receptors in several cell (Yanardag *et al.* 2005).

Table 5.11 : Effect of fig (*Ficus carica)* methanolic extract on FBG level in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14Day	21 Day
	Diabetic					
I	Control	35mg/kg	259.35±6.11^{a} (↑171.25%)*	264.50±5.08^{b} (↑ 173.10%)*	272.86±3.79^{bc} (↑181.79%)*	277.45±4.05^{bc} (↑ 185.23%)*
II	Metformin	50 mg/kg	266.27±6.61^{a}	109.0± 5.81^{b} (↓58.79 %)$^{\#}$	96.85±1.61^{bc} (↓64.50 %)$^{\#}$	90.34±3.36^{bc} (↓ 67.43 %)$^{\#}$
III	Fig extract	500 mg/kg	255.33± 1.90^{a}	197.0± 2.25^{b} (↓ 25.51%)$^{\#}$	187.13±2.38^{bc} (↓31.41 %)$^{\#}$	169.64±4.56^{bc} (↓38.85%)$^{\#}$
	Normoglycemic					
IV	Control group	_	95.61±1.78^{a}	96.85±1.61^{a}	96.83±1.84^{a}	97.27±1.59^{b}
V	Fig extract	500 mg/kg	96.87± 1.34^{a}	96.86±1.43^{a} (↓ 0.01%)*	94.42±4.45^{a} (↓2.48%)*	91.30±5.23^{ab} (↓ 6.13%)*

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

Administration of repeated dose of fig methanolic extract (500 mg/kg) body weight of rats had significantly ($p<0.05$) reduced the FBG level in diabetic rats after seven days. The FBG level significantly ($p<0.05$) reduced on7th day (22.84 %), 14 th day (26.71%) and 21 th day (33.56%) as compared to 0 day. This reduction in FBG level might be due to methanolic fruit extract creates anti- hyperglycemic effect by increasing pancreatic secreation of insulin from β cells (Stanley *et al.* 2004).

Administration of repeated oral dose of fig methanolic extract significantly ($p<0.05$) proved effective for the reduction of FBG level in normal group of rats after seven days. The FBG level reduced on 7 th day (0.01 %), 14th day (2.52 %) and 21th day (5.74 %) as compared to 0 day. As per standard protocol, we used to perform activity for 21 days (Girija *et al*. 2011; Kumar *et al*.2012). Drug treatment for diabetes, if normalizes the effect within 21 days only and significant improvement in all parameters of diabetes were improving so that study was conducted these many days only.

5.3 (b) Effect of fig (*Ficus carica)* methanolic extract on body weight in diabetic and normoglycemic rats

The effect of selected fruit methanolic extract on the body weight in diabetic and normoglycemic rats are depicted in **Table 5.12.** Normal group of rats body weight was significantly ($p<0.05$) increased on 7th day (1.37 %), 14 th day (2.32 %) and 21th day (3.02 %) as compared to 0 day.

The body weight was significantly ($p<0.05$) reduced (4.13 %) on starting 0 day in diabetic control group as compared to normal control group and on 7th day (1.59 %), 14 th day (2.23 %) and 21 thday (3.85 %) as compared to 0 day. The reduction in body weight might be due to muscle wasting (Islam, 2011). Repeated administration of metformin dose was significantly reduced the body weight in diabetic rats on 7th day (0.58 %), 14 th day (1.04 %) but showed improvement on 21 th day (1.24 %) as compared to 0 day. The reduction in body weight in diabetic rats might be due to breakdown of tissue protein (Andulla and Varadacharyulu, 2003).

Table 5.12 : Effect of fig (*Ficus carica)* methanolic extract on body weight in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14 Day	21 Day
	Diabetic					
I	Control	35mg/kg	241.0±4.08[a] (↓4.13 %)[*]	238.40±3.41[a] (↓ 6.37 %)[*]	235.61±4.31[ab] (↓ 8.40 %)[*]	231.72±4.10[b] (↓ 10.53%)[*]
II	Metformin	50 mg/kg	240.10±1.07[a]	238.70±1.78[a] (↑ 0.64 %)	237.60± 2.31[ab] (↑0.84 %)	237.11±3.36[ab] (↑ 2.32 %)[#]
III	Fig extract	500 mg/kg	244.76±1.87[a]	246.13±2.20[a] (↑ 3.24 %)[#]	249.43±2.60[b] (↑ 5.86 %) [#]	252.44±2.09[bc] (↑ 8.94%)[#]
	Normoglycemic					
IV	Control group	-	251.40±1.35[a]	254.85±2.17[b]	257.24 ±1.89[bc]	259.0±1.69[bc]
V	Fig extract	500 mg/kg	252.56±1.35[a]	256.46±1.95[b] (↑ 0.63 %)	258.23±1.43[bc] (↑ 0.38 %)	260.17± 1.01[bc] (↑ 0.45 %)

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

The effect of repeated fig methanolic extract (500 mg/kg b.wt) had significantly ($p<0.05$) improved diabetic rats body weight on 7th day (0.56 %), 14 th day (1.90 %) and 21 th day (3.13 %) as compared to 0 day. This increase in body weight might be due to improved metabolic disturbance by given fruit extract that leads reduction in polyphagia, polyuria and polydipsia. It also helps to control muscle wasting (Whitton and Hems, 1975). Repeated oral dose of fig methanolic extract (500 mg/kg) according to body weight of rats proved very effective to increase the body weight in normal rats on7th day (1.54 %), 14 th day (2.24 %) and 21 th day (3.01%) as compared to 0 day.

5.4 Experimental Design

5.4 (a) Effect of karonda (*Carissa spinarum)* methanolic extract on fasting blood glucose level in diabetic and normoglycemic rats

The aim of the present study is to explored the scientific basis of the utility of karonda (*Carissa spinarum*), fruit methanolic extract to improve FBG level in selected group of rats. The calculated percentage yield of methanolic extract of karonda fruit was 29 per cent. Acute toxicity test revealed non toxic nature of karonda fruit methanolic extract on rats. There was no lethality and toxic reactions at any dose.

The effect of karonda methanolic fruit extract on fasting blood glucose level in rats is depicted in **Table 5. 13**. FBG level was found highest on 21th day (277.45 mg/dl) and lowest on 0 day (259.35 mg/dl). FBG level in normal control group ranged from 95.61 to 97.27 mg/dl. The FBG level were increased in diabetic rats whose having streptozotocin intraperitoneal injection, ranged from 259.35 to 277.45 mg/dl. FBG level significantly ($p<0.05$) increased (171.25%) on starting 0 day in diabetic control group as compared to normal group. And, on 7th day (1.98 %), 14th day (5.20 %) and 21th day (6.97%), FBG level increased after 3 days of streptozotocin intraperitoneal injection to rats as compared to 0 day. The increase in fasting blood glucose level might be due to streptozotocin injection which causes death of β-cells that leads insufficient production of insulin and elevated blood glucose level (Rossetti *et al.* 1990).

Metformin treated diabetic rats fasting blood glucose level ranged from 266.27 to 90.34 mg/dl. FBG level significantly ($p<0.05$) reduced on 7 th day (59.06 %), 14th day (63.62 %) and 21th day (66.07 %) with repeated oral dose administration of metformin (50 mg/kg b.wt.) as compared to 0 day. This decrease in fasting blood glucose level might be due to metformin suppress hepatic glucose production (Stumvoll *et al*.1995) and improved the insulin sensitivity that leads enhancement in binding of insulin to its receptors in several cell (Yanardag *et al.* 2005).

Table 5.13 : Effect of karonda (*Carissa spinarum)* methanolic extract on fasting blood glucose level in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14Day	21 Day
	Diabetic					
I	Control	35mg/kg	259.35±6.11[a] (↑171.25%)[*]	264.50±5.08[b] (↑ 173.10%)[*]	272.86±3.79[bc] (↑181.79%)[*]	277.45±4.05[bc] (↑ 185.23%)[*]
II	Metformin	50 mg/kg	266.27±6.61[a]	109.0± 5.81[b] (↓58.79 %)[#]	96.85±1.61[bc] (↓64.50 %)[#]	90.34±3.36[bc] (↓ 67.43 %)[#]
III	karonda extract	500 mg/kg	264.90±5.50[a]	192.73±6.12[b] (↓ 27.10 %)[#]	178.88±5.39[bc] (↓ 34.44%)[#]	168.22±5.23[bc] (↓39.36%)[#]
	Normoglycemic					
IV	Control group	_	95.61±1.78[a]	96.85±1.61[a]	96.83±1.84[a]	97.27±1.59[b]
V	Karonda extract	500 mg/kg	95.70±1.63[a]	90.10±5.38[b] (↓ 6.96 %)	85.63±2.39[bc] (↓11.56%)	81.72±3.52[bc] (↓ 15.98%)[*]

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

Administration of repeated dose of karonda methanolic extract (500 mg/kg) body weight of rats had significantly ($p< 0.05$) reduced the FBG level in diabetic rats after seven days. The FBG level significantly ($p< 0.05$) reduced on 7 th day (27.24 %), 14th day (32.47 %) and 21th day (36.49%) as compared to 0 day. Administration of repeated oral dose of karonda methanolic extract significantly ($p<0.05$) proved effective for the reduction of FBG level in normal group of rats after seven days. The FBG level reduced on 7 th day (5.85 %), 14th day (10.52%) and 21th day (14.60%) as compared to 0 day. This reduction in FBG level might be due to methanolic fruit extract creates anti- hyperglycemic effect by increasing pancreatic secreation of insulin from β cells (Stanley *et al.* 2004) and due to the presence of flavonoid content and tannin content in methanolic extract of selected fruits (Sanwal and Chaudhory, 2011).

5.4 (b) Effect of karonda (*Carissa spinarum)* methanolic extract on body weight in diabetic and normoglycemic rats

The effect of selected fruit methanolic extract on the body weight in diabetic and normoglycemic rats are depicted in **Table 5.14.**

Table 5.14 : Effect of karonda (*Carissa spinarum)* methanolic extract on body weight in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14Day	21 Day
	Diabetic					
I	Control	35mg/kg	241.0±4.08^{a} (↓4.13 %)*	238.40±3.41^{a} (↓ 6.37 %)*	235.61±4.31^{ab} (↓ 8.40 %)*	231.72±4.10^{b} (↓ 10.53%)*
II	Metformin	50 mg/kg	240.10±1.07^{a}	238.70±1.78^{a} (↑ 0.64 %)	237.60± 0.31^{ab} (↑0.84 %)	237.11±3.36^{ab} (↑ 2.32 %)$^{\#}$
III	karonda extract	500 mg/kg	240.22±7.62^{a}	246.27±2.21^{ab} (↑ 3.30 %) $^{\#}$	248.67±2.71^{bc} (↑ 5.54 %) $^{\#}$	252.27±2.68^{b} (↑ 8.86 %)$^{\#}$
	Normoglycemic					
IV	Control group	-	251.40±1.35^{a}	254.85±2.17^{b}	257.24 ±1.89^{bc}	259.0±1.69^{bc}
V	Karonda extract	500 mg/kg	252.35±1.50^{a}	256.13±2.29^{ab} (↑0.50 %)	257.58±2.30^{b} (↑ 0.13 %)	259.53±1.59^{bc} (↑ 0.20 %)

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

Normal group of rats body weight was significantly ($p<0.05$) increased on 7th day (1.37 %), 14 th day (2.32 %) and 21th day (3.02 %) as compared to 0 day. The body weight was significantly ($p <0.05$) reduced (4.13 %) on starting 0 day in diabetic control group as compared to normal control group and on 7th day (1.59 %), 14 th day (2.23 %) and 21 th day (3.85 %) as compared to 0 day. The reduction in body weight might be due to muscle wasting (Swanston *et al*.1990). Repeated administration of metformin dose was significantly reduced the body weight in diabetic rats on 7th day (0.58 %), 14 th day (1.04 %) but showed improvement on 21 th day (1.24 %) as compared to 0 day. The reduction in the body weight due to breakdown of protein in diabetic rats (Andulla and Varadacharyulu, 2003).

The effect of repeated karonda methanolic extract (500 mg/kg b.wt) had significantly ($p<0.05$) improved diabetic rats body weight on 7th day (2.51 %), 14 th day (3.39 %) and 21 th day (4.77 %) as compared to 0 day. Repeated oral dose of karonda methanolic extract (500 mg/kg) according to body weight of rats proved very effective to increase the body weight in normal rats on7th day (1.49 %), 14 th day (2.07 %) and 21 th day (2.84 %) as compared to 0 day. This increase in body weight might be due to improved metabolic disturbance by given fruit extract that leads reduction in polyphagia, polyuria and polydipsia. It also helps to control muscle wasting (Whitton and Hems, 1975).

5.5 Formulation of value added products with the substitution of fig

5.5 (a) Bun

5.5 (b) Nutritional composition

The moisture content (**Table 5.15**) of wheat flour bun substituted with fresh fig ranged from 6.47 per cent to 8.41 per cent. In control it was only 6.47 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of moisture content i.e. 8.41 per cent was noted in T4. Similar increase in moisture content i.e. 5.96 per cent was reported in bread substituted with bread fruit flour (Malomo *et al*. 2015). This increase in moisture content might be due to high moisture content in fresh fruit (Raj and Masih, 2014).

The ash content of wheat flour bun substituted with fresh fig ranged from 1.10 per cent to 1.19 per cent. The result of ash content increased non significantly ($p<0.05$) in bun samples substituted with fresh fig. Similar increase in ash content i.e. 1.02 to 1.04 per cent was reported in bread substituted with bread fruit flour (Alice *et al*. 2012). Romjaun and Prakash (2015) also reported similar increase in ash content i.e. 0.82 to 1.31 per cent in bread substituted with carrot powder. This increase in ash content might be due to the high mineral content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.15**) of wheat flour bun substituted with fresh fig ranged from 75.52 per cent to 104.58 per cent. In control it was only 75.52 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of carbohydrate content i.e. 104.58 per cent was noted in T4. Similar increase in carbohydrate content i.e.78.69 per cent was reported in cookies substituted with unripe plantain flour(Chinma*etal*.2012). This increase in carbohydrate content might be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour bun substituted with fresh fig ranged from 6.64 per cent to 7.84 per cent. The result of protein content increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. Similar increase in protein content i.e. 4.39 to 7.25 per cent

was reported in bread substituted with soursop fruit flour (Zabidi *et al*. 2014). This increase in protein content might be due to higher addition of fruits at the time of bun development that leads to increase in protein content (Thorvaldsson and Skjoldebrand, 1998).

Table 5.15 Nutritional composition of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
Moisture (%)	6.47± 0.02[a]	6.84±0.01[c] (5.71%)↑	8.26±0.00[b] (27.66%)↑	8.41±0.01[cd] (29.98%)↑
Ash (%)	1.10±0.05[a]	1.13±0.10[a] (2.27 %)↑	1.16±0.05[a] (5.45%)↑	1.19±0.05[a] (8.18 %)↑
Carbohydrate (%)	75.52±0.01[a]	85.85±0.30[b] (13.67 %)↑	95.6±0.1[c] (26.58%)↑	104.58±0.07[cd] (38.47%)↑
Protein (%)	6.64±0.14[a]	7.44±0.08[a] (12.04 %)↑	7.69±0.95[a] (15.81%)↑	7.84±0.08[a] (18.07%)↑
Fat (%)	1.62±0.07[a]	1.73±0.04[a] (6.79 %)↑	1.80±0.38[a] (11.11%)↑	1.92±0.28[a] (18.51%)↑

Where, T1 (control sample) = 100% wheat flour bun, T2=15 % fig, T3=30% fig, T4 =45 % fig)

The fat content (**Table 5.15**) of wheat flour bun substituted with fresh fig ranged from 1.62 per cent to 1.92 per cent. Similar results, i.e. 1.57 per cent was reported by Michael *et al*. (2013) in wheat flour bread. The result of fat content increased non significantly ($p>0.05$) in bun sample substituted with fresh fig. The fat content was highest in T4 (1.92 %) and lowest in T1(1.62%). Similar increase in fat content i.e. 2.55 per cent was reported in bread substituted with pumpkin flour (See *et al.* 2007). This increase in fat content may be due to relative increase of fat content in fruits (Asp and Bjorck, 1992).

5.5 (c) Dietary fiber

The neutral detergent fiber (**Table 5.16**) of wheat flour bun substituted with fresh fig ranged from 23.73 per cent to 24.83 per cent. Similar results, i.e. 23.16 per cent was reported by Krishan *et al*. (1987) in wheat flour bread. NDF increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. The NDF was highest in T4 (24.83 %) and lowest in T1(23.73 %). Similar increase in dietary fiber i.e. 24.20 per cent was reported in bread substituted with watermelon rind (Ho and Dahri, 2016). Lopez *et al.* (2011) also reported similar increase i.e. 25.2 per cent was reported in bread substituted with orange powder. This increase in dietary fiber might be due to high dietary fiber in fruits (Sudha *et al.*2007).

The acid detergent fiber (ADF) of wheat flour bun substituted with fresh fig ranged from 1.30 per cent to 1.60 per cent. The results of ADF increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. ADF increased with increase in fresh fig fruit substitution. Similar increase in dietary fiber i.e. 0.75 to 1.13 per cent was reported in wheat flour cookie substituted with mango seed kernel (Legesse and Emire, 2012).

Hemicellulose content (**Table 5.16**) of wheat flour bun substituted with fresh fig ranged from 23.39 per cent to 23.22 per cent. Hemicellulose content increased significantly ($p<0.05$) in bun samples substituted with fresh fig. The hemicellulose content was highest in T4 (23.22 %) and lowest in T1(22.39 %).

The cellulose content of wheat flour bun substituted with fresh fig ranged from 2.48 per cent to 2.62 per cent. The result of cellulose increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. The cellulose content increased with increase in fresh fig fruit

substitution. Similar increase in cellulose content i.e. 0.02 to 4.40 per cent was reported in cookies substituted with raspberry pomace fruit (Gorecka *et al.* 2010). This increase in dietary fiber might be due to addition of dietary fiber rich fruits in bun, especially cellulose content (Thorvaldsen and Skjoldebrand, 1998).

Table 5.16 Dietary fiber of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
NDF (%)	23.73±0.05[a]	23.80±0.10[a] (0.29%)↑	24.23±0.05[a] (2.10%)↑	24.83±0.98[a] (4.63%)↑
ADF (%)	1.30±0.34[a]	1.40±0.45[a] (7.69%)↑	1.53±0.23[a] (17.69%)↑	1.60±0.17[a] (23.07%)↑
Hemicellulose (%)	22.39±0.00[a]	22.42±0.00[b] (0.13%)↑	22.56±0.00[c] (0.75%)↑	23.22±0.00[cd] (3.70%)↑
Cellulose(%)	2.48±0.10[a]	2.51±0.07[a] (1.20%)↑	2.56±0.03[a] (3.22%)↑	2.62±0.01[a] (5.64%)↑
Lignin (%)	1.23±0.63[a]	1.60±0.10[a] (30.08%)↑	1.73±0.05[a] (40.65%)↑	1.76±0.05[a] (43.08%)↑

The lignin content (**Table 5.16**) of wheat flour bun substituted with fresh fig ranged from 1.23 per cent to 1.76 per cent. The results of lignin content increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. The lignin content was highest in T4 (1.70 %) and lowest in T1(1.56 %). Similar increase in lignin content i.e. 3.98 per cent was reported in cookies substituted with raspberry pomace fruit (Gorecka *et al.* (2010).

5.5 (d) Mineral composition

The calcium content (**Table 5.17**) of wheat flour bun substituted with fresh fig ranged from 10.80 mg/100gm to 73.61 mg/100gm. Similar results, i.e. 10.70 mg/100gm was reported by Surekha *et al*. (2013) in wheat flour cookies. In control it was only 10.80 mg/100gm and increased significantly with more replacement of fresh fig fruit. Maximum value of calcium content i.e. 73.61 mg/100gm was noted in T4. Similar increase in calcium content i.e. 14.0 per cent was reported in wheat flour muffin substituted with pumpkin (Krishanaprabha and Kiruthiga, 2015). Waghray *et al.* (2011) also reported similar increase i.e. 70.80 per cent in wheat flour chapatti substituted with date pulp. This increase in calcium content might be due to high mineral content in fruits i.e. iron, phosphorus and calcium (Armeu *et al.* 2006; Niemen *et al*. 1992). Zabidi and Yunus (2014) also reported increase in mineral content in bun substituted with fruits.

Table 5.17 Mineral composition of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	10.80 ± 0.00^{a}	14.96 ± 0.00^{b} (38.51%)↑	70.14 ± 0.00^{c} (549.44%)↑	73.61 ± 0.00^{cd} (581.57%)↑
Iron (mg/100gm)	25.83 ± 0.00^{a}	284.91 ± 0.00^{b} (1003.01%)↑	310.75 ± 0.00^{c} (1103.05) ↑	344.83 ± 0.00^{cd} (1234.99%)↑
Phosphorus (mg/100gm)	333.39 ± 0.00^{a}	371.70 ± 0.00^{b} (11.49%)↑	423.54 ± 0.00^{c} (27.04%)↑	444.00 ± 0.00^{cd} (33.18%)↑

The iron content of wheat flour bun substituted with fresh fig ranged from 25.83 mg/100gm to 344.83 mg/100gm. The result of iron content increased significantly ($p<0.05$) in bun samples substituted with fresh fig. The iron content increased with increase in fresh fig fruit substitution. Similar increase in iron content i.e. 21 to 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

The phosphorus content (**Table 5.17**) of wheat flour bun substituted with fresh fig ranged from 333.39 mg/100gm to 444.00 mg/100gm.The results of the phosphorus content increased significantly ($p<0.05$) in bun samples substituted with fresh fig. The phosphorus content was highest in T4 (444.00 mg/100gm) and lowest in T1(333.39 mg/100gm). Similar increase in phosphorus content i.e. 377.15 per cent was reported in wheat flour chapatti substituted with date pulp (Waghray *et al.* 2011).

5.5 (e) Organoleptic analysis of bun

Table 5.18 Organoleptic analysis of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
Appearance	7.4±0.69[a]	7.2±0.63 [a]	7.4±0.69 [a]	7.2 ±0.63 [a]
Colour	7.2±0.42 [a]	7.0±0.47 [a]	7.1±0.31 [a]	7.0 ±0.66 [a]
Texture	7.2±0.63 [a]	7.2±0.63 [a]	7.3±0.48 [a]	7.1 ±0.31[a]
Flavour	7.5±0.52 [a]	7.2±0.42 [a]	7.3±0.67 [a]	7.1 ±0.31 [a]
Overall Acceptability	7.3±0.48 [a]	7.2±0.42 [a]	7.3±0.48 [a]	7.0 ±0.66 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant($p<0.05$)

Where, T1 (control sample) = 100% wheat flour bun, T2=15 % fig, T3=30% fig, T4 =45 % fig)

As shown in Table 5.18, sensory characteristics of wheat flour bun substituted with fresh fig T2, T3 and T4 were non significantly ($p>0.05$) different from wheat flour bun T1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour bun substituted

with fresh fig were not affected by increased concentration of fresh fig. . However, all samples were found to be acceptable.

Fig. 5.9 T1 (control sample) = 100% wheat flour bun,

T2=15 % fig,T3=30% fig, T4 =45 % fig)

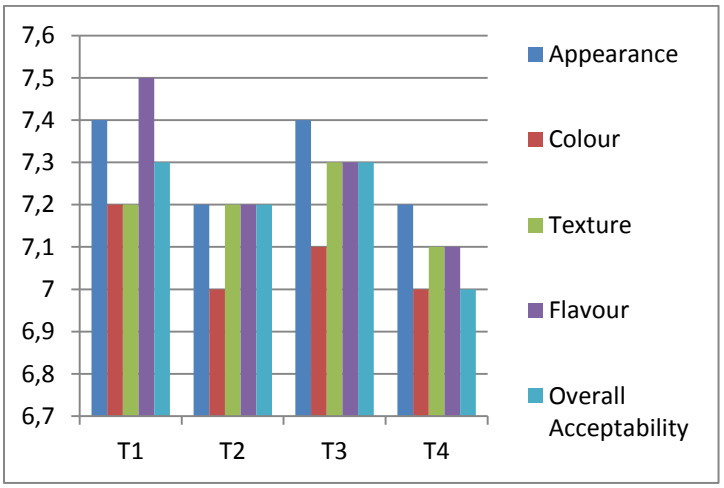

Fig. 5.10 Sensory scores of bun samples

5.6 Muffin

5.6 (a) Nutritional composition

The moisture content (**Table 5.19**) of wheat flour muffin substituted with fresh fig ranged from 10.80 per cent to 20.80 per cent. Similar results, i.e. 10.96 per cent was reported by Uchenna *et al*. (2013) in wheat flour muffin. In control it was only 10.80 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of moisture content i.e. 20.80 per cent was noted in T4. Similar increase in moisture content i.e.20.65 per cent was reported in muffin substituted with young corn powder (Jauharah *et al*. 2014). This increase in moisture content might be due to the presence of fiber content in fruits that leads to enhance the water absorption capacity by hydroxyl group (Rosell *et al.* 2011).

Table 5.19 Nutritional composition of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
Moisture (%)	10.80 ± 0.1^{a}	19.85 ± 0.09^{b} (83.79%)↑	20.15 ± 0.09^{ac} (86.57%)↑	20.80 ± 0.00^{cd} (92.59%)↑
Ash (%)	1.12 ± 0.11^{a}	1.16 ± 0.05^{a} (3.57 %)↑	1.19 ± 0.05^{a} (6.25 %)↑	1.29 ± 0.05^{a} (15.17 %)↑
Carbohydrate (%)	45.45 ± 0.48^{a}	52.48 ± 2.11^{b} (15.46%)↑	62.50 ± 2.54^{c} (37.51%)↑	71.95 ± 2.58^{cd} (58.30%)↑
Protein (%)	6.42 ± 0.12^{a}	6.92 ± 0.11^{a} (7.78%)↑	7.17 ± 0.05^{a} (11.68%)↑	7.38 ± 0.16^{a} (14.95%)↑
Fat (%)	10.33 ± 0.11^{a}	10.73 ± 0.11^{b} (3.87%)↑	11.13 ± 0.11^{c} (7.74%)↑	11.33 ± 0.11^{cd} (9.68%)↑

The ash content of wheat flour muffin substituted with fresh fig ranged from 1.12 per cent to 1.29 per cent. The ash content increased non significantly ($p>0.05$) in muffin samples substituted with fresh fig. Similar increase in ash content i.e. 0.82 to 1.31 per cent was reported in muffin substituted with carrot powder (Romjaun and Prakash, 2014). Mc Clements (2003)

also reported similar increase in ash content in muffin substituted with corn powder. This increase in ash content might be due to high ash content in fruit (Seleem, 2015).

The carbohydrate content (**Table 5.19**) of wheat flour muffin substituted with fresh fig ranged from 45.45 per cent to 71.95 per cent. Similar results, i.e. 45.08 per cent was reported by Krishanaprabha and Kiruthiga (2015) in wheat flour muffin. In control it was only 45.45 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of carbohydrate content i.e. 71.95 per cent was noted in T4. Similar increase in carbohydrate content i.e. 64.81 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).Legesse and Emire (2012) also reported similar increase i.e. 72.12 per cent in wheat flour biscuit substituted with breadfruit flour. Adubofuor and Mensah (2012) also reported increase in carbohydrate content i.e. 51.86 per cent in wheat flour cake substituted with ripe pawpaw pulp. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour muffin substituted with fresh fig ranged from 6.42 per cent to 7.38 per cent. Similar results, i.e. 6.73 per cent was reported by Jauharah *et al.* (2014) in wheat flour muffin. The protein content increased non significantly ($p>0.05$) in protein content was observed in muffin samples substituted with fresh fig. Similar increase in protein content i.e. 6.6 to 7.4 per cent was reported in wheat flour panjiri substituted with potato flour (Kaur and Kochhar, 2014). Jauharah *et al.* (2014) also reported similar increase in protein content in muffin substituted with corn powder. This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.19**) of wheat flour muffin substituted with fresh fig ranged from 10.33 per cent to 11.33 per cent. The fat content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The fat content was highest in T4(11.33 %) and lowest in T1(10.33 %). Similar increase in fat content i.e. 12.50 per cent was reported in muffin substituted with pumpkin powder (Krishanaprabha and Kiruthiga, 2015). Chuen and Aziz (2009) also reported similar increase i.e. 9.23 per cent in muffin substituted with mango pulp flour. This increase in fat content may be due to high fat content in fruits (Seleem, 2015).

5.6 (b) Dietary fiber

The neutral detergent fiber (**Table 5.20**) of wheat flour muffin substituted with fresh fig ranged from 23.66 per cent to 24.46 per cent. NDF increased non significantly ($p>0.05$) in muffin substituted with fresh fig. The NDF was highest in T4 (24.46 %) and lowest in T1(23.66 %). Similar increase in NDF i.e. 24.68 per cent was reported in wheat flour cookie substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to proportionally increase in dietary fiber in fruit mixture (Seleem, 2015).

Table 5.20 Dietary fiber of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
NDF(%)	23.66 ± 0.15^{a}	23.76 ± 0.11^{a} (0.42%)↑	24.06 ± 0.32^{a} (1.69%)↑	24.46 ± 0.86^{a} (3.38%)↑
ADF(%)	5.46 ± 0.63^{a}	5.73 ± 0.56^{a} (4.94%)↑	5.83 ± 0.63^{a} (6.77%)↑	6.03 ± 0.86^{a} (10.43%)↑
Hemicellulose (%)	17.86 ± 0.00^{a}	18.19 ± 0.00^{b} (1.84%)↑	18.32 ± 0.00^{c} (2.57%)↑	18.42 ± 0.00^{cd} (3.13%)↑
Cellulose(%)	4.18 ± 0.19^{a}	4.19 ± 0.19^{a} (0.23%)↑	4.20 ± 0.19^{a} (0.47%)↑	4.24 ± 0.19^{a} (1.43%)↑
Lignin (%)	1.60 ± 0.01^{b}	1.70 ± 0.00^{ab} (6.25%)↑	1.71 ± 0.02^{ac} (6.8%)↑	1.72 ± 0.02^{cd} (7.5%)↑

The acid detergent fiber (ADF) of wheat flour muffin substituted with fresh fig ranged from 5.46 per cent to 6.03 per cent. The ADF increased non significantly ($p>0.05$) in muffin samples substituted with fresh fig. ADF increased with increase in fresh fig fruit substitution. Similar increase in ADF i.e. 1.11 to 8.05 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010).

Hemicellulose content (**Table 5.20**) of wheat flour muffin substituted with fresh fig ranged from 17.86 per cent to 18.42 per cent. Hemicellulose content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The hemicellulose content was highest in T4 (18.42 %) and lowest in T1(17.86 %). Similar increase in dietary fiber i.e.19.00 per cent was reported in wheat flour biscuit substituted with grape pomace (Szkudlarz *et al.* 2013).

The cellulose content of wheat flour muffin substituted with fresh fig ranged from 4.18 per cent to 4.24 per cent. Similar results, i.e. 4.50 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. The cellulose content increased non significantly ($p>0.05$) in muffin samples substituted with fresh fig. The cellulose content increased with increase in fresh fig fruit substitution. Similar increase in dietary fiber i.e. 1.44 to 4.24 per cent was observed in wheat flour cookie substituted with unripe plantain flour (Chinma *et al.* 2012).Similar increase i.e. 0.02 to 4.07 per cent was reported in wheat flour cookie substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to high dietary fiber in fruits(Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.20**) of wheat flour muffin substituted with fresh fig ranged from 1.60 per cent to 1.72 per cent. Similar results, i.e. 1.80 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. Lignin content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The lignin content was highest in T4 (1.72 %) and lowest in T1(1.60 %). Similar increase in dietary fiber i.e. 1.28 per cent was reported in wheat flour mathri substituted with potato flour (Kaur and Kochhar,2014). Gorecka *et al.* (2010) also reported similar increase i.e. 3.98 per cent in wheat flour cookies substituted with raspberry pomace.

5.6 (c) Mineral composition

The calcium content (**Table 5.21**) of wheat flour muffin substituted with fresh fig ranged from 146.79 mg/100gm to 339.29 mg/100gm. In control it was only 146.79 mg/100gm increased significantly with more replacement of fresh fig fruit. Maximum value of calcium content i.e. 339. 29 mg/100gm was noted in T4. Similar increase in calcium content i.e. 148.33 per cent was reported in muffin substituted with carrot powder (Romjaun and Prakash, 2013). This increase in calcium content might be due to high mineral content in fruits (Saunders, 1990).

Table 5.21Mineral composition of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	146.79±0.00^{a}	241.01±0.00^{b} (64.18%)↑	307.95±0.00^{c} (109.78%)↑	339.29±0.00^{cd} (131.13%)↑
Iron (mg/100gm)	10.92±0.00^{a}	16.04±0.00^{b} (46.88%)↑	18.14±0.00^{c} (66.11%)↑	19.88±0.00^{cd} (82.05%)↑
Phosphorus (mg/100gm)	62.40±0.00^{a}	86.65±0.00^{b} (38.86%)↑	120.42±0.00^{c} (92.98%)↑	175.43±0.00^{cd} (181.13%)↑

The iron content of wheat flour muffin substituted with fresh fig ranged from 10.92 mg/100gm to 19.88 mg/100gm. The iron content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The iron content increased with increase in fresh fig fruit substitution. Similar increase in iron content i.e. 21 to 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

The phosphorus content (**Table 5.21**) of wheat flour muffin substituted with fresh fig ranged from 62.40 mg/100gm to 175.43 mg/100gm.The results of the phosphorus content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The phosphorus content was highest in T4 (175.43 mg/100gm) and lowest in T1(62.40 mg/100gm). Similar increase in phosphorus content i.e. 170.22per cent was reported in wheat flour biscuit substituted with date palm fruit (Sharnouby *et al.* 2012). Romjaun and Prakash (2013) also reported similar increase i.e. 119 per cent in wheat flour muffin substituted with carrot powder.

5.6 (d) Organoleptic analysis of muffin

Table 5.22 Organoleptic analysis of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
Appearance	7.9±0.31 [a]	7.4±0.51 [a]	7.7±0.48 [a]	7.4±0.51 [a]
Colour	7.2±0.42 [a]	7.6±0.51 [a]	7.4±0.51 [a]	7.2±0.42 [a]
Texture	7.3±0.48 [a]	7.4±0.51 [a]	7.4±0.51 [a]	7.3±0.48 [a]
Flavour	7.8±0.42 [a]	7.3±0.48 [a]	7.6±0.51 [a]	7.4±0.51 [a]
Overall Acceptability	7.6±0.48 [a]	7.4±0.52 [a]	7.5±0.48 [a]	7.3±0.48 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant($p<0.05$)

Where, T1 (control sample) = 100% wheat flour muffin, T2=15 % fig, T3=30% fig, T4 =45 % fig)

As shown in Table 5.22, sensory characteristics of wheat flour muffin substituted with fresh fig T2, T3 and T4 were non significantly ($p>0.05$) different from wheat flour muffin T1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour muffin substituted with fresh fig were not affected by increased concentration of fresh fig. In conclusion, T2 and T3 was found to be most acceptable as compared to T4, so wheat flour muffin sample was only substituted till 45 per cent.

Fig. 5.11 T1 (control sample) = 100% wheat flour muffin,

T2=15 % fig, T3=30% fig, T4 =45 % fig)

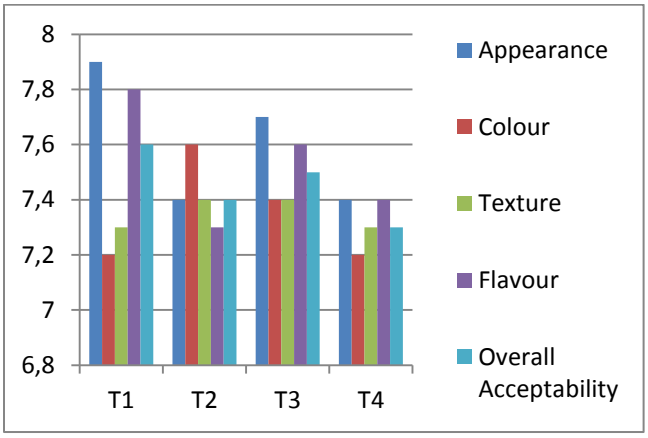

Fig. 5.12 Sensory scores of muffin samples

5.7 Noodles

5.7 (a) Nutritional composition

The moisture content (**Table 5.23**) of wheat flour noodles substituted with dried fig ranged from 6.61 per cent to 8.75 per cent. In control it was only 6.61 per cent increased non significantly with more replacement of dried fig fruit. Maximum value of moisture content i.e. 8.75 per cent was noted in T4. Similar increase in moisture content i.e. 11.35 per cent was reported in noodles substituted with sweet potato powder (Ibitoye *et al*. 2013). Taneya *et al.* (2014) also reported similar increase i.e. 6.27 per cent in wheat flour noodles substituted with potato flour. Similar increase i.e.8.67 per cent was reported in wheat flour noodles substituted with unripe banana flour (Ritthiruangdej *et al*. 2011).This increase in moisture content might be due to high moisture content in fruits (Mansour *et al*. 1999).

Table 5.23 Nutritional composition of noodles substituted with dried fig

Parameters	T1	T2	T3	T4
Moisture (%)	6.61 ± 0.16 [a]	8.26± 0.13 [a] (24.96%)↑	8.45± 0.12 [a] (27.83%)↑	8.75±3.24 [a] (32.37%)↑
Ash(%)	2.13 ± 0.00[a]	2.51± 0.10 [a] (17.84%)↑	2.84 ±0.09 [a] (33.33%)↑	3.67± 1.33 [a] (72.30%)↑
Carbohydrate (%)	85.53±0.01 [a]	95.85±0.30 [b] (12.06%)↑	105.60±0.1 [c] (23.46%)↑	114.58±0.07 [cd] (33.96%)↑
Protein (%)	6.51±0.11 [a]	7.44±0.08 [b] (14.28%)↑	7.48±1.05[bc] (14.90%)↑	7.84±0.08 [cd] (20.43%)↑
Fat (%)	1.56±0.02 [a]	1.62±0.07 [a] (3.84%)↑	1.73±0.04 [ab] (10.89%)↑	1.82±0.05 [bc] (16.66%)↑

The ash content of wheat flour noodles substituted with dried fig ranged from 2.13 per cent to 3.61 per cent. Similar results, i.e. 2.21 per cent was reported by Taneya *et al*. (2014) in wheat flour noodles. The ash content increased non significantly ($p>0.05$)in noodles samples. The ash content increased with increase in dried fig fruit substitution. Similar increase in ash content i.e. 2.21 to 2.44 per cent was reported in wheat flour noodles substituted with potato flour(Taneya *et al*.2014).Similar increase i.e. 0.93 to 1.04 per cent was reported in wheat flour bread substituted with bread fruit flour (Alice *et al.* 2012). Similar increase in ash content i.e. 2.17 to 2.39 per cent was reported in wheat flour cookies substituted with pitaya peel flour (Ho and Latif,2016). This increase in ash content might be due to high ash content in fruit (Brito *et al*.2006).

The carbohydrate content (**Table 5.23**) of wheat flour noodles substituted with dried fig ranged from 85.53 per cent to 114.58 per cent. In control it was only 85.53 per cent increased significantly with more replacement of dried fig fruit. Maximum value of carbohydrate content i.e. 114.58 per cent was noted in T4. Similar increase in carbohydrate content i.e. 97.57 per cent was reported in wheat flour bread substituted with breadfruit flour (Alice *et al.*2012).Ariffin *et al.* (2015) also reported similar increase in carbohydrate content i.e. 86.75 per cent in wheat flour bread substituted with durian flour. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour noodles substituted with dried fig ranged from 6.51 per cent to 7.84 per cent. Similar results, i.e. 6.73 per cent was reported by Ho and Latif (2016) in wheat flour cookies. The protein content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The protein content increased with increase in dried fig fruit substitution. Similar increase in protein content i.e.7.59 to 7.82 per cent was reported in wheat flour cookies substituted with breadfruit flour (Ojinnaka *et al.*2013).Similar increase in protein content i.e. 6.73 to 7.04 per cent was reported in wheat flour cookies substituted with pitaya peel flour (Ho and Latif,2016). This increase in protein content might be due to high protein content in fruits (Brito *et al*.2006).

The fat content (**Table 5.23**) of wheat flour noodles substituted with dried fig ranged from 1.56 per cent to 1.82 per cent. Similar results, i.e. 1.56 per cent was reported by Hardi *et al*. (2007) in wheat flour noodles. The fat content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The fat content was highest in T4 (1.82 %) and lowest in T1(1.56 %). Similar increase in fat content i.e. 1.3 to 3.9 per cent was reported in wheat flour noodles substituted with banana peel (Singh *et al*. 2015). This increase in fat content may be due to high fat content in fruits (Vinod *et al*. 2015).

5.7 (b) Dietary fiber

The neutral detergent fiber (**Table 5.24**) of wheat flour noodles substituted with dried fig ranged from 21.93 per cent to 23.90 per cent. NDF increased non significantly ($p>0.05$) in noodles substituted with dried fig. The NDF was highest in T4 (23.90 %) and lowest in T1(21.93 %). Similar increase in dietary fiber i.e. 24.20 per cent was reported in wheat flour noodles substituted with watermelon rind powder (Ho and Dahri, 2016). This increase in dietary fiber might be due to high dietary fiber in fruit mixture (Nwanekezi *et al.* 2015).

Table 5.24 Dietary fiber of noodles substituted with dried fig

Parameters	T1	T2	T3	T4
NDF (%)	21.93±1.90 [a]	22.50±2.16 [a] (2.59%)↑	23.70±1.70 [a] (8.07%)↑	23.90±0.26 [a] (8.98%)↑
ADF (%)	1.53±0.05 [a]	1.60±0.10 [a] (4.57 %)↑	1.76±0.11 [a] (15.03 %)↑	1.83±0.11 [ab] (19.60%)↑
Hemicellulose (%)	21.4±4.35 [a]	21.90±4.35 [b] (2.33%)↑	22.94±0.00 [c] (7.19%)↑	23.07±4.35 [cd] (7.80%)↑
Cellulose (%)	3.14±0.18 [a]	3.17±0.03 [b] (0.95%)↑	3.21±0.01 [a] (2.22%)↑	3.33±0.10 [a] (6.05%)↑
Lignin (%)	1.46±0.05 [a]	1.50±0.10 [a] (2.73 %)↑	1.53±0.05 [a] (4.79 %)↑	1.63±0.05 [a] (11.64 %)↑

The acid detergent fiber (ADF) of wheat flour noodles substituted with dried fig ranged from 1.53 per cent to 1.83 per cent. The ADF increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The ADF increased with increase in dried fig fruit substitution.

Hemicellulose content (**Table 5.24**) of wheat flour noodles substituted with dried fig ranged from 21.40 per cent to 23.07 per cent. Hemicellulose content increased significantly ($p<0.05$) in muffin samples substituted with dried fig. The hemicellulose content was highest in T4 (23.07%) and lowest in T1(21.40 %).

The cellulose content of wheat flour noodles substituted with dried fig ranged from 3.14 per cent to 3.33 per cent. The cellulose content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The cellulose content increased with increase in dried fig fruit substitution. This increase in dietary fiber might be due to the addition of dietary fiber rich fruits in noodles (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.24**) of wheat flour noodles substituted with dried fig ranged from 1.46 per cent to 1.63 per cent. Similar results, i.e. 1.08 per cent was reported by Gorecka *et al.* (2010) in wheat flour cookies. The results of the lignin content increased non significantly ($p>0.05$) in noodles samples substituted with dried fig. The lignin content was highest in T4 (0.63 %) and lowest in T1(0.46 %). Similar increase in dietary fiber i.e. 3.34 per cent was reported in wheat flour cookies substituted with potato flour (Pratyush *et al*. 2015). Similar increase in dietary fiber i.e. 0.75 per cent was reported in wheat flour biscuits substituted with jackfruit powder (Butool and Butool,2013).

5.7 (c) Mineral composition

The calcium content (**Table 5.25**) of wheat flour noodles substituted with dried fig ranged from 18.96 mg/100gm to 33.91 mg/100gm. In control it was only 18.96 mg/100gm increased significantly with more replacement of dried fig fruit. Maximum value of calcium content i.e. 33.91 mg/100gm was noted in T4. Similar increase in calcium content i.e. 32 per cent was reported in wheat flour cake substituted with beetroot powder (Pinki and Awasthi, 2014).Seleem (2015) also reported increase in calcium content i.e. 20.40 per cent in wheat flour cake

substituted with doum fruit powder. This increase in calcium content might be due to high mineral content in fruits (Seleem, 2015).

Table 5.25 Mineral composition of noodles substituted with dried fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	18.96±0.00 [a]	23.80±0.00 [b] (25.52%)↑	27.89±0.00 [c] (47.09%)↑	33.91±0.00 [cd] (78.85%)↑
Iron (mg/100gm)	10.92± 0.00[a]	14.96 ±0.00 [b] (36.99%)↑	18.14 ±0.00 [c] (66.11%)↑	70.14 ±0.00 [c] (542.30 %)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	333.39±0.00 [b] (2.86 %)↑	444.00±0.00 [c] (36.99%)↑	666.54±0.00 [cd] (105.65%)↑

The iron content of wheat flour noodles substituted with dried fig ranged from 10.92 mg/100gm to 70.14 mg/100gm. The iron content increased significantly ($p<0.05$) in all noodles samples substituted with dried fig. The iron content increased with increase in dried fig fruit substitution. Similar increase in iron content i.e. 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

The phosphorus content (**Table 5.25**) of wheat flour noodles substituted with dried fig ranged from 324.1 mg/100gm to 666.54 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The phosphorus content was highest in T4 (0.16 mg/100gm) and lowest in T1(0.11 mg/100gm).Similar increase in phosphorus content i.e. 467 per cent was reported in wheat flour cakes substituted with beetroot powder (Pinki and Awasthi, 2014).

Fig. 5.13 T1 (control sample = 100% wheat flour noodles,

T2=15 % fig, T3=30% fig, T4 =45 % fig)

5.8 Nugget

5.8 (a) Nutritional composition

The moisture content (**Table 5.26**) of green gram nugget substituted with dried fig ranged from 19.80 per cent to 20.80 per cent. In control it was only 19.80 per cent increased significantly with more replacement of dried fig fruit. Maximum value of moisture content i.e. 20.80 per cent was noted in T4. Similar increase in moisture content i.e.22.98 per cent was reported in composite pulse flour chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in moisture content might be due to high moisture content in fruits (Nwanekezi *et al.* 2015).

Table 5.26 Nutritional composition of nugget substituted with dried fig

Parameters	T1	T2	T3	T4
Moisture (%)	19.80±0.1 [a]	19.85±0.09 [a] (0.25%)↑	20.15±0.09 [b] (1.76%)↑	20.80±0.00 [b c] (5.05%)↑
Ash (%)	1.10±0.05 [a]	1.16±0.05 [a] (5.45%)↑	1.19±0.05 [a] (8.18 %)↑	1.29±0.20 [a] (17.27%)↑
Carbohydrate (%)	65.64±0.22 [a]	72.48±2.11 [b] (10.42%)↑	82.50±1.09 [c] (25.68%)↑	93.78±0.63 [cd] (42.87%)↑
Protein (%)	13.34±0.08 [a]	13.59±0.08 [b] (1.87%)↑	14.39±0.08 [c] (7.87%)↑	14.72±0.08 [cd] (10.34%)↑
Fat (%)	1.85±2.71 [a]	2.20±0.05 [b] (18.91%)↑	2.27±0.02 [bc] (22.70%)↑	2.33± 0.07 [bd] (25.94%)↑

The ash content of green gram nugget substituted with dried fig ranged from 1.37 per cent to 1.77 per cent. The ash content increased non significantly ($p>0.05$) in nugget samples substituted with dried fig. The ash content increased with increase in dried fig fruit substitution. Similar increase in ash content i.e. 1.20 to 1.72 per cent was reported in gram composite flour

chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in ash content might be due to high ash content in fruit(Nwanekezi *et al.* 2015).

The carbohydrate content (**Table 5.26**) of green gram nugget substituted with dried fig ranged from 65.64 per cent to 93.78 per cent. Similar results, i.e. 65.50 per cent was reported by Aziz *et al*. (2012) in nugget. In control it was only 65.64 per cent increased significantly with more replacement of fresh dried fruit. Maximum value of carbohydrate content i.e. 93.78 per cent was noted in T4. Similar increase in carbohydrate content i.e. 65.78 per cent was reported in pulse based weaning food substituted with banana fruit (Mishra *et al.* 2014). Singh *et al.*(2014) also reported similar increase in carbohydrate content i.e. 70.72 per cent in bengal gram dal substituted with kondhara leaves. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of green gram nugget substituted with dried fig ranged from 13.34 per cent to 14.72 per cent. The protein content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The protein content increased with increase in dried fig fruit substitution. Similar increase in protein content i.e. 11.48 to 30.44 per cent protein content was reported in bengal gram dal substituted with kondhara leaves (Sultana *et al.* 2014). Similar increase in protein content i.e. 14.26 to 14.80 per cent was reported in legume composite flour thalipeeth (pan cake like product) substituted with green leafy vegetables (Gupta and Prakash,2011). This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.26**) of green gram nugget substituted with dried fig ranged from 1.85 per cent to 2.33 per cent. Similar results, i.e. 1.30 per cent was reported by Pardeshi *et al*. (2013) in nugget. The fat content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The fat content was highest in T4 (2.33 %) and lowest in T1(1.85 %). Similar increase in fat content i.e. 1.28 per cent was reported in composite gram flour based chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in fat content may be due to high fat content in fruits (Nwanekezi *et al.* 2015).

5.8 (b) Dietary fiber

The neutral detergent fiber (**Table 5.27**) of green gram nugget substituted with dried fig ranged from 23.56 per cent to 24.20 per cent. NDF increased non significantly ($p>0.05$) in nugget samples substituted with dried fig. The NDF was highest in T4 (24.20 %) and lowest in T1 (23.56 %). Similar increase in dietary fiber i.e. 18.15 per cent was reported in composite gram flour chakli (Rosy *et al.* 2015). This increase in dietary fiber might be due to proportionally increase in dietary fiber in fruits (Rupasinghe *et al.* 2008).

Table 5.27 Dietary fiber of nugget substituted with dried fig

Parameters	T1	T2	T3	T4
NDF (%)	23.56±0.11 [a]	23.63±0.11 [a] (3.94%)↑	24.06±0.32 [a] (2.12%)↑	24.20±1.04 [a] (2.71%)↑
ADF (%)	21.06±0.92 [a]	21.33±1.15 [a] (1.28%)↑	21.73±0.23 [a] (3.18%)↑	21.76±1.85 [a] (3.32%)↑
Hemicellulose (%)	1.97±0.00 [a]	2.36±0.00 [b] (19.79%)↑	2.47±0.00 [c] (25.38%)↑	2.50±0.00 [cd] (26.90%)↑
Cellulose (%)	11.88±0.65 [a]	11.51±0.65 [a] (3.11%)↑	11.89±0.61 [a] (0.08%)↑	12.54±0.66 [a] (5.55%)↑
Lignin (%)	1.68±0.00 [b]	1.70±0.00 [a] (1.19%)↑	1.71±0.00 [ac] (1.78%)↑	1.73±0.01 [a] (2.97%)↑

The acid detergent fiber (ADF) of nugget substituted with dried fig ranged from 21.06 per cent to 21.76 per cent. The ADF content increased non significantly ($p>0.05$) in nugget samples substituted with dried fig. The ADF increased with increase in dried fig fruit substitution.

Hemicellulose content (**Table 5.27**) of nugget substituted with dried fig ranged from 1.97 per cent to 2.50 per cent. Hemicellulose content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The hemicellulose content was highest in T4 (2.50 %) and lowest in T1(1.97 %).Similar increase in hemicellulose content i.e.0.38 to 0.51 per cent was reported in gram dal substituted with bathua leaves (Singh *et al.* 2007). Singh *et al.*(2014) also reported similar increase i.e. 0.25 to 5.75 per cent dietary fiber in bengal gram dal substituted with kondhara leaves.

The cellulose content of nugget substituted with dried fig ranged from 11.88 per cent to 12.54 per cent. The cellulose content increased non significantly ($p<0.05$) in cellulose content was observed in all nugget samples substituted with dried fig. The cellulose content increased with increase in dried fig fruit substitution. This increase in cellulose content might be due to addition of dietary fiber rich fruits in nugget (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.27**) of nugget substituted with dried fig ranged from 1.68 per cent to 1.73 per cent. The results of the lignin content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The lignin content was highest in T4 (1.73 %) and lowest inT1(1.68 %). Similar increase in dietary fiber i.e. 1.82 per cent was reported in gram composite flour khakara substituted with carrot powder (Surekha and Naik, 2014).Verma and Singh (2014) also reported similar increase in lignin content i.e. 1.28 per cent in besan laddu substituted with mushroom powder.

5.8 (c) Mineral composition

The calcium content (**Table 5.28**) of nugget substituted with dried fig ranged from 146.79 mg/100gm to 333.29 mg/100gm.In control it was only 146.79 mg/100gm increased significantly with more replacement of dried fig fruit. Maximum value of calcium content i.e. 333.29 mg/100gm was noted in T4. Similar increase in calcium content i.e. 335.0 per cent was

reported in bengal gram dal substituted with kondhara leaves (Singh *et al.*2014).This increase in calcium content might be due to high mineral content in fruits (Armeu *et al.* 2006).

Table 5.28 Mineral composition of nugget substituted with dried fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	146.79± 0.00 [a]	241.01±0.00 [b] (64.18%)↑	307.95±0.00 [c] (109.78%)↑	339.29±0.00 [cd] (131.13%)↑
Iron (mg/100gm)	10.92±0.00 [a]	16.04±0.00 [b] (46.61%)↑	18.14±0.00 [c] (66.11%)↑	19.88±0.00 [cd] (82.05%)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	666.54±0.00 [b] (105.65%)↑	704.27±0.00 [c] (117.30%)↑	754.35±0.00 [cd] (132.75%)↑

The iron content of nugget substituted with dried fig ranged from 10.92 mg/100gm to 19.88 mg/100gm. The iron content significantly increase ($p<0.05$) in nugget samples substituted with dried fig. The iron content increased with increase in dried fig fruit substitution. Similar increase in iron content i.e. 3.90 to 8.99 per cent was reported in legume composite flour thalipeeth (pan cake like product) substituted with green leafy vegetables (Gupta and Prakash, 2011). Singh *et al.*(2014) also reported similar increase in iron content i.e. 7.25 to 28.77 per cent in bengal gram dal substituted with kondhara leaves. Similar increase in iron content i.e. 6.10 to 6.34 per cent was reported in gram composite flour khakara substituted with carrot powder (Surekha and Naik, 2014).

The phosphorus content (**Table 5.28**) of nugget substituted with dried fig ranged from 324.1 mg/100gm to 754.35 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$)in nugget samples substituted with dried fig. The phosphorus content increased with increase in dried fig fruit substitution. The phosphorus content was highest in T3 (754.35 mg/100gm) and lowest in T1(324.1 mg/100gm). Similar increase in phosphorus content i.e. 320 to 378 per cent was reported in gram composite flour roti substituted with methi powder (Kadam *et al*.2012).

Fig. 5.14 T1 (control sample = 100% green gram nugget,

T2=15 % fig, T3=30% fig, T4 =45 % fig)

5.9 Formulation of value added products with the substitution of karonda

5.9 (a) Bun

5.9 (b) Nutritional composition

The moisture content (**Table 5.29**) of wheat flour bun substituted with fresh karonda fruit ranged from 6.47 per cent to 9.87 per cent. In control it was only 6.47 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of moisture content i.e. 9.87 per cent was noted in B4. Similar increase in moisture content i.e. 9.50 per cent was reported in biscuit substituted with date palm fruit (Sharnouby *et al.* 2012). This increase in moisture content might be due to high moisture content in fresh fruit (Rosell *et al.* 2011).

The ash content of wheat flour bun substituted with fresh karonda ranged from 1.10 per cent to 1.29 per cent. The ash content increased non significantly ($p>0.05$) in bun samples substituted with fresh karonda. The ash content increased with increase in fresh karonda fruit substitution. Similar increase in ash content i.e. 1.30 to 1.60 per cent was reported in wheat flour bun substituted with ripe pawpaw pulp (Adubofuor and Mensah, 2012). See *et al.* (2007) also reported similar increase in ash content i.e.1.83 to 2.43 per cent in bread substituted with pumpkin flour. This increase in ash content might be due to the high ash content in fruit (El-Sharnouby *et al.* 2012).

The carbohydrate content (**Table 5.29**) of wheat flour bun substituted with fresh karonda ranged from 75.52 per cent to 107.56 per cent. In control it was only 75.52 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of carbohydrate content i.e. 107.56 per cent was noted in B4. Similar increase in carbohydrate content i.e. 78.69 per cent was reported in cookies substituted with unripe plantain flour (Chinma *et al*. 2012). This increase in carbohydrate content may be due to high carbohydrate content in fruits (Kulkarni and Joshi, 2014).

Table 5.29 Nutritional composition of bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
Moisture (%)	6.47± 0.02[a]	7.45±0.01[b] (15.14%) ↑	8.24±0.66[cd] (52.55%)↑	9.87±0.02[c] (27.35%)↑
Ash (%)	1.10±0.05[a]	1.16±0.05[a] (3.59 %)↑	1.19±0.05[a] (7.91 %)↑	1.29±0.20[a] (23.74 %)↑
Carbohydrate (%)	75.52±0.01[a]	89.58±0.07[b] (18.61%)↑	98.05±0.05[c] (29.83%)↑	107.56±0.05[cd] (42.42%)↑
Protein (%)	6.64±0.14[a]	6.79±0.08[a] (2.25%)↑	7.10±0.1[b] (6.92%)↑	7.52±0.08[bc] (13.25%)↑
Fat (%)	1.62±0.07[a]	1.73±0.04[a] (6.79%)↑	1.82±0.05[a] (12.34%)↑	1.92±0.28[a] (18.52%)↑

Where, B1 (control sample) = 100% wheat flour bun, B2= 15% karonda, B3=30% karonda, B4= 45% karonda)

The protein content of wheat flour bun substituted with fresh karonda ranged from 6.64 per cent to 7.52 per cent. The protein content significantly increase ($p<0.05$) in all bun samples substituted with fresh karonda. The protein content increased with increase in fresh karonda fruit substitution. Similar increase in protein content i.e. 7.01 to 7.69 per cent was reported in bread substituted with bread fruit flour (Alice *et al*. 2012). Youssef *et al.* (2012) also reported similar increase in protein content i.e. 7.01 to 7.69 per cent in wheat flour biscuit substituted with citrus peels powder. This increase in protein content might be due to high protein content in fruits (Thorvaldsson and Skjoldebrand, 1998).

The fat content (**Table 5.29**) of wheat flour bun substituted with fresh karonda ranged from 1.62 per cent to 1.92 per cent. Similar results, i.e. 1.57 per cent was reported by Michael *et al*. (2013) in wheat flour bread. The fat content non significantly increase ($p>0.05$) in bun samples substituted with fresh karonda. The fat content was highest in B4 (1.92 %) and lowest in B1(1.62 %). Similar increase in fat content i.e. 1.41 per cent was reported in wheat flour cookie substituted with unripe plantain flour (Chinma *et al*. 2012). This increase in fat content may be due to relative increase in fat content in fruits (Kulkarni and Joshi, 2014).

5.9 (c) Dietary fiber

The neutral detergent fiber (**Table 5.30**) of wheat flour bun substituted with fresh karonda ranged from 23.73 per cent to 25.66 per cent. Similar results, i.e. 23.16 per cent was reported by Krishan *et al.* (1987) in wheat flour bread. NDF increased significantly ($p<0.05$)in bun samples substituted with fresh karonda. The NDF was highest in B4 (25.66 %) and lowest in B1(23.73 %). Similar increase in dietary fiber i.e. 24.20 per cent was reported in bread substituted with watermelon rind (Ho and Dahri, 2016). Lopez *et al.* (2011) also reported similar increase i.e. 25.20 per cent in bread substituted with orange powder (Lopez *et al.* 2011). This increase in dietary fiber might be due to high dietary fiber in fruits (El- Sharnouby *et al.* 2012).

The acid detergent fiber (ADF) of wheat flour bun substituted with fresh karonda ranged from 1.30 per cent to 1.66 per cent. The ADF content increased non significantly ($p>0.05$)in bun samples substituted with fresh karonda. ADF increased with increase in fresh karonda fruit substitution. Similar increase in dietary fiber i.e. 0.75 to 1.13 per cent was reported in wheat flour cookie substituted with mango seed kernel (Legesse and Emire, 2012).

Table 5.30 Dietary fiber of bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
NDF (%)	23.73±0.10[a]	24.23±0.05[a] (2.10%)↑	24.83±0.98[a] (4.63%)↑	25.66±0.23[ab] (8.13%)↑
ADF (%)	1.30±0.45[a]	1.56±0.20[a] (20.0%)↑	1.60±0.17[a] (23.07%)↑	1.66±0.11[a] (27.69%)↑
Hemicellulose (%)	22.39±0.00[a]	22.69±0.00[a] (1.33%)↑	23.22±0.00[a] (3.70%)↑	23.99±0.00[a] (7.14%)↑
Cellulose (%)	2.48±0.10[a]	2.59±0.04[a] (4.43%)↑	2.64±0.05[a] (6.45%)↑	2.83±0.10[b] (14.11%)↑
Lignin (%)	1.23±0.63[a]	1.63±0.05[a] (32.52%)↑	1.66 ±0.05[a] (34.95 %)↑	1.73±0.05[a] (40.65 %)↑

Hemicellulose content (**Table 5.30**) of wheat flour bun substituted with fresh karonda ranged from 23.39 per cent to 23.99 per cent. Hemicellulose content increased non significantly ($p>0.05$) in bun samples substituted with fresh karonda. The hemicellulose content was highest in B4 (23.99 %) and lowest in B1(22.39 %).

The cellulose content of wheat flour bun substituted with fresh karonda ranged from 2.48 per cent to 2.83 per cent. The cellulose content significantly increased ($p<0.05$) in bun samples substituted with fresh karonda. The cellulose content increased with increase in fresh karonda fruit substitution. Similar increase in cellulose content i.e. 0.02 to 7.66 per cent was reported in

cookies substituted with raspberry pomace fruit (Gorecka *et al.* 2010). This increase in dietary fiber might be due to addition of cellulose rich fruits (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.30**) of wheat flour bun substituted with fresh karonda ranged from 1.23 per cent to 1.73 per cent. The results of the lignin content increased non significantly ($p>0.05$)in bun samples substituted with fresh karonda. The lignin content was highest in B4 (0.75 %) and lowest in B1(0.56 %). Similar increase in lignin content i.e.3.98 per cent was reported in wheat flour biscuits substituted with raspberry pomace fruit (Gorecka *et al.* (2010).

5.9 (d) Mineral composition

The calcium content (**Table 5.31**) of wheat flour bun substituted with fresh karonda ranged from 10.80 mg/100gm to 94.05 mg/100gm. Similar results, i.e. 10.70 mg/100gm was reported by Surekha *et al*. (2013) in wheat flour cookie. In control it was only 10.80 mg/100gm increased significantly with more replacement of fresh karonda fruit. Maximum value of calcium content i.e. 94.05 mg/100gm was noted in B4. Similar increase in calcium content i.e. 32 per cent was reported in wheat flour cake substituted with beetroot powder (Pinki and Awasthi, 2014). Seleem (2015) also reported similar increase in calcium content i.e. 20.40 per cent in wheat flour cake substituted with doum fruit powder. This increase in calcium content might be due to high mineral content in fruits (Kulkarni and Joshi, 2013).

The iron content of wheat flour bun substituted with fresh karonda ranged from 25.83 mg/100gm to 369.12 mg/100gm. The iron content significantly increase ($p<0.05$) in bun samples substituted with fresh karonda. The iron content increased with increase in fresh karonda fruit substitution. Similar increase in iron content i.e. 21 to 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

Table 5.31 Mineral composition of bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
Calcium (mg/100gm)	10.80 ± 0.00^{a}	49.57 ± 0.00^{b} (358.98%)↑	57.40 ± 0.00^{c} (431.48%)↑	94.05 ± 0.00^{cd} (770.83%)↑
Iron (mg/100gm)	25.83 ± 0.00^{a}	307.61 ± 0.00^{b} (1090.90%)↑	355.43 ± 0.00^{c} (1276.03%)↑	369.12 ± 0.00^{cd} (1329.0%)↑
Phosphorus (mg/100gm)	333.39 ± 0.00^{a}	416.77 ± 0.00^{b} (25.0%)↑	443.73 ± 0.00^{c} (33.09%)↑	501.13 ± 5.77^{cd} (50.31%)↑

The phosphorus content (**Table 5.31**) of wheat flour bun substituted with fresh karonda ranged from 333.39 mg/100gm to 501.13 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in bun samples substituted with fresh karonda. The phosphorus content was highest in B4 (501.13 mg/100gm) and lowest in B1(333.39 mg/100gm). Similar increase in phosphorus content i.e.377.15 per cent was reported in wheat flour chapatti substituted with date pulp (Waghray *et al.*2011). Similar increase in phosphorus content i.e. 540 per cent was reported in wheat bran biscuit substituted with palm fruit (El- Sharnouby *et al*. 2012).

5.9 (e) Organoleptic Analysis

Table 5.32 Bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
Appearance	7.4±0.69[a]	7.5±0.52 [a]	7.4±0.51 [a]	7.2±0.42 [a]
Colour	7.2±0.42 [a]	7.4±0.51 [a]	7.6±0.52 [a]	7.2±0.42 [a]
Texture	7.2±0.63 [a]	7.5±0.52 [a]	7.5±0.52 [a]	7.2±0.42 [a]
Flavour	7.5±0.52 [a]	7.4±0.51 [a]	7.6±0.51 [a]	7.3±0.48 [a]
Overall Acceptability	7.3±0.48 [a]	7.5±0.52 [a]	7.5±0.52 [a]	7.2±0.63 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant($p<0.05$)

Where, B1 (control sample) = 100% wheat flour bun, B2=15 % karonda, B3=30% karonda, B4 =45 %karonda)

As shown in Table 5.32, sensory characteristics of wheat flour bun substituted with fresh karonda B2, B3 and B4 were non significantly ($p>0.05$) different from wheat flour bun B1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour bun substituted with fresh karonda were not affected by increased concentration of fresh karonda. However, all samples were found to be acceptable.

Fig. 5.15 B1(control sample) = 100% wheat flour bun,

B2=15 % karonda,B3=30% karonda, B4 =45 % karonda)

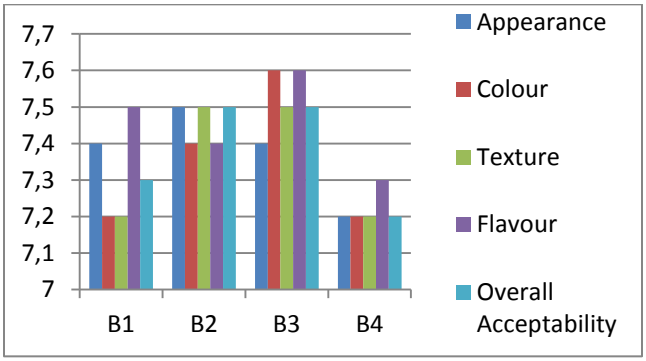

Fig. 5.16 Sensory scores of bun samples

5. 10 Muffin

5.10 (a) Nutritional composition

The moisture content (**Table 5.33**) of wheat flour muffin substituted with fresh karonda ranged from 10.80 per cent to 20.80 per cent. Similar results, i.e. 10.96 per cent was reported by Uchenna *et al*. (2013) in wheat flour muffin. In control it was only 10.80 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of moisture content i.e. 20.80 per cent was noted in B4.Similarincrease in moisture content i.e. 9.50 per cent was reported in wheat bran biscuits substituted with date palm powder (El- Sharnouby *et al.* 2012). Mansour *et al.* (1999) also reported similar increase in moisture content in wheat flour muffin substituted with pumpkin powder. This increase in moisture content might be due to high moisture content in fruits (Rosell *et al.* 2011).

Table 5.33 Nutritional composition of muffin substituted with fresh karonda

Parameters	B1	B2	B3	B4
Moisture (%)	10.80 ± 0.1^{a}	20.66 ± 0.05^{b} (91.29%)↑	19.68 ± 0.09^{c} (102.12%)↑	21.83 ± 0.00^{ad} (82.22%)↑
Ash(%)	1.12 ± 0.11^{a}	1.13 ± 0.10^{a} (0.89 %)↑	1.19 ± 0.05^{a} (6.25 %)↑	1.28 ± 0.19^{a} (14.28 %)↑
Carbohydrate (%)	45.45 ± 0.48^{a}	52.29 ± 2.22^{b} (15.04%)↑	61.16 ± 3.20^{c} (34.56%)↑	70.07 ± 0.02^{cd} (54.16%)↑
Protein (%)	6.42 ± 0.12^{a}	7.16 ± 0.05^{a} (11.52%)↑	7.52 ± 0.08^{b} (17.13%)↑	7.76 ± 0.08^{bc} (20.87%)↑
Fat (%)	10.33 ± 0.11^{a}	11.53 ± 0.11^{b} (11.61%)↑	12.53 ± 0.11^{c} (21.29%)↑	12.73 ± 0.11^{cd} (23.23%)↑

The ash content of wheat flour muffin substituted with fresh karonda ranged from 1.12 per cent to 1.28 per cent. The ash content non significantly increase ($p>0.05$) in muffin samples substituted with fresh karonda. The ash content increased with increase in fresh karonda fruit

substitution. Similar increase in ash content i.e.1.42 to 1.52 per cent was reported in muffin substituted with apple skin powder (Rupasinghe *et al.* 2008). Lopez *et al.* (2011) also reported similar increase in ash content i.e. 2.20 to 3.70 per cent in muffin substituted with orange powder. This increase in ash content might be due to high ash content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.33**) of wheat flour muffin substituted with fresh karonda ranged from 45.45 per cent to 70.07 per cent. Similar results, i.e. 45.08 per cent was reported by Krishanaprabha and Kiruthiga (2015) in wheat flour muffin. In control it was only 45.45 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of carbohydrate content i.e. 70.07 per cent was noted in B4. Similar increase in carbohydrate content i.e. 64.81 per cent was reported in wheat flour biscuit substituted with pumpkin powder (Kulkarni and Joshi, 2013). This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour muffin substituted with fresh karonda ranged from 6.42 per cent to 7.76 per cent. Similar results, i.e. 6.73 per cent was reported by Jauharah *et al.* (2014) in wheat flour muffin. The protein content significantly increase ($p<0.05$) in muffin samples substituted with fresh karonda. The protein content increased with increase in fresh karonda fruit substitution. Similar increase in protein content i.e.6.10 to 7.0 per cent was reported in wheat flour cake substituted with beetroot powder (Pinki and Awasthi, 2014). Jauharah *et al.* (2014) also reported similar increase in protein content in muffin substituted with corn powder. This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.33**) of wheat flour muffin substituted with fresh karonda ranged from 10.33 per cent to 12.73 per cent. The fat content significantly increase ($p<0.05$) in muffin samples substituted with fresh karonda. The fat content was highest in B4 (12.73 %) and lowest in B1(10.33 %). Similar increase in fat content i.e. 12.80 per cent was reported in wheat flour cookies substituted with mango kernel seed (Legesse and Emire,2012). Waghray *et al.* (2011) also reported similar increase in fat content i.e. 7.54 per cent in wheat flour chapatti substituted with dates. This increase in fat content may be due to high fat content in fruits (Asp and Bjorck, 1992).

5. 10 (b) Dietary fiber

The neutral detergent fiber (**Table 5.34**) of wheat flour muffin substituted with fresh karonda ranged from 23.66 per cent to 25.30 per cent. NDF increased non significantly ($p>0.05$) in muffin samples substituted with fresh karonda. The NDF was highest in B4 (25.30 %) and lowest in B1(23.66 %). Similar increase in NDF i.e. 24.68 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to relative increase of fiber content in fruits (Sadiq*et al.* 2003).

Table 5.34 Dietary fiber of muffin substituted with fresh karonda

Parameters	B1	B2	B3	B4
NDF(%)	23.66 ± 0.15^{a}	24.10 ± 0.34^{a} (1.85%)↑	24.46 ± 0.86^{a} (3.38%)↑	25.30 ± 0.86^{a} (6.93) ↑
ADF(%)	5.46 ± 0.63^{a}	6.06 ± 0.63^{a} (10.98%)↑	6.20 ± 1.10^{a} (13.55%)↑	6.56 ± 0.63^{a} (20.14%)↑
Hemicellulose (%)	17.86 ± 0.00^{a}	18.03 ± 0.00^{b} (0.95%)↑	18.25 ± 0.00^{c} (2.18%)↑	18.32 ± 0.00^{cd} (2.57%)↑
Cellulose(%)	4.18 ± 0.19^{a}	4.22 ± 0.19^{a} (0.95%)↑	4.26 ± 0.19^{a} (1.91%)↑	4.27 ± 0.19^{a} (2.15%)↑
Lignin (%)	1.60 ± 0.01^{b}	1.72 ± 0.02^{a} (7.50%)↑	1.73 ± 0.01^{a} (8.12%)↑	1.74 ± 0.01^{ab} (8.75%)↑

The acid detergent fiber (ADF) of wheat flour muffin substituted with fresh karonda ranged from 5.46 per cent to 6.56 per cent. The ADF content non significantly increase ($p>0.05$) in muffin samples substituted with fresh karonda. ADF increased with increase in fresh karonda fruit substitution. Similar increase in ADF i.e. 1.11 to 8.05 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010).

Hemicellulose content (**Table 5.34**) of wheat flour muffin substituted with fresh karonda ranged from 17.86 per cent to 18.32 per cent. Hemicellulose content increased significantly ($p<0.05$) in muffin samples substituted with fresh karonda. The hemicellulose content was highest in B4 (18.32 %) and lowest in B1(17.86 %). Similar increase in dietary fiber i.e. 19.00 per cent was reported in wheat flour biscuit substituted with grape pomace (Szkudlarz *et al.* 2013).

The cellulose content of wheat flour muffin substituted with fresh karonda ranged from 4.18 per cent to 4.27 per cent. Similar results, i.e. 4.50 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. The cellulose content non significantly increase ($p>0.05$) in cellulose content was observed in muffin samples substituted with fresh karonda. The cellulose content increased with increase in fresh karonda fruit substitution. Similar increase in dietary fiber i.e. 1.44 to 4.24 per cent was observed in wheat flour cookies substituted with unripe plantain flour (Chinma *et al.* 2012). Similar increase in cellulose content i.e. 0.02 to 4.07 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to addition of dietary fiber rich fruits in muffin, especially cellulose content (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.34**) of wheat flour muffin substituted with fresh karonda ranged from 1.60 per cent to 1.74 per cent. Similar results, i.e. 1.80 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. The results of lignin content increased significantly ($p<0.05$) in muffin samples substituted with fresh karonda. The lignin content was highest in B4 (1.74 %) and lowest in B1(1.60 %). Similar increase in dietary fiber i.e. 1.28 per cent was reported in wheat flour mathri substituted with potato flour (Kaur and Kochhar,2014).

5.10 (c) Mineral composition

The calcium content (**Table 5.35**) of wheat flour muffin substituted with fresh karonda ranged from 146.79 mg/100gm to 234.41 mg/100gm. In control it was only 146.79 mg/100gm increased significantly with more replacement of fresh karonda fruit. Maximum value of calcium content i.e. 234.41 mg/100gm was noted in B4. Similar increase in calcium content i.e. 148.33 per cent was reported in muffin substituted with carrot powder (Romjaun and

Prakash, 2015). This increase in calcium content might be due to high mineral content in fruits (Waghray *et al.* 2011).

Table 5.35 Mineral composition of muffin substituted with fresh karonda

Parameters	B1	B2	B3	B 4
Calcium (mg/100gm)	146.79±0.00^{a}	148.16±0.00^{a} (0.93%)↑	172.97±0.00^{a} (17.83%)↑	234.41±51.96^{ab} (59.69%)↑
Iron (mg/100gm)	10.92±0.00^{a}	11.33±0.00^{b} (3.75%)↑	12.07±0.00^{c} (10.53%)↑	13.31±0.00^{cd} (21.88%)↑
Phosphorus (mg/100gm)	62.40±0.00^{a}	72.28±0.00^{b} (15.83%)↑	76.86±0.00^{c} (23.17%)↑	81.74±0.00^{cd} (30.99%)↑

The iron content of wheat flour muffin substituted with fresh karonda ranged from 10.92 mg/100gm to 13.31 mg/100gm. The result of iron content significantly increase ($p<0.05$) in muffin samples substituted with fresh karonda. The iron content increased with increase in fresh karonda fruit substitution. Seleem (2013) also reported similar increase in iron content i.e. 4.80 to 5.03 per cent in wheat flour muffin substituted with doum fruit powder.

The phosphorus content (**Table 5.35**) of wheat flour muffin substituted with fresh karonda ranged from 62.40 mg/100gm to 81.74 mg/100gm.The results of the phosphorus content increased significantly ($p<0.05$)in muffin samples substituted with fresh karonda. The phosphorus content was highest in B4 (81.74 mg/100gm) and lowest in B1(62.40 mg/100gm).

5.10 (d) Organoleptic analysis

Table 5.36 Muffin substituted with fresh karonda

Parameters	B1	B2	B3	B4
Appearance	7.9±0.31 [a]	7.4±0.51 [a]	7.4±0.48 [a]	7.2±0.42 [a]
Colour	7.2±0.42 [a]	7.4±0.51 [a]	7.6±0.51 [a]	7.1±0.56 [a]
Texture	7.3±0.48 [a]	7.7±0.48 [a]	7.5±0.52 [a]	7.4±0.51 [a]
Flavour	7.8±0.42 [a]	7.5±0.52 [a]	7.4±0.51 [a]	7.3±0.48 [a]
Overall Acceptability	7.6±0.51 [a]	7.6±0.51 [a]	7.5±0.52 [a]	7.4±0.51 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant ($p<0.05$)

Where, B1 (control sample) = 100% wheat flour bun, B2=15 % karonda, B3=30% karonda, B4 =45 % karonda)

As shown in Table 5.36, sensory characteristics of wheat flour muffin substituted with fresh karonda B2, B3 and B4 were non significantly ($p>0.05$) different from wheat flour muffin B1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour muffin substituted with fresh karonda were not affected by increased concentration of fresh karonda. However, all samples were found to be acceptable.

Fig. 5.17 B1 (control sample) = 100% wheat flour muffin,

B2 =15 % karonda, B3 =30% karonda, B4 =45 % karonda)

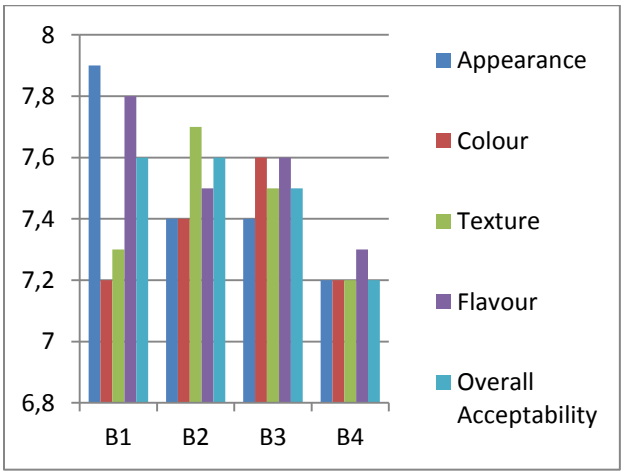

Fig. 5.18 Sensory scores of muffin samples

5.11 Noodles

5.11 (a) Nutritional composition

The moisture content (**Table 5.37**) of wheat flour noodles substituted with dried karonda ranged from 6.61 per cent to 9.88 per cent. In control it was only 6.61 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of moisture content i.e. 9.88 per cent was noted in B4. Similar increase in moisture content i.e. 9.73 per cent in wheat flour pasta substituted with orange fiber (Crizel *et al.* 2015). Similar increase in moisture content i.e. 8.67 per cent was also reported in wheat flour noodles substituted with unripe banana flour (Ritthiruangdej *et al*. 2011). This increase in moisture content might be due to relative increase of moisture content in fruits (Raj and Masih, 2014).

The ash content of wheat flour noodles substituted with dried karonda ranged from 2.00 per cent to 2.13 per cent. Similar results, i.e. 2.21 per cent was reported by Taneya *et al*. (2014) in wheat flour noodles. The ash content non significantly increase ($p>0.05$) in noodles samples substituted with dried karonda. The ash content increased with increase in dried karonda fruit substitution. Similar increase in ash content i.e. 0.87 to 1.64per cent was reported in wheat flour spaghetti substituted with banana flour (Diaz *et al.*2014). This increase in ash content might be due to high ash content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.37**) of wheat flour noodles substituted with dried karonda ranged from 85.53 per cent to 112.56 per cent. In control it was only 85.53 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of carbohydrate content i.e. 112.56 per cent was noted in B4. Similar increase in carbohydrate content i.e. 97.57 per cent was reported in wheat flour bread substituted with breadfruit flour (Alice *et al.* 2012). Ariffin *et al.* (2015) also reported similar increase in carbohydrate content i.e. 86.75 per cent in wheat flour bread substituted with durian fruit flour. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

Table 5.37 Nutritional composition of noodles substituted with dried karonda

Parameters	B1	B2	B3	B4
Moisture (%)	6.61 ± 0.16 [a]	7.44± 0.01 [b] (12.56%)↑	7.65 ± 0.99 [cd] (49.47%)↑	9.88 ± 0.04 [c] (15.73%)↑
Ash(%)	2.00± 0.05 [a]	2.04 ± 0.10 [a] (2.00%)↑	2.11 ± 0.05 [a] (5.50%)↑	2.13 ± 0.00[a] (6.50%) ↑
Carbohydrate (%)	85.53±0.01 [a]	94.58±0.07 [b] (10.58%)↑	103.05±0.05[c] (20.48%)↑	112.56±0.05 [cd] (31.60%)↑
Protein (%)	6.51±0.11 [a]	6.79±0.08 [b] (4.30%)↑	7.10±0.1 [c] (9.06%)↑	7.52±0.08 [cd] (15.51%)↑
Fat (%)	1.56±0.02 [a]	2.20±0.07 [b] (41.02%)↑	2.70±0.39[bc] (73.07%)↑	3.59±0.03 [cd] (130.12%)↑

The protein content of wheat flour noodles substituted with dried karonda ranged from 6.51 per cent to 7.52 per cent. Similar results, i.e. 6.73 per cent was reported by Ho and Latif (2016) in wheat flour cookies. The protein content significantly increase ($p<0.05$) in noodles samples substituted with dried karonda. The protein content increased with increase in dried karonda fruit substitution. Similar increase in protein content i.e. 6.73 to 7.04 per cent was reported in wheat flour cookies substituted with pitaya peel flour (Ho and Latif, 2016). This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.37**) of wheat flour noodles substituted with dried karonda ranged from 1.56 per cent to 3.59 per cent. Similar results, i.e. 1.56 per cent was reported by Hardi *et al*. (2007) in wheat flour noodles. The fat content significantly increase ($p<0.05$) in noodles samples substituted with dried karonda. The fat content was highest in B4 (3.59 %) and lowest in B1(1.56 %). Similar increase in fat content i.e. 5.20 per cent was reported in wheat flour noodles substituted with banana peel (Singh *et al.* 2015). This increase in fat content may be due to relative increase of fat content in fruits (Vinod *et al*. 2015).

5.11 (b) Dietary fiber

The neutral detergent fiber (**Table 5.38**) of wheat flour noodles substituted with dried karonda ranged from 21.93 per cent to 25.16 per cent. NDF increased non significantly ($p>0.05$) in noodles substituted with dried karonda. The NDF was highest in B4 (25.16 %) and lowest in B1 (21.93 %). Similar increase in dietary fiber i.e. 24.2 per cent was reported in wheat flour noodles substituted with watermelon rind powder (Ho and Dahri, 2016). This increase in dietary fiber might be due to high dietary fiber in fruits (Vinod *et al*. 2015).

Table 5.38 Dietary fiber of noodles substituted with dried karonda

Parameters	B1	B2	B3	B4
NDF (%)	21.93±1.90 [a]	23.36±1.53 [a] (6.52%)↑	23.70±1.70 [a] (8.07%)↑	25.16±0.77 [a] (14.72%)↑
ADF (%)	1.53±0.05 [a]	1.63±0.11 [a] (6.53 %)↑	1.70±0.20 [a] (11.11%)↑	1.83±0.11 [a] (19.60%)↑
Hemicellulose (%)	21.4±4.35 [a]	21.73±0.00 [a] (1.54%)↑	23.00±0.00 [a] (7.47%)↑	24.33±0.00 [a] (13.69%)↑
Cellulose (%)	3.14±0.18 [a]	3.18±0.22 [a] (1.27%)↑	3.20±0.02 [a] (1.91%)↑	3.23±0.00 [a] (2.86%)↑
Lignin (%)	1.46±0.05 [a]	1.56±0.05 [a] (6.84%)↑	1.63±0.05 [ab] (11.64 %)↑	1.76±0.05 [b] (20.54 %)↑

The acid detergent fiber (ADF) of wheat flour noodles substituted with dried karonda ranged from 1.53 per cent to 1.83 per cent. The ADF non significantly increase ($p>0.05$) in ADF was observed in noodles samples substituted with dried karonda. The ADF increased with increase in dried karonda fruit substitution.

Hemicellulose content (**Table 5.20**) of wheat flour noodles substituted with dried karonda ranged from 21.40 per cent to 24.33 per cent. Hemicellulose content increased non significantly ($p>0.05$) in noodles substituted with dried karonda. The hemicellulose content was highest in B4 (24.33%) and lowest in B1 (21.40 %).

The cellulose content of wheat flour noodles substituted with dried karonda ranged from 3.14 per cent to 3.23 per cent. The cellulose content non significantly increase ($p>0.05$) in noodles samples substituted with dried karonda. The cellulose content increased with increase in dried karonda fruit substitution. This increase in dietary fiber might be due to addition of dietary fiber rich fruits (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.38**) of wheat flour noodles substituted with dried karonda ranged from 1.46 per cent to 1.76 per cent. Similar results, i.e. 1.08 per cent was reported by Gorecka *et al.* (2010) in wheat flour cookies. The results of the lignin content increased significantly ($p<0.05$) in noodles samples substituted with dried karonda. The lignin content was highest in B4 (0.76 %) and lowest in B1(0.46 %). Similar increase in dietary fiber i.e. 0.75 per cent was reported in wheat flour biscuits substituted with jackfruit powder (Butool and Butool, 2013).

5.11 (c) Mineral composition

The calcium content (**Table 5.39**) of wheat flour noodles substituted with dried karonda ranged from 18.96 mg/100gm to 22.67 mg/100gm. In control it was only 18.96 mg/100gm increased significantly with more replacement of dried karonda fruit. Maximum value of calcium content i.e. 22.67 mg/100gm was noted in B4. Similar increase in calcium content i.e. 20.40 per cent was reported in wheat flour cake substituted with doum fruit powder. This increase in calcium content might be due to high mineral content in fruits (Niemen *et al*. 1992).

Table 5.39 Mineral composition of noodles substituted with dried karonda

Parameters	B1	B2	B3	B4
Calcium (mg/100gm)	18.96±0.00 [a]	19.71±0.00 [b] (3.95%)↑	22.19±0.00 [c] (17.03%)↑	22.67±0.00 [cd] (19.56%)↑
Iron (mg/100gm)	10.92±0.00 [a]	16.04±0.00 [b] (11.11%)↑	19.88±0.00 [cd] (33.33%)↑	23.80±0.00 [b] (77.77%)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	344.83±0.00 [cd] (9.09%)↑	423.54±0.00 [c] (36.36%)↑	513.20±0.00 [b] (45.45%)↑

The iron content of wheat flour noodles substituted with dried karonda ranged from 10.92 mg/100gm to 23.80 mg/100gm. The iron content significantly increase ($p<0.05$) in noodles samples substituted with dried karonda. The iron content increased with increase in dried karonda fruit substitution.

The phosphorus content (**Table 5.39**) of wheat flour noodles substituted with dried karonda ranged from 324.1 mg/100gm to 513.20 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in noodles samples substituted with dried karonda. The phosphorus content was highest in B4 (0.16 mg/100gm) and lowest in B1(0.11 mg/100gm). Similar increase in phosphorus content i.e. 467 per cent was reported in wheat flour cakes substituted with beetroot powder (Pinki and Awasthi, 2014).

Fig. 5.19 B1 (control sample = 100% wheat flour noodles, B2 =15 % karonda, B3 =30% karonda, B4 =45 % karonda)

5.12 Nugget

5.12 (a) Nutritional composition

The moisture content (Table 5.40) of green gram nugget substituted with dried karonda ranged from 19.68 per cent to 21.83 per cent. In control it was only 19.68 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of moisture content i.e. 21.83 per cent was noted in B4. Similar increase in moisture content i.e. 22.98 per cent was reported in composite pulse flour chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in moisture content might be due to high moisture content in fruits (Raj and Masih, 2014).

Table 5.40 Nutritional composition of nugget substituted with dried karonda

Parameters	B1	B2	B3	B4
Moisture (%)	19.68±0.09 ^{ac}	19.80±0.1 ^{a} (0.60%)↑	20.66±0.05 ^{b} (4.97%)↑	21.83±0.00 ^{c} (10.92%)↑
Ash (%)	1.10±0.05 ^{a}	1.13±0.10 ^{a} (2.72 %)↑	1.16±0.05 ^{a} (5.45 %)↑	1.19±0.05 ^{a} (8.18 %)↑
Carbohydrate (%)	65.64±0.22 ^{a}	74.53±0.40 ^{b} (13.54%)↑	82.99±0.24 ^{c} (26.43%)↑	93.30±1.04 ^{cd} (42.13%)↑
Protein (%)	13.34±0.08 ^{a}	14.00±0.1 ^{b} (4.94%)↑	14.10±0.1 ^{bc} (5.69%)↑	14.37±0.12 ^{cd} (7.72%)↑
Fat (%)	1.85±2.71 ^{a}	2.74±0.05 ^{b} (48.10%)↑	3.31±0.24 ^{c} (78.91%)↑	3.96±0.30 ^{cd} (114.05%)↑

The ash content of green gram nugget substituted with dried karonda ranged from 1.10 per cent to 1.19 per cent. Similar results, i.e. 1.64 per cent was reported by Sharma and Chopra (2015) in nugget. The ash content non significantly increase ($p>0.05$) in nugget samples substituted with dried karonda. The ash content increased with increase in dried karonda fruit substitution. Similar increase in ash content i.e. 0.76 to 2.30 per cent was reported in green gram

dal substituted with bathua leaves (Singh *et al.* 2007). This increase in ash content might be due to high ash content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.40**) of green gram nugget substituted with dried karonda ranged from 65.64 per cent to 93.30 per cent. Similar results, i.e. 65.50 per cent was reported by Aziz *et al*. (2012) in nugget. In control it was only 65.64 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of carbohydrate content i.e. 93.30 per cent was noted in B4. Similar increase in carbohydrate content i.e. 70.72 per cent was reported in bengal gram dal substituted with kondhara leaves (Singh *et al.* 2014). This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of green gram nugget substituted with dried karonda ranged from 13.34 per cent to 14.37 per cent. Similar results, i.e. 12.86 per cent was reported by Singh and Sharma (2003) in bengalgram roll. The protein content significantly increase ($p<0.05$) in nugget samples substituted with dried karonda. The protein content increased with increase in dried karonda fruit substitution. Similar increase in protein content i.e. 11.48 to 30.44 per cent was reported in bengal gram dal substituted with kondhara leaves (Sultana *et al.* 2014). This increase in protein content might be due to high protein content in fruits (Waghray *et al.* 2011).

The fat content (**Table 5.40**) of green gram nugget substituted with dried karonda ranged from 1.85 per cent to 3.96 per cent. Similar results, i.e. 1.30 per cent was reported by Pardeshi *et al*. (2013) in nugget. The fat content significantly increase ($p<0.05$) in fat content was observed in nugget samples substituted with dried karonda. The fat content was highest in B4 (3.96%) and lowest in B1(1.85 %). Similar increase in fat content i.e. 1.28 per cent was reported in gram flour based chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in fat content may be due to high fat content in fruits (Vinod *et al*. 2015).

5.12 (b) Dietary fiber

The neutral detergent fiber (**Table 5.41**) of green gram nugget substituted with dried karonda ranged from 23.56 per cent to 25.30 per cent. NDF increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The NDF was highest in B4 (25.30 %) and lowest in B1 (23.56 %). This increase in dietary fiber might be due to high dietary fiber in fruits (Choo and Aziz, 2010).

Table 5.41 Dietary fiber of nugget substituted with dried karonda

Parameters	B1	B2	B3	B4
NDF (%)	23.56±0.11 [a]	23.93±0.32 [a] (1.57%)↑	24.30±0.95 [a] (3.14%)↑	25.30±0.86 [ab] (7.38%)↑
ADF (%)	21.06±0.92 [a]	21.73±0.23 [a] (3.18%)↑	21.76±1.85 [a] (3.32%)↑	22.63±1.45 [a] (7.45%)↑
Hemicellulose (%)	1.97±0.00 [a]	2.20±0.00 [b] (11.67%)↑	2.33±0.00 [c] (18.27%)↑	2.54±0.00 [cd] (28.93%)↑
Cellulose (%)	11.88±0.65 [a]	12.23±0.00 [a] (2.94%)↑	12.67±0.58 [a] (6.64%)↑	12.97±0.63 [a] (9.17%)↑
Lignin (%)	1.68±0.00 [a]	1.72±0.01 [a] (1.17%)↑	1.73±0.01 [a] (1.76%)↑	1.74±0.01 [ab] (2.35%)↑

The acid detergent fiber (ADF) of nugget substituted with dried karonda ranged from 21.06 per cent to 22.63 per cent. The ADF increased non significantly ($p>0.05$) in nugget samples substituted with dried karonda. The ADF increased with increase in dried karonda fruit substitution.

Hemicellulose content (**Table 5.41**) of nugget ranged from 1.97 per cent to 2.54 per cent. Hemicellulose content increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The hemicellulose content was highest in B4 (2.54 %) and lowest in B1(1.97

%). Similar increase in hemicellulose content i.e. 0.25 to 5.75 per cent was reported in dietary fiber in bengal gram dal substituted with kondhara leaves (Singh *et al.* 2014). Singh *et al.* (2007) also reported similar increase i.e. 0.38 to 0.51 per cent in green gram dal substituted with bathua leaves.

The cellulose content of nugget ranged from 11.88 per cent to 12.97 per cent. The cellulose content non significantly increase ($p>0.05$) in all nugget samples substituted with dried karonda. The cellulose content increased with increase in dried karonda fruit substitution. This increase in dietary fiber might be due to presence of high dietary fiber in fruits (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.41**) of nugget ranged from 1.68 per cent to 1.74 per cent. The results of the lignin content increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The lignin content was highest in B4 (1.74 %) and lowest in B1(1.68 %). Similar increase in lignin content i.e. 1.28 per cent was reported in besan laddu substituted with mushroom powder (Verma and Singh, 2014).

5.12 (c) Mineral composition

The calcium content (**Table 5.42**) of nugget ranged from 146.79 mg/100gm to 204.41 mg/100gm. In control it was only 146.79 mg/100gm increased significantly with more replacement of dried karonda fruit. Maximum value of calcium content i.e. 204.41 mg/100gm was noted in B4. Similar increase in calcium content i.e.116.93 per cent was reported in legume based pan cake (thalipeeth) substituted with shepu dried greens (Gupta and Prakash, 2011).

The iron content of nugget ranged from 10.92 mg/100gm to 13.31mg/100gm. The iron content significantly increase ($p<0.05$) in nugget samples substituted with dried karonda. The iron content increased with increase in dried karonda fruit substitution. Similar increase in iron content i.e. 3.90 to 8.99 per cent was reported in legume composite flour thalipeeth (pan cake like product) substituted with green leafy vegetables (Gupta and Prakash, 2011). Singh *et al.*(2014) also reported similar increase in iron content i.e. 7.25 to 28.77 per cent in bengal gram dal substituted with kondhara leaves .

Table 5.42 Mineral composition of nugget substituted with dried karonda

Parameters	B1	B2	B3	B4
Calcium (mg/100gm)	146.79± 0.00 [a]	148.16±0.00 [b] (0.93%)↑	172.97±0.00 [c] (16.74%)↑	204.41±0.00 [cd] (39.25%)↑
Iron (mg/100gm)	10.92±0.00 [a]	11.33±0.00 [b] (3.75%)↑	12.07±0.00 [c] (210.53%)↑	13.31±0.00 [cd] (21.88%)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	422.81±0.00 [b] (30.45%)↑	468.62±0.00 [c] (44.59%)↑	517.43±0.00 [cd] (59.65%)↑

The phosphorus content (**Table 5.42**) of nugget ranged from 324.1 mg/100gm to 517.43 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The phosphorus content was highest in B4 (517.43 mg/100gm) and lowest in B1(324.1 mg/100gm). Similar increase in phosphorus content i.e. 320 to 378 per cent was reported in gram composite flour roti substituted with methi powder (Kadam *et al*.2012).

Fig. 5.20 B1 (control sample) = 100% green gram nugget,

B2 =15 % karonda, B3 =30% karonda, B4 =45 % karonda)

6. SUMMARY AND CONCLUSIONS

Fruits are important source of vitamins, minerals and fibers. Fresh fruits are classified as perishable commodities due to presence of higher moisture content (Orsat *et al.* 2006). Nowadays, perishable crops are dried in the world (Grabowski *et al.* 2003) and due to their international trade, consumers have access to various unseasonable fruits around the world. In comparison of imported fruits, locally available fruits are very cheap, fresh but short life span. Therefore, processing methods must be use to enhance their shelf life.

So, present investigation entitled **"Influence of processing on nutritional and phytochemical composition of Fig (*Ficus carica*) and Karonda (*Carissa spinarum*)"** was undertaken the thesis work on locally available two underutilized fruits, fig and karonda with following objectives:

1. To evaluate proximate, nutritional, physical and phytochemical composition of fresh fig and karonda fruits.
2. To assess the influence of processing methods viz. sun drying, microwave drying and freezing on physicochemical, nutritional and phytochemical composition of selected fruits.
3. To evaluate the effect of fruit extract of fig and karonda on FBG level of normoglycemic and diabetic wistar rats.
4. To develop various value added products from the selected fruits and analyze their nutritional composition during 6 months of storage.

These two local varieties of fruits were procured from Bilaspur (Himachal Pradesh), India and processed under the influence of freezing, sun drying and microwave drying method and studied for physical composition, nutritional composition, anti- nutritional composition and mineral composition. Results demonstrated a wide variation in the nutrient composition of fresh and processed fruit. Drying method reduced the length, width and density in fruits. Drying method increased significantly ($p<0.05$) the ash content, carbohydrate content, fat content, protein content and dietary fiber (NDF, ADF, hemicellulose, cellulose, lignin) and showed reduction in the moisture content. After processing, microwave dried method

exhibited significantly ($p<0.05$) higher phytochemical composition (phenolic content and flavonoid content). The antioxidant activity was also found to be increased in microwave dried method. Drying method decreased significantly ($p<0.05$) the tannin content, alkaloid content, anthocyanin content and increased the calcium content, iron content and phosphorus content.

Underutilized fruits also proved beneficial to control many diseases. Traditional point of view these fruits are popular with hypoglycemic activities (Perez *et al.* 1999). So, present study examined the influence of these selected fruits (fig and karonda) on FBG level in normoglycemic and diabetic rats.

Animal trial was carried out by using fourty two male albino rats. The rats were weighed and allotted twelve for toxicity test and after that distributed into seven groups (n=6) for further study purpose. Group I as normoglycemic rat group, group II as diabetic group having 35 mg streptozotocin according to body weight of rat, group III as diabetic group having 50 mg metformin according to body weight of rat, group IV as diabetic group having 500 mg fig methanolic extract according to body weight of rat , group V as diabetic group having 500 mg karonda methanolic extract according to body weight of rat, group VI as normoglycemic group having 500 mg fig methanolic extract, group VII as normoglycemic group having karonda methanolic extract (500 mg/kg b.wt.). Fasting blood glucose (FBG) level and body weight of rats were measured after 0 day, 7^{th} day, 14^{th} day and 21^{th} day. In result, methanolic extract of fig and karonda extract decreased significantly ($p<0.05$) higher FBG level on 21^{th} day as compared to 0 day in diabetic control group as well as in normoglycemic group of rats. And, also proved effective to improve higher body weight of rats on 21^{th} day as compared to 0 day in diabetic control group as well as in normoglycemic group of rats.

This study also proved beneficial to explored the possibilities of the utilization of nutrient rich under-utilized fruits to make innovative food products. According to objectives of the study these underutilized fruits were selected for the development of value added products because of their higher nutritional quality and easy availability. Different value added products such as bun, muffin, noodles and nuggets were formulated with the substitution of

15 per cent, 30 per cent and 45 per cent of karonda and fig to improve the overall nutritional quality. And, increased significantly ($p<0.05$) the moisture content, ash content, carbohydrate content, protein content, fat content, dietary fiber (ADF, NDF, hemicellulose, cellulose, lignin), iron content, calcium content and phosphorus content. The value added products, bun and muffin were also evaluated organoleptically for appearance, colour, texture, flavour, overall acceptability and accepted well by panel of judges. Thus, these underutilized fruits could be successfully used in the production of the value added products and proved to be nutritious convenience products for the human consumption.

The study concludes that drying method proved to be more effective for nutrient retension and significantly ($p<0.05$) reduced FBG level in diabetic control group as well as in normoglycemic group of rats. Further, the substitution of fruits showed significant effect to increase the nutritional quality in developed value added products.

7. BIBLIOGRAPHY

Abou ElHana, N. H. (2008). Microwave drying of apple. *Misr Journal of Agriculture Engineering, 25*, 980-1003.

Abou-Zaid, A. A., Ramadan, M. T., and Al-Asklany, S. A. (2011). Utilization of faba vegetables. *Biochemistry, 18*(2), 121–125. www.bioline.org.br/request

Abu-Goukh, A. A., Shattir, A. E., and Balla, M. M. E. (2003). Effect of harvesting method on quality and storability of dry dates in Sudan. *Tropical Science, 43*, 53-56.

Adubofuor, J., and Mensah, M. A. (2012). Sensory evaluation and proximate composition of rock buns and cakes prepared from partially- dried ripe pawpaw pulp incorporated into wheat flour. *Journal Agriculture Food Technology, 2*(11),172-177.

Agent (1994). *A survey of the market for fruits and vegetables in the hotel and restaurant industry*. Agent's business production, processing and marketing information centre,19,Colombo, 25.

Agoreyo, B. O., Akiroroh, O., Orukpe, O. A., Osaweren, O. R., and Owabor, C. N. (2011). The effects of various drying methods on the nutritional composition of *Musa paradisiacal, Dioscorea rotundata* and *Colocasia esculenta. Asian Journal of Biochemistry, 6*(6),458-464.

Ahmad, F., and Raj, A. (2012). Buckwheat: a legacy on the verge of extinction a Ladakh. *Current. Science,103*(1),13.

Ahmad, M. Z., Ali, M., and Mir, S. R. (2013). Anti- diabetic activity of *Carissa spinarum* L. stem barks and isolation of two new flavonol esters from the plant by using spectroscopic techniques. *Asian Journal of Biomedical and Pharmaceutical Sciences, 3*(18),22-28.

Ahuja, M. M. S. (1979). *Epidemiological studies on diabetes mellitus in India*. In :Ahuja MMS, Editor, Epidemiology of diabetes in developing countries. New Delhi: Imprint, 29-38.

Akhijahani, H. S., and Khodaei, J. (2011). Some physical properties of strawberry (Kurdistan Variety). *World Applied Science Journal,13*(2),206-212.

Akinhanmi, T. F., Atasie, V. N., and Akintokun, P. O. (2008). "Chemical composition and physicochemical properties of cashew nut (*Anacardium occidentale*) oil and cashew nut shell liquid." *Journal of Agricultural, Food and Environmental Sciences, 2*(1), 1–10.

Alam, M. J., Talukder, M. U., and Rahman, M. N. (2013). Evaluation of the nutritional and sensory quality of functional breads prepared from whole wheat and soyabean flour. *Annals. Food Science and Technology,14* (2),171-175.

Albers, S., Muchova, Z., and Fikselova, M. (2009). The effects of different treated brans additions on bread quality. *Scientia Agriculture Biochemica,40*(2),67-72.

Aleid, S. M., Elansari, A. M., Tang, Z. X., and Sallam, A. A. (2014). Effect of cold storage and packing type on Khalas and Sukkary dates quality. *Advance Journal of Food Science and Technology,6*(5),603-608.

Alfaro, S., Mutis, A., Quiroz, A., Seguel, I., and Scheuermann, E. (2014). Effects of drying on murtilla fruit polyphenols and antioxidant activity. *Journal of Food Research,3*(5),73-82.

Al-Farsi, M., Alsavar, C., Morris, A., Baron, M., and Shahidi, F. (2005). Comparison of antioxidant activity, anthocyanin, carotenoids and phenolics of three native fresh and sun dried date (*Phoenix dactylifera L.)* varieties grown in Oman. *Journal of Agriculture and Food Chemistry,53*, 7592-7599.

Alice, A. O., Oshundahunsi, O. F., Rahman, A., Kayode, A., Abiodun, A. et al. (2012). Proximate composition and sensory qualities of snacks produced from breadfruit flour. *Global Journal of Science Frontier Research Biological Sciences,12*(7),2249-4626.

Aljane, F., Toumi, I., and Ferchichi, A. (2007). HPLC determination of sugars and atomic absorption analysis of mineral salts in fresh figs of Tunisian cultivars. *African Journal of Biotechnology,6*(5),599-602.

Al-Ogaidi, H. K., and Mutlak, H. H. (1986). The phenolic compounds of four date cultivars during maturity stages. *Date Palm Journal,4*(4),191-196.

Al-Yahayai, R., and Al-kharusi, L. (2012). Physical and chemical quality attributes of freeze-stored dates. *International Journal Agriculture Biology, 14*, 97-100.

Amalina, N. I., Nordin, A., Ariffin, H., Andou, Y., Hassan, M. A., Shirai, Y. et al. (2013). Modification of oil palm mesocarp fiber characteristics using superheated steam treatment. *Molecules,18*, 9132-9146.

Amreen, F., Prem, P. S., Parul, A., Raghuveer, I., Shashi, A. *et al.* (2013). Treatment of various diseases by *Carissa spinarum* L. promising shrub. *International Journal Pharma Science Research,*4 (7), 2489-2495.

Anantawat, V. (2015). Effects of spray drying conditions on characteristics, nutritional value and antioxidant activity of gac fruit aril powder. *Integrated Business and Economic Resource,4,*1-11.

Ancos, B., Gonza, E. M., and Cano, M. P. (2000). Ellagic acid, vitamin C and total phenolic contents and radical scavenging capacity affected by freezing and frozen storage in raspberry fruit. *Journal Agriculture Food Chemistry, 48,* 4565-4570.

Andulla, B., and Varadacharyulu, N. C. H. (2003). Antioxidant role of mulberry leaves in streptozotocin – diabetic rats. *Clinica Chimica Acta, 338,*3-10.

Anon (2011). The general information about figs. www.erbeyliincir.gov.tr *(Accessed 4 June 2)(Turkish).*

Anonymous (1950). In the wealth of India : A Dictionary of Indian raw materials and industrial products, *CSIR NEW DELHI,3,*22.

Anonymous (1999). The wealth of India: *A dictionary of India raw materials and industrial products*. Council of Scientific and Industrial Research New Delhi, 4.

Anonymous (2001). The Wealth of India*: A dictionary of Indian raw materials and industrial products, first supplemented series.* National Institutes of Science Communicaton, *New* Delhi,2 CI-CY XXXV.

AOAC, Official method of analysis international. (2010). *Spectrophotometric method,7* (2), 161-4.

Ara, R., Jahan, S., Abdullah, A. T. M., Fakruddin, A. N. M., and Saha, B. K. (2014). Physico-chemical properties and mineral content of selected tropical fruits in Bangladesh. *Bangladesh Journal of Scientific and Industrial Research ,49*(3),131-136.

Aremu, M. O., Olaofe, O., and Akintayo, T. E. (2006). A comparative study on the chemical and amino acid composition of some Nigerian under-utilized legume flours. *Pakistan Journal of Nutrition, 5,* 34-38.

Ariffin, F., Baharom, M. A., Kaur, B., and Maurd, M. (2015). The physicochemical properties and sensory evaluation of bread made with a composite flour from wheat and Tempoyak (fermented Durian). *American Journal of Applied Sciences, 12* (11), 775.784.

Ariffin, H., Hassan, M. A., Kalsom, M. S. U., Abdullah, N., and Shirai, Y. (2000). Effect of physical, chemical and thermal pretreatments on the enzymatic hydrolysis of oil palm empty fruit bunch (OPEFB). *Journal of Tropical Agriculture and Food Science,36*(2), 000-000.

Arslan, D. (2015). Effects of degradation preventive agents on storage stability of anthocyanins in sour cherry concentrate. *Agronomy Research,13*(4), 892–899.

Asp, N. G., and Bjorck, I.(1992).Resistant starch. *Trends in Food Science and Technology, 3*,111-114.

Association of Official Analytical Chemists. (1975). *Official methods of analysis (12th editio*n). The Assocation: Washington, D.C.

Atlabachew, M., Chandravanshi, B. S., Abshiro, M. R., Torto, N., Chigome, S. et al .(2013). Evaluation of the effect of various drying techniques on the composition of the psychoactive phenylpropylamino alkaloids of Khat *(Catha Edulis for SK)* chewing leaves. *Bull. Chemical Society Ethiopa,27*(3), 347-358.

Avila, P. A., Namiesnik, J., Toledo,F., Werner, E., Ayala, A. L. M., Guzman, N. E. R., Infante, J. A. G. et al. (2012). The influence of different time durations of thermal processing on berries quality. *Food Control, 26* ,587-593.

Ayadi, A., Mechlouch, R. F., Bessaoud, C., Bennour, H., and Debouba, M. (2014). Effect of microwave and solar drying methods on the physicochemical properties of kiwifruit. *Journal of Agricultural Technology,10* (4),365-379.

Aydin, C. (2002). Physical properties of hazel nuts. *Biosystems Engineering, 82* (3), 297-303.

Aziz, N., Noor, M. A., and Ho, L. H. (2012). Physico-chemical and organoleptic properties of cookies incorporated with legume flour. *International Food Research Journal*,19(4),1539-1543.

Babiker, W. A. M., Abdel, M. E. S., Sirekhatim, B. E., and Elamin, A. K. (2013). Physicochemical properties of wheat bread supplemented with orange peel by-products. *International Journal of Nutrition and Food Sciences,2*(4),1-4.

Badola, H. K., and Aitken, S. (2010). Biological resources and poverty alleviation in the Indian Himalayas. *Biodiversity, 11*(3), 8-18.

Baker, A. A. and Gawish, R. A. (1997). Trials to reduce nitrate and oxalate content in some leafy vegetables. Interactive effects of the manipulating of the soil nutrient supply, different blanching media and preservation methods followed by cooking process. *Journal of Science, Food and Agriculture, 42*, 169-178.

Balasubramanian, D. (2001). Physical properties of raw cashew. *Nutrition Journal of Agricultural Engineering Research,78* (3),291-297.

Baliga, M., Bhat, H., Pai, R., Boloor, R., and Palatty, P. (2011). The chemistry and medicinal uses of the underutilized Indian fruit tree *Garcinia Indica Choisy* (kokum): A review. *Food Research International. In Press.*

Bernard, R., Issah, A. P., and Emmanuel, M. (2014). Effect of drying methods on phytochemical composition of orange fruit (*Citrus sinesis, L.)* peel flour in biscuit making. *Journal of Environmental Science, Toxicology and Food Technology,8*(10),72-75.

Bey, M. B., and Louaileche, H. (2015). A comparative study of phytochemical profile and *in vitro* antioxidant activities of dark and light dried fig (*Carissa spinarum* L.) varieties. *The Journal of Psychopharmacology, 4*(1), 41-48.

Bhogaonkar, P. Y., Chauhan, V. N., and Kanerkar, U. R. (2014). Nutritional potential of *Ficus racemosa L.* fruits. *Bioscience Discovery,5*(2),150-153.

Blois, M. S. (1958). Antioxidant determination by the use of stable free radicals. *Nature, 181*, 1199-2000.

Boca, S., Galoburda, R., Skrupskis, I., and Skrupska, D. (2014). The effect of freezing and hydrocolloids on the physical parameters of strawberry mass- based desserts. *Proc. Latvia University Agriculture, 31*(326), 12-24.

Boonsumrej, S., Chaiwanichsiri, S., and Tantratian, S. (2007). Effect of freezing and thawing on the quality changes of tiger shrimp (*Penaeus monodon*) frozen by air-blast and cryogenic freezing. *Journal of Food Engineering, 80,*292–299.

Borchani, C., Besbes, S., Masmoudi, M., Blecker,C., and Paquot, H. A. (2011). Effect of drying methods on physico-chemical and antioxidant properties of date fiber concentrates. *Food Chemistry, 125,*1194–1201.

Bouzari, A., Hilstege, D., and Barrett, D. M. (2015). Mineral, fiber and total phenolic retention in eight fruits and vegetables: A comparison of refrigerated and frozen storage. *Journal of Agriculture and Food Chemistry, 63*, 951-956.

Brackmann, A., Mazaro, S. M., and Saquet, A. A. (1997). Cold storage of persimmons *(Diospyros kaki L.)* cultivars Fuyu and Rama Forte. *Ciencia-Rural, 27,* 561 - 565.

Brito, B., Rodriguez, M., Samaniego, I., Jaramillo, M. I., and Valliant, F. (2006). Characterizing polysaccharides in cherimoya (*Annona cherimola Mill*) pure and their enzymatic liquefaction. *Europe Food Resource Technology, 115*(4),377-378.

Brooker, D. B., Bakker, A. F. W., and Hall, C. W. (1974). Drying cereal grains. *The AVI publishing company, Inc*, Westport,Co,USA,265.

Burke, J. L., Waghorn, G. C., Brookes, I. M., and Attwood, G. T. (2000). Formulating total mixed rations from forages- defining the digestion kinetics of contrasting species. *Proceedings of New Zealand Society of Animal Production 60*,9-14.

Butool, S., and Butool, M. (2013). Nutritional quality on value addition to jack fruit seed flour. *International Journal of Science and Research, 4* (4),2406-2411.

Candrawinata, V. I., Golding, J. B., Roach, P. D. and Stathopoulos, C. E. (2014). Total phenolic content and antioxidant activity of apple pomace aqueous extract: effect of time, temperature and water to pomace ratio. *International Food Research Journal, 21*(6), 2337-2344.

Caprez, A., Arrigoni, E., Amado, R., and Neucom, H. (1986). Influence of different types of thermal treatment on the chemical composition and physical properties of wheat bran. *Journal Cereal Science, 4*, 233–239.

Chaparzadeh, N., and Yavari, B. (2013). Antioxidant responses of Golden delicious apple under cold storage conditions. *Iranian Journal of Plant Physiology,4* (1), 907-915.

Chauhan, K., Sharma, S., Chawla, E., and Chauhan, B. (2010). Development of food products on corporating dry powdered figs to explore their hypercholestrolemic potential. *Food Science Research Journal, 2*(1), 196-201.

Chawla, A., Kaur, R., and Sharma, A. K. (2012). *Carissa spinarum* Linn. : A Review on its pharmacognostical, phytochemical and pharmacological aspects. *International Journal of Pharmaceutical and Phytopharmacological Research,1*(4),215-232.

Cheftel, J. C., Cheftel, H., and Besancon, P. (1989). Methods de conservation. In: Cheftel, J. C., Cheftel, H., Besancon, P., (Ed). Introduction a la bioquimica tecnologia de los alimentos. *Zaragoza: Acribia, cap,7,*173-299.

Chen, M. L., and Morris, W. C. (1990). Effect of heat treatments on the chemical analysis of dietary fiber. *Journal of Food Science, 55,* 1647-1650.

Cheng, M. (2011). Effects of drying temperature on the flavonoid, phenolic acid and antioxidative capacities of the methanol extract of citrus fruit (*Citrus sinensis* L.) peel. *International Journal of Food Science and Technology, 46*(6),1179-1185.

Chinma, C. E., Igbabul, B. D., and Omotayo, O. O. (2012). Quality characteristics of cookies prepared from unripe and defatted sesame flour blends. *American Journal of Food Technology,7*(7),398-408.

Chinyere, G.C. and Obasi, N. A. (2013). Vitamins and phytochemical contents in four leafy vegetable subjected to different processing methods. *African Journal of Biotechnology,12* (26),4168-4173.

Chism, G. W., and Haard, N. F. (1996). Characteristics of edible plant tissues. In: Food Chemistry. OR *Fennema New York*: *Dekker,* 943-1011.

Chobanian, A. V., Bakris, G. L., Black, H. R., Cushman, W. C., Green, 1. L. A., Izzo, J. L. J. et al. (2003). National Heart, Lung and Blood Institute Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure; National High Blood Pressure Education Program Coordinating Committee. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA, 289,* 2560-72.

Chomnawang, C., Nantachai, K., Yongsawatdigul, J., Thawornchinsombut, S., and Tungkwa-chara, S. (2007). Chemical and biochemical changes in hybrid catfish fillet stored at 4°C and its gel properties. *Food Chemistry, 103*,420–427.

Choo, C. L., and Aziz, N. A. (2010). Effects of banana flour and β- glucan on the nutritional and sensory evaluation of noodles. *Food Chemistry, 119*, 34–40.

Choudhary, S., Pathak, A. K., Khare, S., and Kushwah, S. (2011). Evaluation of antidiabetic activity of leaves and fruits of *Ficus religiosa* Linn. *International Journal of Pharmacy and Life Sciences,2* (12),1325-1327.

Chuen, Y. S., and Aziz, N., A. A. (2009). Chemical and physical properties of muffin prepared from different levels of mango (*Mangifera indica)* variety Chokanan pulp flour. Food Technology Division, School of Industrial Technology, University Sains Malaysia,11800 Minden, Penang, Malaysia.

Chumyam, A., Wangchai, K., Jungklang, J., and Faiyue, B. (2013). Effects of heat treatments on antioxidant capacity and total phenolic content of four cultivars of purple skin eggplants. *Science Asian*, *39*,246-251.

Clary, C. D., Meza, M. E., Wang, S., and Petrucci, V. E. (2007). Improving grape quality using microwave vacuum drying associated with temperature control. *Journal of food science,72*(1),23-28.

Crizel, T. M., Rios, A. O., Thys, R. C. S., and Flores, S. H. (2015). Effects of orange by-product incorporation on the functional and technological properties of pasta. *Food Science Technology, campinas, 35*(3), 546-551.

Dalal, R. P. S., Thakur, N. A. and Singh, A. (2010). Nutritional value of Karonda *(Carissa carandas* Linn*).* A non- conventional fruit under semi- arid condition of Punjab. *Indian Journal of Agroforestry,12*(2),102-104.

Damiani, C., Silva, F. A. D., Lage, M. E., Pereira, D. E. P., Becker, F. S. et al. (2013). Stability of frozen marolo pulp during storage. *Food Science Technology Campinas*, *33*(4),713-721.

Dangcham, S., Bowen, J., Ferguson, I. B., and Ketsa, S. (2008). Effect of temperature and low oxygen on pericarp hardening of mangosteen fruit stored at low temperature. *Postharvest Biology and Technology 50*,37–44.

Darjazi, B. B. (2011). Morphological and pomological characteristics of fig (*Carissa spinarum*) cultivars from varamin, Iran. *African Journal of Biotechnology, 10* (82), 19096-19105.

Davey, M. W. V., Montagu, M., Inzé, D., Sanmartin, M., Kanellis, A. et al. (2000). Plant L-ascorbic acid: Chemistry, function, metabolism, bioavailability and effects of processing. *Journal of the Science of Food and Agriculture*, *80*(7), 825–860.

De- Ancos, B., Gonzáles, E. M., and Cano, M. P. (2000a). Ellagic acid, vitamin C and total phenol contents and radical scavenging capacity affected by freezing and frozen storage in raspberry fruit. *Journal Agriculture Food Chemistry*, 48,4565-4570.

Diaz, P. O., Hernansezl, J. J. I., Avevedol, E. A., Ambrizl, S. L. R., Pardo, M. E. S. et al. (2014). Chemical, starch digestibility and sensory characteristics of durum wheat/ unripe whole banana flour blends for spaghetti formulation. *Food and Nutrition Sciences, 5*, 264-270.

Din, K. (2008). Physico-chemical properties fruit Karonda *(Carissa carandas)* Dans fat works Pastilnya, (QK495K452008 FRB).

Donovan, J. L., Meyer, A. S., and Waterhouse, A. L. (1998). Phenolic composition and antioxidant activity of prunes and prune juice (*Prunus domestica*). *Journal of Agriculture and Food Chemistry*,*46*(4),1247-1252.

Duen, M., Alonso, J. J., Buelga, C. S., and Bailo, T. E. (2008). Anthocyanin composition in (*Carissa spinarum*). *Journal of Food Composition and Analysis, 21*, 107–115.

Dunas, W., Jin, S., Zhao, G., and Sun, P. (2015). Microwave-assisted extraction of anthocyanin from Chinese bayberry and its effects on anthocyanin stability. *Food Science Technology, Campinas, 35*(3),524-530.

El- Sharnouby, G. A., Aleid, M. S., and Otaibi, M. M. (2012). Nutritional quality of biscuit supplemented with wheat bran and date palm fruits (*Phoenix dactylifera* L.). *Food and Nutrition Sciences, 3*, 322-328.

Elhana, N. H. A. (2008). Microwave drying of apple. Misr. *Journal of Agriculture, 25*(3),980-1003.

Elizabeth, K. G., and Poojara, R. H. (2014). Organoleptic attributes of garden cress seed incorporated snacks suitable for adolescents. *International Journal of Food and Nutritional Sciences,3*(6),126-129.

Embaby, H. E. S. (2011). Effect of heat treatment on certain antinutrient and *vivo* protein digestibility of peanut and sesame seeds. *Food Science Technology Research, 17*(1),31-38.

Ertekin, C., Gozlekci, S., Heybeli, N., Gencer, A., Adak, N., and Sengul, B. (2014). Drying of strawberry with infrared dryer. *International Conference of Agriculture Engineering,* C0689,1-7.

Eze, J., and Akubor, P. (2012). Effect of drying methods and storage on the physicochemical properties of Okra. *Journal of Food Processing and Technology*,3,8,177.

Famurewa, J. A. V. and Olumofin, K. M. (2015). Drying kinetics and influence on the chemical characteristics of dehydrated okra (*Abelmoschuesculentus*) using cabinet dryer. *European Journal of Engineering and Technology,3*(2),7-19.

FAO. (2003). State of food insecurity in the world: Monitoring progress towards the World Food Summit and Millenium Development Goals. FAO, Rome.

FAO. (2014). State of food insecurity in the world 2003: Monitoring progress towards the World Food Summit and Millenium Development Goals. FAO, Rome.

Farsi, M. A., Alasalvar, C., Morris, A., Baron, M., and Shahidi, F. (2005). Comparison of antioxidant activity, anthocyanins, carotenoids and phenolics of three native fresh and sun dried

date(*Phoenix dactylifera L.*) varieties grown in Oman. *Journal of Agriculture and Food Chemistry,1*-9.

Fatima, A., Singh, P. P., Irchhaiya, and R., Agarwal, P. (2013). Effect of leaves of *Carissa spinarum* linn. on blood glucose and lipid profile in alloxan induced diabetic rats. *American Journal of Phytomedicine and Clinical Therapeutics,* 4,385-394.

Fedha, M. S., Mwasaru, M. A., Njoroge, C. K., Ojijo, N. O., and Ouma, G. O. (2010). Effect of drying on selected proximate composition of fresh and processed fruits and seeds of two pumpkin species. *Agriculture and Biology Journal of North America,1*(6),1299-1302.

Fennema (1976). Principles of food science. Food chemistry. New York: Marcel Dekker Inc.

Gajanana, T. M., Gowda, I. N. D., and Reddy, B. M. C. (2010). Exploring market potential and developing linkages– A case of underutilized fruit products in India. *Agricultural Economics Research Review,* 23, 437- 443.

Galoburda, R., Boca, S., Skrupskis, I., and Seglina, D. (2014). Physical and chemical parameters of strawberry puree. *Foodbalt,* 172-177.

Garcia, J. M., Infante, J. A., Guzman, N. E. R., Baca, P. R., Cadillo, M. G. C., and Laredo, R. F. G. (2013). Drying parameters of half-cut and ground figs (*Carissa spinarum L.)* var. Mission and the effect on their functional properties. *Journal of Engineering,*10830,1-8.

Garmakhany, A. D., Kashaninejad, M., Amiri, S. S., and Nikoo, M. A. R. (2013). Effect of moisture content on biophysical properties of pomegranate seeds. *Minerva Biotechnologica, 25* (1), 9-16.

Geeta, K., and Sharda, K. (2013). Nutritional evaluation of Giloe (*Tinospora cordifolia*) extract incorporated energy dense food product. *Indian Journal of Research Paripex, 2*(9),41-43.

Gezer, I., H. H., and Demir, F. (2002). Some physical properties of Hacihaliloglu apricot pit and kernel. *Journal of Food Engineering, 56,* 49–57.

Gilani, A. H., Mehmood, M. H., Janbaz, K. H., and Khan, A. U. (2008). Ethnopharmacological studies on antispasmodic and antiplatelet activities of *Ficus carica*. *Journal of Ethnopharmacology, 119*, 1-5.

Girija, k., Lakshman, K., Udaya , C., Sachi, G. S., Divya, T.(2011). Anti- diabetic and anti-cholesterolemic activity of methanol extracts of three species of *Amaranthus*. *Asian Journal of Tropical Biomedicine;2* (1), 133-138.

Giusti, M. M., and Wrolstad, R. E. (2001). Characterization and measurement of anthocyanins by UV-visible spectroscopy. Unit F1.2. In Current Protocols in Food Analytical Chemistry. New York*:* John Wiley and Sons, Inc.

Gorecka, D., Pacholek, B., Dziedzic, K., and Gorecka, M. (2010). Raspberry pomace as a potential fiber source for cookies enrichment. *ACTA, Scientarium Polonorium Technologia Alimenariat, 9*(4),451-462.

Guesmi, F., Ferchichi, A., Fares, K., and Touil, L. (2006). Identification and differentiation of *Carissa spinarum L.* cultivars using inter simple sequence repeat markers. *African Journal Biotechnology, 5*(15), 1370-1374.

Gupta, P., Bhatnagar, I., Kim, K. S., Verma, A. K., and Sharma, A. (2014). *In-vitro* cancer cell cytotoxicity and alpha amylase inhibition effect of seven tropical fruit residues. *Asian Pacific of Tropical Biomedicine*,*4*(2),S665-S671.

Gupta, S., and Prakash, J. (2011). Nutritional and sensory quality of micronutrient-rich traditional products incorporated with green leafy vegetables. *International Food Research Journal, 18,* 667-675 .

Guvenc, M., Tuzcu, M., and Yilmaz, O. (2009). Analysis of fatty acid and some lipophilic vitamins found in fruits of the *Carissa spinarum* variety picked from the Adiyaman district. *Research Journal of Biological Sciences*,*4* (3),320-323.

Hakkinen, S. H., and Torronen, A. R. (2000). Content of flavonols and selected phenolic acids in strawberries and *Vaccinium* species: influence of cultivar, cultivation site and technique. *Food Research International Journal,33*, 517–24.

Hakkinen, S., Heinonen, M., Karewlampi, S., Mykkanen, H., and Torronen, A. R. (2000). Influence of domestic processing and storage on flavonols contents in berries. *Journal of Agriculture Food Chemistry, 48* (7), 2960-2965.

Hanwate, B. D., Kadam, R. M., and Yadav, D. N. (2005). Utilization of Karonda (*Carissa caranda*) juice in the manufacture of flavoured milk. *Department of Animal Husbandry and Dairy Science,*21-22.

Harborne, J. B. (1973). Phytochemical methods. *Chapman and Hall Ltd. London,* 11-113.

Hardi, Z. U., Zukic, M., Komlenic, D. K., Sabo, M., and Hardi, J. (2007). Quality parameters of noodles made with various supplements. *Czech Journal of Food Science,25*(3),151-157.

Hassan, S.W., Umar, R.A., Maihanu, H. M., Matazu, I. K., Faruk, U.Z., and Sani, A.A. (2007). The effect of drying methods on the nutrients and non- nutrients composition of leaves of *Gynandropsis gynandra* (*Capparaceae*). *Asian Journal of Biochemistry,*2, 349-353.

Hayat, K., Zhang, X., Farooq, U., Abbas, S., Xia, S., Jia, C. et al. (2016). Effect of microwave treatment on phenolic content and antioxidant activity of citrus mandarin pomace. *Food chemistry, 123,*423-429.

Hazbavi, E., Khoshtaghaza, M. H., Mostaan, A., and Banakar, A. (2014). Effect of storage duration on some physical properties of date palm (cv. Stamaran). *Journal of the Saudi Society of Agricultural Sciences, XXX,* XXX-XXX.

Hedge, J. E., and Hofreiter, B. T. (1962). In carbohydrate chemistry its stability in model systems. New York Academic Press. *Journal of Food Science and Technology, 30* (4), 246-8.

Heshe, G. G., Haki, G. D. and Woldegiorgis, A. Z. (2015). Effect of refined milling on the nutritional value and antioxidant capacity of wheat types common in Ethiopia and a recovery attempt with bran supplementation in bread. *Journal Food Process Technology,6*,11.

Ho, L. H., and Dahari, N. C. (2016). Effect of watermelon rind powder on physicochemical, texture and sensory properties of wet noodles. CyTA-*Journal of Food*, 14(3),465-472.

Ho, L. H., Latif, N. W. B. A. (2016). Nutritional composition, physical properties, and sensory evaluation of cookies prepared from wheat flour and pitaya (*Hylocereus undatus*) peel flour blends. *Cogent Food and Agriculture*, 2, 1-10.

Holland, N., Menezes, H. C., and Lafuente, M. T. (2002). Carbohydrate as related to the heating induced chilling tolerance and respiratory rate of 'Fortune' mandarin fruit harvested at different maturity stages. *Postharvest Biological Technology, 25*, 181–191.

Hosseinaei, O., Wang, S., Enayati, A. A., and Rials, T. G. (2012). Effects of hemicellulose extraction on properties of wood flour- plastic composites. *Composite Part A , 43*,686-694.

Hui, Y. H., Puil, C., Isabel, G. L., Miang, H. L., Murrell, K. D. et al. (2004). Hand book of frozen foods. *Marcel Dekker Incorporated*, 74 – 75.

Hultman, L., and Rustard, T. (2004). Iced storage of Atlantic salmon (*Salmo salar*) effects on endogenous enzymes and their impact on muscle proteins and texture. *Food Chemistry, 87*,31–34.

Hussain, I., Amjad, S. A. M., and Ahmeed, R. (2015).Effect of modified sun drying techniques on fruit quality characters of dates harvested at rutab stage. *Journal of Agriculture Research,52*(3),415-423.

Ibitoye, W. O., Afolabi, M. O., Otegbayo, B. O., and Akintola, A. C. (2013). Preliminary studies of the chemical composition and sensory properties of sweet potato starch- flour blend noodles. *Official Journal of Nigerian Institute of Food Science and Technology,31*(2),48-51.

Ibrahim, K. M., Shawi, N. A., and Juboury, A. A. (2014). A Study on the Hypoglycemic effect of *Carissa spinarum* L. leaves aqueous extract against alloxan-induced diabetes in rabbits. *Medical Journal of Babylon, 6*,1-3.

Incedayi, B., Tamer, C. E., Sinir, G. O., Suna, S., and Copur, O. U. (2016). Impact of different drying parameters on colour, beta carotene, antioxidant activity and minerals of apricot *(Prunus armeniaca L.).Food Science and Technology, 36*(1), 171-178.

Intankar, P. R., Lokhande, S. J., Verma, P. R., and Arora, S. K. (2011). Antidiabetic potential of unripe *Carissa carandas* linn. fruit extract. *Journal of Ethanopharmacology, 135*,430-433.

Ioannou, I., Hafsam, I., Hamdi, S., Charbonnel, C., and Ghoul, M. (2012). Review of the effects of food processing and formulation on flavonoid and anthocyanin behavior. *Journal of Food and Engineering,111*, 208-217.

Irondi, A. E., Anokam, K. K., and Ndidi, U. S. (2013). Effect of drying methods on the phytochemicals composition and antioxidant activities of *Carica papayas* seed. *International Journal of Biosciences,3*(11),154-163.

Islam, M. S. (2011). Effects of the aqueous extract of white tea (*Camellia sinensis*) in a streptozotocin- induced diabetic model rats. *Phytomedicine*, 19, 25- 31.

Itankar, P. R., Lokhande, S. J., Verma, P. R., Arora, S. K., and Patil, A. T. (2011). Antidiabetic potential of unripe *Carissa carandas* Linn. fruit extract. *Journal of Ethanopharmacology,17*, 135(2),430-433.

Jahromi, G., Shahdadi, A., and Nasabpour, R. (2014). Composition of phenolic- compounds antioxidant activity and microbial quality of two varieties of fresh and frozen date-palm fruit during eight months storage in freezer. *International Journal of Farming and Allied Sciences, 3* (9),1025-1030.

Jan, I., and Rab, A. (2012). Influence of storage duration on physico-chemical changes in fruit of apple cultivars. *The Journal of Animal and Plant Science,22*(3),708-714.

Jauharah, M. Z., Rosli, W. I., and Robert, D. S. (2014). Physicochemical and sensorial evaluation of biscuit and muffin incorporated with young corn powder. *Sains Malaysian, 43*(1), 45-52.

Jayakumar, S. P., Seni, M., Jagadeesan, M., and Sundararajan, R. (2014). Antidiabetic and antioxidant effects of ethanolic extract of Anjir leaves *(Ficus carica)* in alloxan induced diabetic rat. *Asian Journal of Phytomedicine and Clinical Research, 2*(1), 1 - 10.

Jeong, S. M., Kim, S. Y., Kim, D. R., Jo, S. C., Nam, K. C. et al. (2004). Effect of heat treatment on the antioxidant activity of extracts from citrus peels. *Journal of Agriculture and Food Chemistry,52*,11, 3389-3393.

Jha, S. N., Kingsly, A. R. P., and Chopra, S. (2006). Physical and mechanical properties of mango during growth and storage for determination of maturity. *Journal of Food Engineering, 72*,73-76.

Jin, P., Wang, S. Y., Wang, C. Y., and Zheng, Y. (2011). Effect of cultural system and storage temperature on antioxidant capacity and phenolic compounds in strawberries. *Food Chemistry, 124*,262-270.

Johnson, J. T., Iwang, E. U., Hemen, J. T., Odey, M. O., Efiong, E. E., and Eteng, O. E. (2012). Evaluation of anti-nutrient of watermelon *Citrullus lanatus*. *Annals of Biological Research,3*(11),5145-5150.

Joseph, B., and Raj, S. J. (2011). Pharmacognostic and phytochemical properties of *Carissa spinarum* Linn- An overview. *International Journal of Pharm Tech Research, 3* (1),8-12.

Juan, J. M. G., Alberto, G. I., Nuria, E. R. G., Patricia, R. B., Maria, G. C. C. et al. (2013). Drying parameters of half-cut and ground figs *(Ficus carica)* var. Mission and the effect on their functional properties. *Journal of Engineering*, 1-8,710830.

Juhaimi, F. A., Uslu, N., Bozkurt, D., Ghafoor, K., Babiker, E. E. et al. (2015). Effects of oven and microwave drying on phenolic contents and antioxidant activities in four apple cultivars. *Quality Assurance and Safety of Crops and Foods, Article in Press*, 1757-837X.

Jung, S. T., Park, S. Y., Zachwieja, M. F., Barton, H., Piotrowicz, E. K. et al. (2005). Some essential phytochemical and the antioxidant potential in fresh and dried persimmon. *International Journal of Food Science and Nutrition, 65*(2),105-113.

Kadam, M. L., Salve, R. V., Mehrajfatema, Z. M., and More, S. G. (2012). Development and evaluation of composite flour for missi roti /chapatti. *Journal Food Processing Technology, 3*,134,2-7.

Kamiloglu, S., and Capanoglu, E. (2015). Polyphenol content in Figs (*Carissa spinarum* L.). Effect of sun drying. *International Journal of Food Properties, 18*,521–535.

Kamiloglu, S. (2012). Effect of sun- drying on polyphenols and in vitro bioavailability of Sarilop and Bursa Siyahi figs *(Carissa spinarum L.).* Istanbul Technical University. *Graduate School of Science Engineering and Technology,* 1-140.

Kamiloglu, S., Serali, O., Unal, N., and Capanoglu, E. (2013). Antioxidant activity and polyphenol composition of black mulberry *(Morus nigra L.)* products. *Journal of Berry Research,3*,41-51.

Kanuur, C., and Khandelwal, K. (2014). Pharmacognostical investigation and evaluation of *Carissa spinarum* fruit extract for adaptogenic activity. *International Journal of Pharmaceutical Sciences and Research,* 5 (5), 2022-2032.

Kar, D. M., Maharana, L., Pattnaik, S., and Dash, G. K. (2006). Studies on hypoglycemic activity of *Solanum xanthocarpum* Schrad. And wendl. fruit extract in rats. *Journal of Ethnopharmacology ,108*, 251 - 56.

Kashaninejad, M., Mortazavi, A., Safekori, A., and Tabil, L. G. (2006). Some physical properties of pistachio *(Pistacia vera L.)* nut and its kernel. *Journal Food Engineering*,72,30-38.

Kaur, A., and Kochhar, A. (2014).Sensory and nutritional evaluation of value added products using potato flour for nutritional and health benefits. *International Journal of Medical Sciences, 7*(1),1-6.

Kawka, A., Gorecka, D., and Gasiorowski, H. (1999). The effects of commercial barley flakes on dough characteristic and bread composition. *Food Science and Technology,2*(2).

Khan, M. N., Sarwar, A., Adeel, M., and Wahab, M. F. (2011). Nutritional evaluation of *Carissa spinarum* indigenous to Pakistan. *African Journal of Food Agriculture, Nutrition and Development, 11*(5),1684-5374.

Khan, M. N., Sarwar, A., Adeel, M., and Wahab, M. F. (2011). Nutritional evaluation of *Carissa spinarum* on the contents of sugars,organic acid and phenolic compounds. *Journal of Agriculture and Food Chemistry, 59,*11696 -11702.

Khan, A., and Vincet, J. F. V. (1996). Mechanical damage induced by controlled freezing in apple and potato. *Journal Texture Studies*, 27,143-153.

Khanal, R. C., Howard, L. R., and Prior, R. L. (2010). Effect of heating on the stability of grape and blueberry pomace procyanidins and total anthocyanins. *Food Research International,43,*1464-1469.

Khapre, A. P., Satwadhar, P. N., and Deshpande, H. W. (2015). Studies on standardization of fig fruits (*Ficus carica*) powder enriched cookies and its composition. *Asian Journal of Dairy and Food Research,4*, 71-74.

Khapre, A. P., and Satwadhar, P. N. (2010). Physico-chemical characteristics of fig fruits (*Ficus carica)* cv Dinkar and its cabinet dried powder. *Food Science Resources Journal,2*(1),23-25.

Kojic, A. B., Planinic, M., Tomas, S., Jokic, S., Bilic, M., and Velic, D. (2011). Effect of extraction condition on the extractability of phenolic compounds from lypophilised fig fruits (*Ficus carica). Polish Journal of Nutritional Science,61*(3),195-199.

Komolka, P., Gorecka, D., and Dziedzic, K. (2012).The effect of thermal processing of cruciferous vegetables on their content of dietary fiber and its fractions. *Acta Scientarium Polonorum Technologia Alimentaria,11*(4),347-354.

Krishan, P. G., Chang, K. C., and Brown, G. (1987). Effect of commercial oat bran on the composition of bread. *Cereal Chemistry,64*(1),55-58.

Krishanprabha, V., and Kiruthiga, V.(2015). Development and analysis of nutrients, antioxidants in sweet potato and pumpkin powder incorporated value added products. *International Journal of Advanced Research in Biological Sciences, 2*(4),65-71.

Kshetrimayum, R., Shukla, R. N., and Mishra, A. (2015). Study on drying and quality characteristics of tray and microwave dried guava slices. *International Journal of Science, Engineering and Technology, 3*(4),965-969.

Kulkarni, A.S., and Joshi, D.C.(2013). Effect of replacement of wheat flour with pumpkin powder on textural and sensory qualities of biscuit. *International Food Research Journal, 20*(2), 587-591.

Kulkarni, S. S., Deasai, A. D., Ranveer, R. C., and Sahoo, A. K. (2012). Development of nutrient rich noodles by supplementation with malted ragi flour. *International Food Research Journal,19(1*),309-313.

Kumar, S., Kumar, V., Parkash, M. (2012). Antidiabetic and hypolipidemic activities of kigelia pinnata flowers extract in a streptozotocin induces diabetic rats. *Asian Journal of Tropical Biomedicine;2* (7), 543-546.

Kumari, V. P., and Sangeeta, N. (2014). Process development and evaluation of quality characteristics of multilegume pasta. *Asian Journal Dairy and Food Research*, 33 (3) ,190-196.

Kwok, B. H. L., Durance, H. C., and Kitts, D. D. (2004). Dehydration techniques affects phytochemical contents and free radical scavenging activities of Saskatoon berries *(Amelanachier alnifolia Nutt.). Journal of Food Science,69*(3),122-126.

Laleh, G. H., Frydoonfar, H., Heidary, R., Jameei, R., and Zare, S. (2006). The effect of light, temperature, pH and species on stability of anthocyanin pigments in four *Berberis* Species. *Pakistan Journal of Nutrition, 5*(1), 90-92.

Lee, S. C., Kim, J. H., Jeong, S. M., Kim, D. R., Ha, J. U. et al. (2003). Effect of far- infrared radiation on the antioxidant activity of rice hulls. *Journal Agriculture Food Chemistry, 51,* 4400-4403.

Legesse, M. B., and Emire, S. A. (2012). Functional and physicochemical properties of mango seed kernels and wheat flour and their blends for biscuit production. *African Journal of Food Science and Technology*,3(9),193-203.

Leong, S. Y., and Oey, I. (2012). Effect of processing on anthocyanins, carotenoids and vitamin C in summer fruits and vegetable. *Food Chemistry,133,*1577-1587.

Lisa, A., and Felicetti, L. (2002). Fiber digestibility and nitrogen requirements of Blue Duikers. *Journal of Zoology Biology, 21*,123-134.

Lisa, L. P. (1997). Wild plant food in agricultural environment: A study of occurrence, management and gathering rights in North East Thailand. *Human Organization, 56,* 209-221.

Liu, S. C., and Tsai, C. W. (2012). Effect of heating time on the antioxidative capacities of citrus fruit *(Citrus sinesis)* by products. *Food Science Technology Resources,18*(4),505-513.

Lohchoompol, V., Srzednicki, G., and Craske, J. (2004). The change of total anthocyanin in blueberries and their antioxidant effect after drying and freezing. *Journal of Biomedicine and Biotechnology,5,*248-252.

Lopez, J., Galvez, A. V., Torres, M. J., Mondaca, L. R., Quispe, I. F., and Scala, K. D. (2013).Effect of dehydration temperature on physico-chemical properties and antioxidant capacity of goldenberry (*Physalis peruviana* L.). *Chilean Journal of Agricultural Research,73*,1-3.

Lopez, M. R. R., Diaz, P. O., Perez, L. A. B., Tovar, J., and Nicanor, A. B. (2011). Fiber concentrates from orange (*Citrus sinesis* L.) Bagase: Characteristics and application as backery product ingredients. *International Journal of Molecular Science*, 12, 2174-2186.

Lutz, M., Hernandez, J., and Henriquez, C. (2015). Phenolic content and antioxidant capacity in fresh and dry fruits and vegetables grown in Chile. *CyTA Journal of Food*, *13*(4), 541-547.

Macias, M. A., Martinez, A, C., Mounir, S., Gaitan, G. M., and Allaf, K. (2013). Comparative study of the effects of drying methods on antioxidant activity of dried strawberry (*Fragaria* Var. *Camarosa*). *Journal of Food Research*, *2*(2),92-107.

Mahapatra, A. K., Mishra, S., Basak, U. C., and Panda, P. C. (2012). Nutrient analysis of some selected wild fruits deciduous forests of India: an explorative study towards non conventional bio-nutrition. *Advance Journal of Food Science and Technology 4*(1),15-21.

Mahmoud, M. H., Qura, A. Z. E., Badawy, I. H., Yehya, A., Hady, A. et al. (2013). Hypocholesterolemic effect of antioxidant containing fruits in rats fed on high cholesterol and fat diet. *Journal of Applied Sciences Research, 9* (7), 4233-4244.

Malomo, S. A., Eleyinmi, A. F., and Fashakin, J. B. (2011). Chemical composition, rheological properties and bread making potentials of composite flours from breadfruit, breadnut and wheat. *African Journal of Food Science, 5*(7), 400 – 410.

Manach, C., Scalbert, A., Moorand, C., Remesy, C., and Jimenez, L. (2004). Polyphenols: food sources and bioavailability. *American Journal Clinical Nutrition,79,*727-747.

Mansour, E. H., Dworschak, E., Pollhamer, Z., Gergely, A., Matazu, I. K. et al. (1999). The effect of drying method on the nutrients and non-nutrients composition of the front of *Hibiscus esculentus*(Okra). *Nigeria Journal Renewable Energy, 11,* 9-13.

Mansour, E. H., Dworschak, E., Pollhamer, Z., Gergely, A., and Hovari, J. (1999). Pumpkin and canola seed proteins and bread quality. *Acta Alimentaria*,28,59-70.

Matazu, I.K. and Haroun, A. A. (2004). The effect of drying method on the nutrients and non-nutrients composition of the fruits of *Hibiscus esculentus* (Okra). *Nigerian Journal Renewable Energy*, 11, 9-13.

Matsuo, T., and Itoo, S. (1978). The chemical structure of kaki - Tannin from immature fruit of the persimmon *(Diospyros kaki L.). Agricultural Biological Chemistry, 42,*1637 - 1643.

Mc Clement, D. J. (2003). Analysis of Food Products. Accessed July 26,2012. http:// people.u.mass.edu/-mcclemen/581Ash$Minerals.html.

Mc Donald, J. k., Caflin, N. A., Sommano. S., and Cocksedge, R. (2006). The Effect of post analysis of food Products. Accessed July26,2012.http://people.umass.edu/mcclemen/581Ash and minerals.html.

Mechlouch, R. F., Elaskesh, E. O., Elfalleh, H. H. W., and Thabet, A. A. G. (2015). Changes in the physico-chemical properties of palm date using different drying methods. *University, Bulletin,17*(1),59-78.

Meda, V., Gupta, M., and Opoku, A. (2008). Drying kinetics and quality characteristics of microwave–vacuum dried Saskatoon berries. *Journal of Microwave Power and Electromagnetic energy, 42*(4),42-44.

Mehraj, H., Sikder, R. K., Haider, M. N., Hussain, M.S., and Uddin, A. F. M. J. (2013). Fig (*Ficus carica*). A new crop in Bangladesh. *International Journal of Buisness, Social and Scientific Research, 1*(1),2309-7892.

Mehta, S. (1995). *Evaluation of different cultivars of Anola (Emblica officinalis Garten) for processing* . MSc. Thesis.CCS HAU, Hisar.

Mhalaskar, S. R., Lande, S. B., Satwadhar, P. N., Deshpande, H. W., and Babar, K. P. (2012). Development of technology for fortification of fig (*Ficus carica*) fruit into its value added product- fig toffee. *International Journal of Processing and Post Harvest Technology,3* (121),176-179.

Michael, O. A., Gernah, D. I., and Igbabul, D. (2013). Physico-chemical and sensory evaluation of wheat bread supplemented with stabilized undefatted rice bran. *Food and Nutrition Sciences*, 4, 43-48 .

Mihajer, S., Taha, R. M., and Mohajer, M. (2016). Effects of cryopreservation and relative humidity on viability and nutritional composition of sainfoin (*Onobrychis vicifolia scop*.). *Journal of Animal and Plant Science, 26* (2),116-122.

Miletic, N., Popovic, B., Mitrovic, O., Kandic, M., and Leposavic, A. (2014). Phenolic compounds and antioxidant capacity commonly consumed in Serbia. Czech. *Journal of Food Science,32* (4),360-368.

Ministry of Health and Family Welfare. (2008). Department of Ayurveda yoga and neuropathy, Unani siddha homoeopathy, *New Delhi, First edition (AYUSH),VI* (1),340.

Mishra, G., Mishra, A. A., and Shukla, R. N. (2014). Development of pulse, banana and pineapple pomace based weaning food and its quality evaluation during storage. *International Journal of Development Research,* 4 (6),1257-1262.

Mishra, D. K., Dolan, K. D., and Yang, L. (2008). Confidence intervals for modeling anthocyanin retention in grape pomace during non isothermal heating. *Journal of Food Science, 73,* E9–E15.

Mishra, R. M., and Gupta, P. (2005). Frugivory and seed dispersal of *Carissa spinarum (* L.*)* in a tropical deciduous forest of central India. *International Society for Tropical Ecology*,46(2),151-156.

Mithanka, D. M. T. (2012). Polyphenol content and antioxidant analysis of *Pseudolachinostylis Maprouneifolia Pax* Var Dikindtii used as livestock feed farmers from Eastern Botswana. *Journal of Pharmaceutical and Scientific Innovation,1*(5),51-57.

Mohammadian, M. A., Mobrami, Z., and Sajedi, R. H. (2011). Bioactive compounds and antioxidant capacities in the flavedo tissue of two citrus cultivars under low temperature. *Brazilian Society of plant physiology, 23*(3), 203-208.

Mohsenin, N. N. (1986). Physical Properties of Plant and Animal Materials, New York: Gordon and Breach Science Publishers.

Mohsenin, N. N. (1970). Physical Properties of Plant and Animal Materials. Gordon and Breach Science Publishers, New York, USA.

Moldovan, B., and David, L. (2014). Studied the temperature and preserving agents on the stability of cornelian cherries anthocyanins. *Molecules, 19*, 8177-8188.

Monica, A., Madeau, E., Piscopo, A. E., Sanguinetti, E., Caro, A. D., Poiana, M. E., Romeo, V. et al. (2009). *European Food Resources, 228*,441-448.

Mori, K., Yamamoto, N. G., Kitayama, M., and Hashizume, K. (2007). Loss of anthocyanins in red- wine grape under high temperature. *Journal of Experimental Botany, 58*(8),1935–1945.

Morris, A., Barnett, A., and Burrows, O. (2004). Effect of processing on nutrient content of foods. *Cajarticles, 37*,160-164.

Morton, J. (1987). Fruits of warm climates. (Book. Fl. Ig. Miami, 2005), 47-50.

Morton, J. F. (1987). Fruits of warm climates. Creative Resources Systems, *Inc. Winterville*, N.C.,USA,503.

Mrabet, A., Gutierrez, G. R., Bejarano, R. G., Arcos, R. R., Ferchichi, A., Sindic, M., and Araujo, A. J. (2015). Valorization of Tunisian secondary date varieties (*Phoenix dactylifera L*.) by hydrothermal treatments: New fiber concentrates with antioxidant properties. *LWT-Food Science and Technology, 60*,518-524.

Mule, P. R., Barbind, R. P., Korake, R. L., and Gavit, D. P. (2014). Proximate composition, sensory evaluation and production cost of fig milk shake prepared from buffalo milk. *Animal Science, 8*(2),43-47.

Mullen, W., Stewart, A. J., Michael, E., Jean, J., Gardner, P., Garry, G. D. et al. (2002). Effect of freezing and storage on the phenolic, ellagitannins, flavonoids and antioxidant capacity of red raspberries. *Journal of Agriculture and Food Chemistry, 50*,5197-5201.

Musa, A. (2013). Effect of freezing on some plant toxins and micronutrients in the leaves of *Amaranthus Cruenthus*. *Journal of Food Studies,2*(1),75-92.

Musa, K. H., Abdullah, A., Jusoh, K., and Subramaniam, V. (2011) Antioxidant activity of pink-flesh guava (*Psidium guajava* L.): effect of extraction techniques and solvents. *Food Analytical Method, 4*, 100–7.

Mutso, M., and Satrino, M. L. (2010). Fruit responses to postharvest heat treatment time: characterization of heat-treated strawberry (*Fragaria x ananassa*) cv. 'Candonga' fruits. *Agronomy Research 8*, (1), 815–826.

Nackilcioglu, E., and Hisil, Y. (2013). Research on the phenolic compounds in Sarilop (*Carissa spinarum* L.) fig variety. *GIDA, 38*(5), 267-274.

Nakamura (2008). Preliminary studies on the removal of astringency by freezing in Japnese persimmons. *Journal of the Japnese Society for Horticultural Science, 30*(1),73-76.

Nandan, U., and Bhardwaj, R. (2014). The role of underutilized fruits in nutritional and economic security of tribals: a review. *Critical Reviews in Food Science and Nutrition*,54 (7),880-890.

National Sample Survey Office. (2012). Ministry and Statistics and Programme Implementation, New Delhi Government of India.

Neal, M. C. (1965). In Gardens of Hawaii, University of Hawaii and Bishop Museum, Honolulu, Hawaii, USA, 40.

Nermin, B. (2008). Utilization of buckwheat flour in gluten-free noodles production. *Journal of Food, Agriculture environment, 62* (20),113-115.

Ngueguim, T. F., Dimo, T., Dzeufiet, D. P. D., Vouffo, B., Dongo, E., Renaud, B. et al. (2007). Antidiabetic activities of methanol-derived extract of *Dorstenia picta* twigs in normal and streptozotocin-induced diabetic rats. *Asian Journal of Traditional Medicines,2* (4), 140 - 148.

Nicoli, M. C., Anese, M., and Parpinel, M. (1999). Influence on processing on the antioxidant properties of fruits and vegetables. *Trends in Food Science and Technology,10*, 94-100.

Nieman, D. C., Butterworth, D. E., and Nieman, C. N. (1992) Nutrition. *WmC. Brown Publishers*, Dubugye, 237-312.

Nilsson, J. S., Stegmark, R., and Akesson, B. (2004). Total antioxidant capacity in different pea *(Pistum sativum)* varieties after blanching and freezing. *Food Chemistry,86,*501-507.

Nimkar, P. M., and Chattopadhyay, P. K. (2001). Some physical properties of green gram. *Journal of Agricultural Engineering Resources*, *80* (2), 183-189.

Nithiyanantham, S., Varadharajan, S., and Siddhuraju, P. (2012). Differential effects of processing methods on the total phenolic content, antioxidant and antimicrobial activities of three species of Solanum. *Journal of Food and Drug Analysis,20*(4),844-854.

Njiida, A. A. (2010). Chemical composition, fiber fraction and anti-nutritional substances of semi arid browse forages of North- Eastern Nigeria. *Nigerian Journal of Basic and Applied Science, 18* (2),181-188.

Noonan, S. C., and Savage, G. P. (1999).Oxalate content of foods and its effect on humans. *Asia Pacific Journal Clinical Nutrition,8,*64-74.

Nordin, N. I. A. A., Ariffin, H., Andou, Y., Hassan, M. A., Shirai, Y., Nishida, H. et al. (2013). Modification of oil palm mesocarp fiber characteristics using superheated steam treatment. *Molecules, 18*, 9132-9146.

Noutchogoue, V. K., Kapseu, C., Tchiegang, C., Piffaut, B., and Parmentier, M. (2005).Textural and Biochemical changes associated with the hardening phenomenon in aiele fruit (*Canarium Schweinfurthi Eng). Journal of Food Technology,3*(2),143-148.

Nwanekezi, E. C., and Agbugba, R. U. (2015). Effect of substitution of sucrose with date palm (*Phoenix dactylifera*) fruit on quality bread. *Food Processing and Technology,6*(9),484.

Nwaogwe, J. O., and Adejumo, B. A. (2015). Qualities of African breadfruit (*Treculia Africana*) seed flour influenced by thermal processing methods and duration. *International Journal of Technology Enhancement and Emerging Engineering Research, 3*(4),102-104.

Oancea, S., Moiseenco, F., and Traldi, O. P. (2014). Effects of freezing and oven drying of Romanian wild and cultivated red raspberries on total anthocyanins and total antioxidant capacity. *Romanian Biotechnological Letters, 19*(2), 9241-9247.

Obiegbuna, J. E., Akubor, P. I., Ishiwu, C. N., and Ndife, J. (2013). Effect of substituting sugar with date palm pulp meal on the physicochemical, organoleptic and storage properties of bread. *African Journal of Food Science*,7(6),113-119.

Oboh, G., Ademosun, A. O., Olasehinde, T. A., Oyeleye, S. I., and Ehiakhamen, E. O. (2015). Effect of processing methods on the antioxidant properties and inhibition of alpha amylase and alpha glucosidase by African pear (*Dacryodes edulis*) fruit. *Nutra foods*, *14*, 19-26.

Ogbadoyi, E. O., and Musa, A. (2013). Effect of freezing on some plant toxins and micronutrients in the leaves of *Amaranthus cruentus. Journal of Food Science,2* (1),75-92.

Ogunbanwo, S. T., Azinat, S., Olufunke, A., and Fadahunsi, I. F. (2013). Microbiological and nutritional evaluation of water melon juice (*Citrullus lanatus*). *Academia Arena,5*(3),36-41.

Ojinnaka, M. C., Anyanwu, F. A., and Ihemeje, A. (2013). Nutritional evaluation of cookies produced from African breadfruit (*Treculia africana)* starch and wheat flour. *International Journal of Agricultural and Food Science*, 3(3), 95-99.

Olajire, A. A., and Azeez, L. (2011). Total antioxidant activity, phenolic, flavonoid and ascorbic acid contents of Nigerian vegetables. *African Journal of Food Science and Technology, 2*(2), 022-029.

Omer, U. C., and Canan, E. T. (2014). Fruit processing. Strategies for quality assessment. *Food Engineering Series*, DOI 10.1007/978-1-4939-1378-7-2.

Oyaizu, M. (1986). Studies on products of browning reaction: antioxidative activities of products of browning reaction prepared from glucosamine. *Jap*nese *Journal ofNutrition,44*, 307-315.

Ozcan, M., Arslan, D., and Unver, A. (2004). Effect of drying methods on the mineral content of basil (*Ocimum basilicum L.*). *Journal of Food Engineering, 69,* 375-379.

Oztekin, S., Erdem, T., and Karaaslan, S. (2011). Effect of hot air and microwave drying on some physical properties of laurel berry. *African Journal of Agricultural Research*, 6(12), 2676-2679.

Pacco, H. C., and Menegalli, F. (2004). Drying of sliced figs of 'Gigante de Valinhos' variety (*Carissa spinarum*). In Silva, M. A. and Rocha, S.C.S. (eds.) *Drying. Proceeding of the 14 th International Drying Symposium*, Sao Paulo, Brazil, 1851- 1858.

Pacco, H. C., Vigneault, C., Castro, L. R., Menegalli, F. C., and Cortez, L. A. B. (2007). Temperature effect on drying kinetics of 'Gigante de Valinhos' figs. *Journal of Food and Environment, 5*(2),70-75.

Padulosi, S., Hoeschle- Zeledon, I., and Bordoni, P. (2008). Minor crops and underutilized species: lessons and prospects In: N. Maxted, B.V. Ford-Lloyd, S.P. Kell, J.M. Iriondo, M.E. Dulloo, J. Turok eds. *Crop wild relatives, conservation and use.* Wallingford, UK: CAB International.

Pandey, A. K., Ojhav, V., Yadav, S., and Sandhu, S. K. (2011). Phytochemical evaluation and radical scavenging activity of *Bauhinia variegate, Saraca asoka* and *Terminalia arjuna* barks. *Resource Journal Phytochemistry,2*,89-97.

Pandey, A. K., Dubey, A. K., Singh, R. K., and Vida, E. (2014). Addressing the problem of micronutrient malnutrition in Neh region- underutilized vegetables as a source of food. *International Journal of Food and Nutritional Science, 3*(3),75-83.

Papu, S., Singh, A., Javir, S., Sweta, S., Arya, A. M., and Singh, B. R. (2014). Effect of drying characteristics of garlic – a review. *Journal Food Process Technology,5*(4),1-6.

Pardeshi, I. L., Bhuskade, S. A., and Kalmegh, V. B. (2013). Development of cold extruded ready to cook (*Vigna radiate L.)* nuggets. *Journal of Food Research and Technology,1*(1),21-28.

Parmar, C., and Kaushal, M. K. (1982). *In: Wild Fruits.* Kalyani Publishers, New Delhi, India,15-18.

Patel, D. K., Kumar, R., Prasad, S. K., Sairam, K., and Hemalatha, S. (2011). Antidiabetic and *in vitro* antioxidant potential of *Hybanthus enneaspermus* (Linn) F. Muell in streptozotocin-induced diabetic rats. *Asian Pacific Journal of Tropical Biomedicine*,1,316-22.

Pathak, P. K., Preeti, D., and Kumar, S. (2009). Effect of post-harvest treatments on shelf-life of aonla (*Emblica officinalis*) fruits damaged during harvesting. *Journal of Food Science Technology, 46*, 283–285.

Patras, A., Brunton, N. P., Donnell, C. O., and Tiwari, B. K. (2010). Effects of thermal processing on anthocyanin stability in foods; mechanisms and kinetics of degradation. *Trends in Food Science and Technology 21*,3-11 .

Perez, C., Dominquez, E., Canal, J. R., Campillo, J. E., and Tarres, M. D. (2000). Hypoglycemic activity of aqueous extract from *Carissa spinarum* fig tree leaves in streptozotocin diabetic rats. *Pharm Biology*,38(3),181-186.

Pewlong, W., Sajjabut, S., Eamsiri, J., and Chookaew, S. (2014). Evaluation of antioxidant activities, anthocyanins, total phenolic content, vitamin C content and cytotoxicity of *Carissa carandas* Linn. *Food and Applied Biosciences,13*(1),509-517.

Piga, A., Del, C. A., and Corda, G. (2003). From plums to prunes: Influence of drying parameters on polyphenols and antioxidant activity. *Journal of Agriculture and Food Chemistry, 51*,3675-3681.

Pimia, R. P., Hakkinen, S. T., Aarni, M., Suortti, T., Lampi, A. M., Eurola, M. et al. (2003). Blanching and long term freezing affect various bioactive compounds of vegetables in different ways. *Journal Science Food Agriculture,83*,1389-1402.

Pinki and Awasthi, P. (2014). Sensory and nutritional evaluation of value added cakes formulated by incorporating beetroot powder. *International Journal of Food and Nutrition Science,3*(6),145-148.

Planinic, M., Aliakbarian, B., Perego, P., Greganic, K., Tomas, S., and Kojic, A. B. (2015). Influence of temperature and drying time on extraction yield of phenolic compounds from grape pomace variety "Portogizac". *Chemical and Biochemical Engineering Quarterly,29*(3),343-350.

Poiana, M. E., Moigradean, D., and Alexa, E. (2010). Influence of home- scale freezing and storage on antioxidant properties and colour quality of different garden fruits. *Bulgarian Journal of Agriculture Science, 16* (2),163-171.

Pradhan, R. C., Naik, S. N., Bhatnagar, N., and Vijay, V. K. (2009). Moisture dependent physical properties of jatropa fruit. *Industrial Crops and Products, 29,* 341-347.

Pragati, D., and Dhawan, S. S. (2003). Effect of drying methods on nutrition composition of dehydrated aonla fruit (*Emblica officinalis Garten*) during storage. *Plant Foods for Human Nutrition, 58,* 1–9.

Pragati, S., Dahiya, S., and Dhawan, S. S. (2003). Effect of drying methods on nutritional composition of dehydrated anola fruit (*Emblica officinalis Garten*) during storage. *Plant Foods for Human Nutrition, 58*,1-9.

Prakash, D., Upadhyay, G., and Pushpangadna, P. (2011). Antioxidant potential of some under-utilized fruits. *Indo-Global Journal of Pharmaceutical Sciences, 1*(1), 25-32.

Pratyush, K., Masih, D., and Sonkar, C. (2015). Development and quality evaluation of pumpkin powder fortified cookies. *International Journal of Science, Engineering and Technology, 3*(4),1034-1038.

Price, M. L., Socoyoc, S. V. and Butler, L. G. (1978). A Critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. *Journal Agriculture Food Chemistry,* 26, 1214-1218.

Price, K. R., and Rhodes, M. J. C. (1997). Analysis of the major flavonoid glycosides present in four varieties of onion and changing in composition resulting from autolysis. *Journal of Science, Food and agriculture,74*,331-335.

Rabeta, M. S. and Lin, S. P. (2015). Effect of different drying methods on the antioxidant activities of leaves and berries of *Cayratia trifolia*. *Sains Malaysian, 44*(2),275-280.

Raffo, A., Leonardi, C., Fogliano, V., Ambrosino, P., Salucci, M., Gennaro, L. et al. (2002). Nutritional value of cherry tomatoes (*Lycopersicon esculentum* cv. Naomi F1) harvested at different ripening stages. *Journal Agriculture Food Chemistry,50,* 6550–6.

Rahman, S., M., Islam, M., R., Rahman, S., Mosaiab, T., Ahmed, F. K., Nusratun, N., Ahsan, S. et al. (2011). Antihyperglycemic studies with methanol Extract of *Annona reticulata* L. (Annonaceae) and *Carissa carandas* L. (Apocynaceae) leaves in swiss albino mice. *Advances in Natural and Applied Sciences, 5*(2),218-222.

Rai, N., Asati, B. S., Patel, R. K., and Yadav, D. S. (2005). Underutilized horticultural crops in North Eastern region. *ENVIS Bulletin: Himalayan Ecology, 13*(1),1-11.

Raj, A., and Masih, D. (2014). Physico chemical and rheological properties of wheat flour muffin supplemented with orange peel powder. *International Journal of Science and Research,3*(8),2319-7064.

Raji, A. O., Akinoso, R., and Raji, M. O. (2016). Effect of freeze- thaw cycles on the nutritional quality of some selected Nigerian soups. *Food Science and Nutrition, 4*(2),163-180.

Ramaswamy, H. S., and Tung, M. A. (1981). Thermophysical properties of apples in relation to freezing. *Journal of Food Science, 46,*724-728.

Rani, B., and Kawatra, A. (1994). Fiber constituents of some foods. *Plant Foods for Human Nutrition,45,*343-347.

Rashidi, A. A., and Noureddini, M. (2011). Hypoglycemic effect of the aromatic water of leaves of *Carissa spinarum* in normal and streptozotocin induced diabetic rats. *International Journal of Current Pharmaceutical Research,1,*372-379.

Ratti, C. (1994). Shrinkage during drying of foodstuffs. *Journal of Food Engineering, 23*(1),91-105.

Raupp, D. S., Rodrigues, E., Rockenbach, I. I., Carbonar, P. F. C., and Borasto, R. F. (2011). Effect of processing on antioxidant potential and total phenolic in beet(*Beta vulgaris L.). Cien. Technology Aliment. Campinas*,*31*(30),688-693.

Razavi, S. M. A., Pourfarzad, A., Sourky, H., and Jahoromy, S. H. R. (2010).The physical properties of fig *(Ficus carica)* as a function of moisture content and variety. *The Philippine Agricultural Scientist,41*,896-904.

Redddy, D. K., Jangabelli, M., and Singh, J. K. (2014). Utilization of an underexploited fruit (*Ficus carica*) as a preserved product. *Journal of Agroecology and Natural Resource Management,1*(2),78-81.

Rehman, S., Nandeem, M., Ahmad, F., Mushtaq, Z. (2013). Biotechnological production of xylitol rom banana peel and its impact on physicochemical properties of rusks. *Journal Agriculture Science Technology,15*,747-756.

Reyes, Y. C., Alvarez, L. D., Baez, D. A., Esquivel, O. O., and Moreno, A. O. (2013). Polyphenol oxidase inactivation by microwave oven and its phenolic profile of loquat (*Eriobotrya Japonica)* fruit. *Food and Nutrition Science*,4 (9B),87-94.

Rickman, J. C., Barrett, D. M., and Bruhn, C. M. (2007). Nutritional comparison of fresh,frozen and canned fruits and vegetables. Part1. Vitamins C and B and phenolic compounds. *Journal of the Science of Food and Agriculture,87*, 930-944.

Rickman, J. C., Bruhn, C. M., and Barrett, D. M. (2007). Nutritional comparison of fresh, frozen and canned fruits and vegetables II. Vitamin A and carotenoids, vitamin E, minerals and fiber. *Journal of Science of Food and Agriculture*, 0022-5142.

Rithiruangdej, P., Parnbankled, S., Donchedee, S., Wongsagonsup, R. (2011). Physical, chemical, textural and sensory properties of dried wheat noodles supplemented with unripe banana flour. *Kasetstar Journal (Natural Science),45*(3),500-509.

Rodríguez, R., Jiménez, A., Fernández-Bolaños, J., Guillén, R., and Heredia, A. (2006). Dietary fiber from vegetable products as source of functional ingredients. *Trends Food Science Technology, 17*, 3-15.

Romjaun, Z. Z., and Prakash, J. (2013). Development and assessment of fiber- enriched muffins. *Advances in Food Science,* 35(4), 159165.

Rosell, C. M., Rojas, J. A., and Benedita, B. C. (2011). Influence of hydrocolloids on dough rheology and bread quality. *Food Hydro-colloid,15*,75-81.

Rossetti, L., Fronzo, R. A., and Gharezi, R. (1990). Effect of metformin treatment on insulin action in diabetic rats: *in vivo* and *in vitro* correlations. *Metabol*, 39, 425-435.

Rosy, K., Gupta, A., and Sarita, S. (2015). Development and sensory optimization of low cost micronutrient rich nutritious product by using locally available food resources. *International Journal of Food and Nutritional Science,5*(1).

Rout, S. P., Kar, D. M., Mohapatra, S. B., and Swain, S. P. (2013). Anti-hyperglycemic effect *Annona Reticulata* L. leaves on experimental diabetic rat model. *Asian Journal of Pharmaceutical and Clinical Research, 6*(1),56-60.

Rozier, A., Lean, M. E. J., McDonald, M. S., and Black, C. (1995). Quantitative analysis of the flavonoid content of commercial tomatoes, onion, lettuice and celery. *Journal of Agriculture Food Chemistry, 42*, 281-285.

Rukayah, A. (1992). Buahbuahan Nadir Semonanjung Malaysia, Dewan Bahasadan Pustaka, Kuala Lumpur, Malaysia.

Rupasinghe, H. P. V., Wang, L., Huber, G. M., and Pittis, N. L. (2008). Effect of baking on dietary fiber and phenolics of muffins incorporated with apple skin powder. *Food Chemistry, 107*,1217-1224.

Ryder, J. M., Fletcher, G. C., Stec, M. G. and Seelye, R. J. (1993). Sensory, microbiological and chemical changes in hake stored in ice. *International Journal of Food Science Technology,28,* 169-180.

Sachin, A., Shreesh, K. O., and Divya, V. (2009). Characterization of streptozotocin induced diabetes mellitus in swiss albino mice. *Global Journal of Pharmacology, 3* (2),81-84.

Sadiq, I. S., Izugaize, T., Shiaibu, M., Dogoyaro, A. L., Garba, A. et al. (2013). The nutritional evaluation and medicinal value of date palm (*Phoenix dactylifera*). *International Journal of Modern Chemistry,4*,147-154.

Sae-kang, V., and Suphantharika, M. (2006). Influence of P^H and xanthan gum addition on freeze thaw stability of tapioca starch pastes. *Carbohydrate polymer,* 65,371-380.

Safy, F. S. E. (2014). Drying characteristics of laquot slices using different dehydration methods by comparative evaluation. *World Journal of Dairy and Food Sciences, 9* (2), 272-284.

Sakhale, B. K., Chalwad, R. U., and Pawar, V. D. (2012). Standardization of process for preparation of fig- mango mixed toffee. *International Food Research Journal,19*(3), 889-891.

Salgado, S. M., Guerra, N. B., and Filho, A. B. (1999). Frozen fruit pulps: Effects of the processing on dietary fiber contents. *Revista de Nutrico,50*,281-285.

Salim, N., Quatmane, A., Latrache, H., Ennhali, S., Zinelabidine, L. H. et al . (2014). Bioactive components and antioxidant activity of Morrocan Paprika (*Capscium annuum L.)* under different storage time and conditions. *Turkish Journal of Agricultural and Natural Sciences*, 1734-742.

Salmanian, S., Mahoonak, S. A. R., Alami, M., and Ghorbani, M. (2014). Phenolic Content, antiradical, antioxidant and antibacterial properties of Hawthorn (*Crataegus elbursensis*) seed and pulp extract. *Journal of Agricultural Science and Technology, 16*(2), 343-354.

Sandhu, M. K. (1990).“Fig’’ in fruits tropical and subtropical, T.K. Bose and Mitra, S. K, Eds, *Naya Prokash, Calcutta, India,* 650-663.

Sangeeta, S., and Mahanta, C. L. (2013). Effect of steaming, boiling and microwave cooking on the total phenolics, flavonoids and antioxidant properties of different vegetables of Assam, India. *International Journal of Food and Nutritional Science,2*(3)47-52.

Sanwal, R., and Chaudhary, A. K. (2011). Wound healing and antimicrobial potential of *Carissa spinarum* Linn. in albino mice. *Journal Ethnopharmacology,*135(3),792-6.

Sarkis, J. R., Jaeschke, D. P., Tessaro, I. C., and Marczak, D. F. (2013). Effects of ohmic and conventional heating on anthocyanin degradation during the processing of blueberry pulp. *Food Science and Technology, 51,* 79-85.

Saunders, R. M. (1990). "The Properties of Rice Bran as a Food Stuff," *Cereal Foods World, 35,* (7), 632-639.

Scheirber, A., Keller, P., and Carle, R. (2001). Determination of phenolic acids and flavonoids of apple and pear by high- performance liquid chromatography. *Journal of Chromatography A, 910,* 265-273.

Schmidt, B. M., Erdman, J. W., and Lila, M. A. (2005). Effects of food processing on blueberry antiproliferation and antioxidant activity. *Journal of Food Science,70* (6), S389-S394.

Schutz, H. G., and Cardello, A. V. (2001). A labeled affective magnitude (LAM) scale for assessing food liking/disliking. *Journal of Sensory Studies, 16,* 117–159.

Scibisz, I., and Mitek, M. (2007).The changes of antioxidant properties in high bush blueberries (*Vaccinium corymbosum* L.). During freezing and long –term frozen storage. *Acta Scientarium Polonrum Technologia Alimentaria, 6* (4),75-82.

See, E. F., Nadiah, W. A., Aziah, N. A. A. (2007). Physico chemical and sensory evaluation of breads supplemented with pumpkin flour. *Asian Food Journal,14*(2),123-130.

Seeminska, M.D., Najda, A., Dyduch, J., Gantner, M., and Klimek, K. (2015). The content of secondary metabolites and antioxidant activity of wild strawberry fruit (*Freagaria vesca* L.). *Journal of Analytical Methods in Chemistry, 83,*1238,1-8.

Seleem, H. A. (2015). Effect of blending doum (*Hyphaene thebacia*) powder with wheat flour on the nutritional value and quality of cake. *Food and Nutrition Science,6*,622-632.

Shaheel, S. K., Swami, D. V., Prasanna, B. K., and Krishna, U. K. (2015). Effect of blending of karonda (*Carissa caranda*) juice with guava, papaya and pineapple juice on its quality and organoleptic evaluation. *Plant archives,15*,187-192.

Sharifian, F., Motlagh, A. M., and Nikbakht, A. M. (2012). Pulsed microwave drying kinetics of fig fruits(*Carissa spinarum L*). *Australian Journal of Crop Science,6*(10),1441-1447.

Sharma, A., and Gupta, A. P. (2013). Evaluation of antioxidant activity and validated method for analysis of polyphenols from non – edible parts of Indian tropical fruits by using microwave assisted extraction and LC-MS/MS. *International Journal of Bio Science and Pharma,4,*(1),227-241.

Sharma, S. and Chopra, R. (2015). Formulation, chemical and textural analysis of biscuits prepared with malted green gram (*Vigna radiata*). *International Journal of Agricultural and Food Science,* 5(3),98-103.

Sharma, V., and Chawla, P. (2011). Development and nutrient evaluation of oat supplementated products for old age people with constipation. *Ethno Medicine*,5(3),161-164.

Sharnouby, G. A., Aleid, M. S., and Otaibi, M. A. (2012). Nutritional quality of biscuit supplemented with wheat bran and date palm fruits (*Phoenix dactylifera* L.). *Food and Nutrition Science,3*,322-328.

Shen, Y., Fukushima, M., Ito, Y., Murak, E., Honsono, T., Seki, T., Ariga, T. (2010). Verification of the antidiabetic effects of cinnamon (*Cinnamomum zeylancium*) using insulin uncontrolled type 1 diabetic rats and cultured adipocytes. Biosciences Biotechnology Biochemistry,74, 2418- 2425.

Shivasharanappa, K., and Londonkar, R . (2014). Evaluation of total phenolic content and free radical scavenging activity of *Ficus glomerata Roxb. International Journal of Pharmaceutical and Clinical Research, 6*(2), 133-137.

Shobaki, F. A., Bahay, A. M., and Esmail, R. S. A. (2010). Effect of fig fruits (*Ficus carica)* and its leaves on hyperglycemia in alloxan diabetic rats. *World Journal of Diary and Food Sciences,5*(1),47-57.

Sikora, E., Bieniek, M. I., and Borczak, B. (2013). Composition and antioxidant properties of fresh and frozen stored blackthorn fruits (*Prunus Spinosa L.). Acta Scientarium Polonorum Technologia,12*(4),365-372.

Silva, E. P., Cardoso, A. F. L., and Fante, C. (2013). Effect of postharvest temperature on the shelf life of gabiroba fruit (*Campomanesia pubescens*). *Food Science and Technology,33*(4),632-637.

Simonyan, K. J., Yiljep, Y. D., Oyatoyan, O. B., and Bawa, G. S. (2009). "Effects of Moisture Content on Some Physical Properties of *Lablab purpureus* (L.) Sweet Seeds". *Agricultural Engineering International,* 1279,(XI).

Singh, A., Grover, K., and Sharma, N. (2014). Nutritional evaluation of value added products using dehydrated greens for security of haematinic nutrient. *Food Science Research Journal,5* (2),168-173.

Singh, L., Yadav, N., Kumar, A. R., Gupta, A. K., Chacko, J. et al. (2007). Preparation of value added products from dehydrated bathua leaves (*Chenopodium album Linn*.). *Natural Product Radiance,6*(1),6-10.

Singh, S., Bala, N., Verma, A., and Srivastava, S. (2015). Development of noodles using banana peels as a functional ingredient. *International Journal of Pure Applied and Bio Science, 3* (1),87-91.

Singh, P., and Sharma, H. R. (2003). Nutritional and organoleptic evaluation of *Colocasia* leaf rolls supplemented with different protein sources. *Journal of Human Ecology,*14(6),467-469.

Singh, S., Singh, A. K., Joshi, H. K., Bagle, B. G., and Dhandar. D. G. (2009). Evaluation of packages for transportation and storability of aonla (*Emblica officinalis*) under semi-arid environment of Western India. *Journal of Food Science Technology, 46,*127–131.

Singleton, V. L., Orthofer, R., and Raventos, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-ciocalteau reagent. *Methods in Enzymology*, *299*,152-178.

Siriwattananon, L., and Maneerate, J. (2016). Effect of drying methods on dietary fiber content in dried and vegetable from non-toxic agricultural field. *International Journal of Geomate,11*(28),2896-2900.

Skrede, G. (1996). Fruits. In *Freezing Effects on Food Quality*; Jeremiah, L. E., Ed.; Dekker: New York.

Skupien, K. (2006). Evaluation of chemical composition of fresh and frozen blueberry fruit (*Vaccinium corymbosum* L.*). Acta. Sci.Pol. Hortorum Cultus,5*(1),19-25.

Slatnar, A., Klancar, U., Stampar, F., and Veberic, R. (2011). Effect of drying of figs (*Carissa spinarum* L.*)*on the contents of sugars, organic acid and phenolic compounds. *Journal of Agriculture Food Chemistry,9* (59),21,11696-702.

Sobota, A., and Luczak, J. (2010). Badania skladu chemicnego makaronow instant, Bromat. *Chem. Toksykol., XLIII*(4),515-522.

Solomon, A., Golubowicz, S., Yablowicz, Z., Grossman, S., Bergman, M., Gottlieb, H. E., Altman, A., Kerem, Z. et al. (2006). Antioxidant activities and anthocyanin content of fresh fruits of common fig *(Carissa spinarum L.). Journal of Agricultural and Food Chemistry, 54*(20),7717-7723.

Sonasong, P., Srzednicki, G., and Lohachoompol, V. (2010). Effects of preconditioning on quality of dried blueberries, 10th International Working Conference on Stored Product Protection, Julius-Kühn-Archiv, 425, 264-269.

Soni, N., Mehta, G. S., and Gupta, R. K. (2014). Estimation of nutritional, phytochemical, antioxidant and anti-bacterial activity of dried *Ficus carica*. *Journal of Pharmacy and Phytochemistry*, *32* (2), 158-165.

Sozzi, G. O., Abrajan-Villasenor, M. A., Trinchero, G. D., and Fraschina, A. A. (2005). Post harvest response of 'Brown Turkey' figs *(Carissa spinarum* L.*)* to the inhibition of ethylene perception . *Journal of the Science of Food and Agriculture,85*,2503-2508.

Stanley, M., Prince, P., Kamalakkannan, N., Venugopal, P., and Menon,V. P. (2004). Antidiabetic and antihyperlipidemic effect of alcoholic *Syzigium cumini* seeds in alloxan induced diabetic albino rats. *Journal Ethanopharmacology,91*,209-213.

Statin, C., Dineshkumar, P., and Nithiyananthan, K. (2012). Evaluation of antidiabetic activity of methanolic leaf extract of *Carissa spinarum* in alloxan- induced diabetic rats. *Asian Journal of Pharmaceutical and Clinical Research, 5* (3),85-87.

Stumvoll, M., Nurjhan, N., and Perriello, G. (1995).Metabolic effects of metformin in non-insulin-dependent diabetes mellitus. *The New England Journal of Medicine*, 333,550-554.

Sudha, M. L., Baskaran, V., and Leelavathi, K. (2007). Apple pomace as a source of dietary fiber and polyphenols and its effect on the rheological characteristics and cake making. *Food* Chemistry, *104*(2), 686-692.

Sudha, N. L., Vertrimani, L., and Leelavathi, K. (2007). Influence of fiber from different cereals on the rheological characteristics of wheat flour dough and biscuit quality. *Food Chemistry,100*,1365-1370.

Sultana, B., Anwar, F., Ashraf, M., and Saari, N. (2012). Effect of drying techniques on the total phenolic contents and antioxidant activity of selected fruits. *Journal of Medicinal Plants Research, 6* (1),161-167.

Sultana, A., Rahman, T. R., Islam, M., Rahman, M., and Alim, M. A. (2014). Evaluation of quality of chapatti enriched with jackfruit seed flour and bengal gram flour. *Journal of Environmental Science, Toxicology and Food Technology, 8(*5),73-78.

Sunmola, A. I., David, M. G., Olanrewaju, and Chizea, O. T. V. (2011). Biochemical effect of some food processing methods on the health promoting properties of under-utilized *Carissa papaya* seed. *Journal of Natural Products, 4*,17-24.

Surekha, N., and Naik, R. S. (2014). Development of value added khakara from barn yard millet consumer acceptability, nutritional and shelf- life evaluation. *Asian Journal of Home Science*,9(1),60-65.

Swami, G., Nagpal, N., Rahar, S., and Singh, P. (2010). Effect of aqueous leaves extract of *Carissa* linn. on blood glucose levels of normoglycemic and alloxan- induced diabetic wister rats. *International Journal of Current Pharmaceutical Research*, *2*(3),65-67.

Swanston, F. S. K., Day, C., Bailey, C. J., and Flat, P. R. (1990). Traditional plant treatment for diabetes. Studies in normal and streptozotocin diabetic mice. *Diabetologia*, 33,462-4.

Szczesniak, A. S. (1998). *Effect on storage on texture*. In I. A. Taub and R.P. Singh. Food storage stability . Boca Raton: CRC Press.

Szkudlarz, S. M., Bajerska, J., Wojtasiak, R. Z., and Gorecka, D. (2013). White grape pomace as a source of dietary fiber and polyphenols and its effect on physical and nutraceutical characteristics of wheat biscuits. *Journal Science Food and Agriculture,93*,389-395.

Taneya, M. L. J., Biswas, M. M. H., and Din, S. U. (2014). The studies on the preparation of instant noodles from wheat flour supplementing with sweet potato flour. *Journal of Bangladesh Agriculture University,12*(1),135-142.

Tanwar, B., Andallu, B., and Modgil, B. (2014). Influence of processing on physicochemical, nutritional and phytochemical composition of *Carissa spinarum* products. *Asian Journal Dairy and Food Resources,33*(1),37-43.

Thakur, M. (2014). Underutilized food crops: treasure for the future India. *Food Science Resource Journal*, 5(2),174-183.

Thimmaiah, S. K. (1999). Standard Methods of Biochemical Analysis, Kalyani Publishers.

Thomas, L. R., William, E., Connor, D. S., and Warner, S. (2015). The interaction of dietary fibers and cholesterol upon the plasma lipids and lipoproteins, sterol balance and bowel function in human subjects. *The journal of clinical investigation,60*,1429-1437.

Thoravaldson, K., and Skjoldebrand, C. (1998).Water diffusion in bread during baking. *Lebensmittel Wissenchatt and Technologies,31*,658-663.

Tiwari, B. K., Brennan, C. S., Jaganmohan, R., Surbhi, A. and Alagusundaram, K. (2011). Utilization of pigeon pea (*Cajanus cajan L*) by product in biscuit manufacture. *LWT-Food Science and Technology,44,*153-159.

Turkmen, N., Sari, F., Sedat, Y., and Velioglu, S. (2005). The effect of cooking methods on total phenolics and antioxidant activity of selected green vegetables. *Food Chemistry, 93*,713-718.

Uchenna, O. A., Nkiruka, I. V., Eze, E. P., and Chinazaekpere, O. C. (2013). Nutrient, phytochemical composition and sensory evaluation of formulated diabetic snacks made from Nigeria foods, *Afzelia Africana* and *Detarium Microcapium* seed flour. *Pakistan Journal of Nutrition, 12*(2),108-113.

Uchenna, O.A., Nikiruka, I. V., Eze, E. P., and Chinazaekpere, O. C. (2013). Nutrient, phytochemical composition and sensory evaluation of formulated diabetic snacks made from Nigeria foods, *Afzelia Africans* seed flour and *Detarium Microcapium* seed flour. *International Journal of Basic and Applied Sciences,13*(2),40-44.

Udomkun, P., Argyropoulous, D., Nagle, M., and Mahayothee, B. (2015). Sorption behavoiur of papayas as affected by compositional and structural alterations from osmotic pretreatment and drying. *Journal of Food Engineering,157*,14-23.

Updegroff, D.M. (1969). *Anal. Biochemistry,* 32, 420.

Van der Piji, L. (1972). Principles of dispersal in higher plants . Springer- Verlag, New York.

Van, K. H. H., de Boer, B. C. J., and Tijuburg, L. B. M . (2000). Carotenoid bioavailability in humans from tomatoes processed in different ways determined from the carotenoids response in the triglyceride- rich lipoprotein fraction of plasma after a single consumption and in plasma after four days of consumption. *Journal Nutrition,130*,1189-1196.

Van, P. J., and Robertson, J. B. (1977).What is fiber and fiber in food? *Nutrition Review,35*, 12.

Vankatartanam, L. (1988). Packing of figs. A souvenir on packing of fruits and vegetables in India; Agriculture Horticultural Society Public Gardner: Hyderabad, India.

Vasisthala, H., and Srivastava, N. A. (2013). Effect of soaking and cooking on dietary fiber components of different type of chickpea genotypes. *Journal of Food Science Technology,50* (3),579-584.

Vazhacharickal, P. J., Mathew, J. J., Kumar, N. K., and Sebastin, M. (2015). A study on the vitamin C contents of various neglected and underutilized fruits from western ghat region in Kerala. *International Journal of Food, Agriculture and Veterinary Sciences, 5*(1),94-105.

Verma, A., and Singh, V. (2014). Nutritional value and organoleptic evaluation of mushroom powder fortified Indian recipe: Besan laddu. *Asian Journal of Home Science,* 9(1),78-81.

Verma, I., and Gupta, R. K. (2015). Estimation of phytochemical, nutritional, antioxidant and antibacterial activity of dried fruit of sacred figs (*Ficus religiosa*) and formulation of value added product(Hard candy). *Journal of Pharmacognosy and Phytochemistry,4*(3),257-267.

Vidal, V., and Frias, C. (1991). Legumes processing effects on dietary fiber components. *Journal Food Science, 56*,1350-1352.

Vinod, D., Nandkule, D. M., Chitra, S., and Devendrasing, D. P. (2015). Development and quality evaluation of Jackfruit seed and soy flour noodles. *International Journal of Science, Engineering and Technology, 3*(3),802-806.

Vinson, J. A. (1999). Functional food properties of figs. *Cereal Foods World, 44*(2),82-87.

Vinson, J. A., Zubik, L., Bose, P., Samman, N., and Proch, J. (2005). Dried fruits: excellent *in vitro and in vivo* antioxidants. *Journal of American College of Nutrition, 24* (1),44-50.

Waghray, K., Gulla, S., and Bhanuteja, K. (2011). Sensory attributes of wheat (*Triticum species*) flour based chapatti incorporated with soy flour (*Glycine max*) and dates (*Pheonix dactylifera*). *Journal of Dairying, Foods and Home Science, 30* (4), 262 – 266.

Wang, R., Ding, S., Zhao, D., Wang, Z., Wu, J., and Hu, X. (2016). Effect of dehydration methods on antioxidant activities, phenolic content, cyclic nucleotides and volatiles of jujube fruits. *Food Science and Biotechnology*, *25*(1),137-143.

Wang, C. Y., Chen, C., T., and Wang, S. Y. (2009). Changes of flavonoid content and antioxidant capacity in blueberries after illumination with UV-C. *Food Chemistry, 117*,426–431

Wang, G., Wang, H., Song, Y., Jia, C., Wang, Z. et al. (2004). Studies on anti-HSV effect of *Carissa spinarum* leaves. *Journal of Chinese Medicinal Materials*, 27,754-6.

Wang, S. Y., Zheng, W., and Galletta. G. J. (2002) Cultural system affects fruit quality and antioxidant capacity in strawberries. *Journal Agriculture Food Chemistry, 50,* 6534–42.

Wani, R. A., Prasad, V. M., Hakeem, S. A., Sheema, S., Anguchuk, S. *et al.* (2013). Shelf life of Karonda jams (*Carissa caranda*) under ambient temperature. *African Journal of Agriculture Research, 8* (21),2447-2449.

Wetwitayaklung, P., Sarunyakasitharin, K., and Phaechamud, T. (2008). Total phenolic content and antioxidant activity of fresh and preserved fruits of *Ellaeocarpus hygrophilus Kurz*. *Thai Pharmaceutical Health Science Journal,4* (1),21-28.

Whitton, P. D., and Hems, D. A. (1975). Glycogen synthesis in perfused liver of streptozotocin diabetic rats. *Biochemical Journal*,21,150-153.

Wich, A., and Prasad, M. (2012). Drying of Karonda (*Carissa spinarum*) pomace and its tablet product. *KKU Science Journal, 40* (3),887-889.

Williams, J. T., and Haq, N. (2002). Global research on underutilized crops - an assessment of current activities and proposals for enhanced cooperation.

Wilson, V., Shetye, S. S., Kaur, K., and Shetty, S. (2016). Study of synergistic effects on antioxidant activity and antimicrobial activity of polyherbal formulations containing *Ficus* species. *International Journal of Pharmacy and Pharmaceutical Sciences, 8*(4),51-53.

Wojdylo, A., Figiel, A., and Oszmianski, J. (2007). Influence of temperature and time of apple drying on phenolic compounds content and their antioxidant activity. *Polish Journal of Food and Nutrition Sciences,57*,(4), 601-605.

Wojdylo, A., Figiel, A., Lech, K., Nowicka, P., and Oszmianski, J. (2014). Effect of convective and vacuum- microwave drying on the bioactive compounds, colour and antioxidant capacity of sour cherries. *Food Bioprocess Technology,7*, 829-841.

Wojdylo, A., Figiel, A., and Oszmianski, J. (2009). Effect of drying methods with the application of vacuum microwaves on the bioactive compounds, colour and antioxidant activity of strawberry fruits. *Journal Agriculture Food Chemistry*,*57*(4),1337-1343.

World Health Organization. (2003). Diet, nutrition and prevention of chronic disease, World Health Organization, *Genevia,* 89.

Wrolstad, R. E. (2004). Interaction of natural colour with other ingredients: anthocyanin pigments-bioactivity and colouring properties. *Journal of Food Science,69,* C419-425.

Wu, X., Gu, L., Holden, J., Haytowitz, D. B., Gebhardt, S. E., Beecher, G. et al. (2004) Development of a database for total antioxidant capacity in foods: a preliminary study. *Journal Food Composition Anal., 17,* 407–22.

Xu, G., Ye, X., Chen, J., and Liu, D. (2007). Effect of heat treatment on the phenolic compounds and antioxidant capacity of citrus peel extract. *Journal of agriculture and Food Chemistry,55,*330-335.

Yadav, D.N., Gaikwad, R. P., Kadam, R. M., Bhambure, C. V., and Joshi, S. V. (2005). Incorporation of Karonda (*Carissa carandas*) pulp in ice-cream. *Department of Animal Husbandry and Dairy Science,*21-22.

Yamaguchi, T., Taeko, M., Rie, K., Hiroko, M. F., Junji, T., Hitoshi, T. et al. (2001). "Radical-scavenging activity of vegetables and the effect of cooking on their activity." *Food Science and Technology Research*, 7(3), 250-257.

Yan, L. Y., Teng, L. T., and Jhi, T. J. (2006). Antioxidant properties of guava fruit: comparison with some local fruits. *Sunway Academic Journal*, *3*, 9–20.

Yanardag, R., Ozsoy- Sacan, O., and Bolkent, S. (2005). Protective effects of metformin treatment on the liver injury of the streptozotocin-diabetic rats. *Human and Experimental Toxicology*, 24,129-135.

Yin, M. C., and Cheng, W. S. (1998). Antioxidant activity of several allium members. *Journal Agriculture Food Chemistry*, *46*, 4097-101.

Yoshioka, H., Tsuyumu, S., and Takayanagi, K. **(**1990). Radical formation during the processing of green tea. *Agricultural and Biological Chemistry*, *54*,203-204.

Yun, Z., Gao, H., Liu, P., Liu, S., Luo, T., Jin, S., Xu, Q. et al. (2013). Comparative proteomic and metabolomic profiling of citrus fruit with enhancement of disease resistance by postharvest heat treatment. *BMC Plant Biology*,13, 44.

Yusufu, M. I., and Obiegbuna, J. E. (2015). Effect of processing methods on the phytochemical content and consumer acceptability of two selected green leafy vegetables. *Agricultural Science Research Journal, 5*(7),105-110.

Zabidi, M. A., and Yunus, A. M. (2014). Effect on physicochemical and sensory attributes of bread substituted with different levels of matured soursop *(Anona muricata*) flour. *World Academy of Science, Engineering and Technology, 8*(7),740-744.

Zaenuri, L. A., Susilawati, T., Sumitro, S. B., and Wahyuningsih, S. (2014). Effects of additional crude extract of fig fruit (*Carissa spinarum*) into Tris egg yolk based extender on quality of buck semen. *Journal of Biology, Agriculture and Healthcare, 4*(9), 21-27.

Zaidel, D. N. A., Makhtar, N. A., Jusoh, Y. M. M., and Muhamad, I. I. (2015). Efficiency and thermal stability of encapsulated anthocyanins from red dragon fruit (*Hylocereus polyrhizus* (Weber) Britton and Rose) using microwave-assisted technique. *Chemical Engineering Transactions,43*,1-6.

Zavala, J. F. A., Wang, S. Y., Wang, C. Y., and Aquilar, G. A. (2004). Effect of storage temperature on antioxidant capacity and aroma compounds in strawberry fruit. *Lebensm-Wiss.U-Technology,37*,687-695.

Zilic, S., Dodig, D., Sermesic, M. M., Kandic, V., Kostandinovic, M. et al. (2011). Small grain cereals compared for dietary fibre and protein contents. *Genetika,43*(2),381-395.

Zivkovic, M., Rakic, S., Maletic, R., Povrenovic, D., Nikolic, M. et al. (2011). Effect of temperature on the physical changes and drying kinetics in plum (*Prunus domestica L.)* Pozegaca variety. *Chemical Industry and Chemical Engineering Quaterly,17*(3),283-289.

Zolfaghari, M., Sahari, M. A., Barzegar, M., and Samadloiy, H. (2010). Physicochemical and enzymatic properties of five kiwi fruit cultivars during cold storage. *Food Bioprocess Technology*, *3*, 239-246.

8. Appendix I

SENSORY EVALUATION OF THE PANELIST

Name of the panelist: **date:**

S.No.	Appearence	Colour	Texture	Flavour (Aroma/Taste)	Overall acceptability (If any)	Comments (If any)

Hedonic Scale

Expression	Points to be assigned
Liked very much	9
Liked moderately	8
Liked slightly	7
Neither liked nor disliked	6
Disliked slightly	5
Dislike moderately	4
Dislike very much	3
Dislike extremely	2
	1

Signature_____

8. Appendix I

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7. BIBLIOGRAPHY

Abou ElHana, N. H. (2008). Microwave drying of apple. *Misr Journal of Agriculture Engineering, 25*, 980-1003.

Abou-Zaid, A. A., Ramadan, M. T., and Al-Asklany, S. A. (2011). Utilization of faba vegetables. *Biochemistry, 18*(2), 121–125. www.bioline.org.br/request

Abu-Goukh, A. A., Shattir, A. E., and Balla, M. M. E. (2003). Effect of harvesting method on quality and storability of dry dates in Sudan. *Tropical Science, 43*, 53-56.

Adubofuor, J., and Mensah, M. A. (2012). Sensory evaluation and proximate composition of rock buns and cakes prepared from partially- dried ripe pawpaw pulp incorporated into wheat flour. *Journal Agriculture Food Technology, 2*(11),172-177.

Agent (1994). *A survey of the market for fruits and vegetables in the hotel and restaurant industry*. Agent's business production, processing and marketing information centre,19,Colombo, 25.

Agoreyo, B. O., Akiroroh, O., Orukpe, O. A., Osaweren, O. R., and Owabor, C. N. (2011). The effects of various drying methods on the nutritional composition of *Musa paradisiacal, Dioscorea rotundata* and *Colocasia esculenta. Asian Journal of Biochemistry, 6*(6),458-464.

Ahmad, F., and Raj, A. (2012). Buckwheat: a legacy on the verge of extinction a Ladakh. *Current. Science,103*(1),13.

Ahmad, M. Z., Ali, M., and Mir, S. R. (2013). Anti- diabetic activity of *Carissa spinarum* L. stem barks and isolation of two new flavonol esters from the plant by using spectroscopic techniques. *Asian Journal of Biomedical and Pharmaceutical Sciences, 3*(18),22-28.

Ahuja, M. M. S. (1979). *Epidemiological studies on diabetes mellitus in India*. In :Ahuja MMS, Editor, Epidemiology of diabetes in developing countries. New Delhi: Imprint, 29-38.

Akhijahani, H. S., and Khodaei, J. (2011). Some physical properties of strawberry (Kurdistan Variety). *World Applied Science Journal,13*(2),206-212.

Akinhanmi, T. F., Atasie, V. N., and Akintokun, P. O. (2008). "Chemical composition and physicochemical properties of cashew nut (*Anacardium occidentale*) oil and cashew nut shell liquid." *Journal of Agricultural, Food and Environmental Sciences, 2*(1), 1–10.

Alam, M. J., Talukder, M. U., and Rahman, M. N. (2013). Evaluation of the nutritional and sensory quality of functional breads prepared from whole wheat and soyabean flour. *Annals. Food Science and Technology,14* (2),171-175.

Albers, S., Muchova, Z., and Fikselova, M. (2009). The effects of different treated brans additions on bread quality. *Scientia Agriculture Biochemica,40*(2),67-72.

Aleid, S. M., Elansari, A. M., Tang, Z. X., and Sallam, A. A. (2014). Effect of cold storage and packing type on Khalas and Sukkary dates quality. *Advance Journal of Food Science and Technology,6*(5),603-608.

Alfaro, S., Mutis, A., Quiroz, A., Seguel, I., and Scheuermann, E. (2014). Effects of drying on murtilla fruit polyphenols and antioxidant activity. *Journal of Food Research,3*(5),73-82.

Al-Farsi, M., Alsavar, C., Morris, A., Baron, M., and Shahidi, F. (2005). Comparison of antioxidant activity, anthocyanin, carotenoids and phenolics of three native fresh and sun dried date (*Phoenix dactylifera L.)* varieties grown in Oman. *Journal of Agriculture and Food Chemistry,53*, 7592-7599.

Alice, A. O., Oshundahunsi, O. F., Rahman, A., Kayode, A., Abiodun, A. et al. (2012). Proximate composition and sensory qualities of snacks produced from breadfruit flour. *Global Journal of Science Frontier Research Biological Sciences,12*(7),2249-4626.

Aljane, F., Toumi, I., and Ferchichi, A. (2007). HPLC determination of sugars and atomic absorption analysis of mineral salts in fresh figs of Tunisian cultivars. *African Journal of Biotechnology,6*(5),599-602.

Al-Ogaidi, H. K., and Mutlak, H. H. (1986). The phenolic compounds of four date cultivars during maturity stages. *Date Palm Journal,4*(4),191-196.

Al-Yahayai, R., and Al-kharusi, L. (2012). Physical and chemical quality attributes of freeze-stored dates. *International Journal Agriculture Biology, 14*, 97-100.

Amalina, N. I., Nordin, A., Ariffin, H., Andou, Y., Hassan, M. A., Shirai, Y. et al. (2013). Modification of oil palm mesocarp fiber characteristics using superheated steam treatment. *Molecules,18*, 9132-9146.

Amreen, F., Prem, P. S., Parul, A., Raghuveer, I., Shashi, A. *et al.* (2013). Treatment of various diseases by *Carissa spinarum* L. promising shrub. *International Journal Pharma Science Research,*4 (7), 2489-2495.

Anantawat, V. (2015). Effects of spray drying conditions on characteristics, nutritional value and antioxidant activity of gac fruit aril powder. *Integrated Business and Economic Resource,4,*1-11.

Ancos, B., Gonza, E. M., and Cano, M. P. (2000). Ellagic acid, vitamin C and total phenolic contents and radical scavenging capacity affected by freezing and frozen storage in raspberry fruit. *Journal Agriculture Food Chemistry, 48,* 4565-4570.

Andulla, B., and Varadacharyulu, N. C. H. (2003). Antioxidant role of mulberry leaves in streptozotocin – diabetic rats. *Clinica Chimica Acta, 338,*3-10.

Anon (2011). The general information about figs. www.erbeyliincir.gov.tr *(Accessed 4 June 2)(Turkish).*

Anonymous (1950). In the wealth of India : A Dictionary of Indian raw materials and industrial products, *CSIR NEW DELHI,3,*22.

Anonymous (1999). The wealth of India: *A dictionary of India raw materials and industrial products*. Council of Scientific and Industrial Research New Delhi, 4.

Anonymous (2001). The Wealth of India*: A dictionary of Indian raw materials and industrial products, first supplemented series.* National Institutes of Science Communicaton, *New* Delhi,2 CI-CY XXXV.

AOAC, Official method of analysis international. (2010). *Spectrophotometric method,7* (2), 161-4.

Ara, R., Jahan, S., Abdullah, A. T. M., Fakruddin, A. N. M., and Saha, B. K. (2014). Physico-chemical properties and mineral content of selected tropical fruits in Bangladesh. *Bangladesh Journal of Scientific and Industrial Research ,49*(3),131-136.

Aremu, M. O., Olaofe, O., and Akintayo, T. E. (2006). A comparative study on the chemical and amino acid composition of some Nigerian under-utilized legume flours. *Pakistan Journal of Nutrition, 5,* 34-38.

Ariffin, F., Baharom, M. A., Kaur, B., and Maurd, M. (2015). The physicochemical properties and sensory evaluation of bread made with a composite flour from wheat and Tempoyak (fermented Durian). *American Journal of Applied Sciences, 12* (11), 775.784.

Ariffin, H., Hassan, M. A., Kalsom, M. S. U., Abdullah, N., and Shirai, Y. (2000). Effect of physical, chemical and thermal pretreatments on the enzymatic hydrolysis of oil palm empty fruit bunch (OPEFB). *Journal of Tropical Agriculture and Food Science,36*(2), 000-000.

Arslan, D. (2015). Effects of degradation preventive agents on storage stability of anthocyanins in sour cherry concentrate. *Agronomy Research,13*(4), 892–899.

Asp, N. G., and Bjorck, I.(1992).Resistant starch. *Trends in Food Science and Technology, 3*,111-114.

Association of Official Analytical Chemists. (1975). *Official methods of analysis (12th editio*n). The Assocation: Washington, D.C.

Atlabachew, M., Chandravanshi, B. S., Abshiro, M. R., Torto, N., Chigome, S. et al .(2013). Evaluation of the effect of various drying techniques on the composition of the psychoactive phenylpropylamino alkaloids of Khat *(Catha Edulis for SK)* chewing leaves. *Bull. Chemical Society Ethiopa,27*(3), 347-358.

Avila, P. A., Namiesnik, J., Toledo,F., Werner, E., Ayala, A. L. M., Guzman, N. E. R., Infante, J. A. G. et al. (2012). The influence of different time durations of thermal processing on berries quality. *Food Control, 26* ,587-593.

Ayadi, A., Mechlouch, R. F., Bessaoud, C., Bennour, H., and Debouba, M. (2014). Effect of microwave and solar drying methods on the physicochemical properties of kiwifruit. *Journal of Agricultural Technology,10* (4),365-379.

Aydin, C. (2002). Physical properties of hazel nuts. *Biosystems Engineering, 82* (3), 297-303.

Aziz, N., Noor, M. A., and Ho, L. H. (2012). Physico-chemical and organoleptic properties of cookies incorporated with legume flour. *International Food Research Journal*,19(4),1539-1543.

Babiker, W. A. M., Abdel, M. E. S., Sirekhatim, B. E., and Elamin, A. K. (2013). Physicochemical properties of wheat bread supplemented with orange peel by-products. *International Journal of Nutrition and Food Sciences,2*(4),1-4.

Badola, H. K., and Aitken, S. (2010). Biological resources and poverty alleviation in the Indian Himalayas. *Biodiversity, 11*(3), 8-18.

Baker, A. A. and Gawish, R. A. (1997). Trials to reduce nitrate and oxalate content in some leafy vegetables. Interactive effects of the manipulating of the soil nutrient supply, different blanching media and preservation methods followed by cooking process. *Journal of Science, Food and Agriculture, 42*, 169-178.

Balasubramanian, D. (2001). Physical properties of raw cashew. *Nutrition Journal of Agricultural Engineering Research,78* (3),291-297.

Baliga, M., Bhat, H., Pai, R., Boloor, R., and Palatty, P. (2011). The chemistry and medicinal uses of the underutilized Indian fruit tree *Garcinia Indica Choisy* (kokum): A review. *Food Research International. In Press.*

Bernard, R., Issah, A. P., and Emmanuel, M. (2014). Effect of drying methods on phytochemical composition of orange fruit (*Citrus sinesis, L.)* peel flour in biscuit making. *Journal of Environmental Science, Toxicology and Food Technology,8*(10),72-75.

Bey, M. B., and Louaileche, H. (2015). A comparative study of phytochemical profile and *in vitro* antioxidant activities of dark and light dried fig (*Carissa spinarum* L.) varieties. *The Journal of Psychopharmacology, 4*(1), 41-48.

Bhogaonkar, P. Y., Chauhan, V. N., and Kanerkar, U. R. (2014). Nutritional potential of *Ficus racemosa L.* fruits. *Bioscience Discovery,5*(2),150-153.

Blois, M. S. (1958). Antioxidant determination by the use of stable free radicals. *Nature, 181*, 1199-2000.

Boca, S., Galoburda, R., Skrupskis, I., and Skrupska, D. (2014). The effect of freezing and hydrocolloids on the physical parameters of strawberry mass- based desserts. *Proc. Latvia University Agriculture, 31*(326), 12-24.

Boonsumrej, S., Chaiwanichsiri, S., and Tantratian, S. (2007). Effect of freezing and thawing on the quality changes of tiger shrimp (*Penaeus monodon*) frozen by air-blast and cryogenic freezing. *Journal of Food Engineering, 80,*292–299.

Borchani, C., Besbes, S., Masmoudi, M., Blecker,C., and Paquot, H. A. (2011). Effect of drying methods on physico-chemical and antioxidant properties of date fiber concentrates. *Food Chemistry, 125,*1194–1201.

Bouzari, A., Hilstege, D., and Barrett, D. M. (2015). Mineral, fiber and total phenolic retention in eight fruits and vegetables: A comparison of refrigerated and frozen storage. *Journal of Agriculture and Food Chemistry, 63*, 951-956.

Brackmann, A., Mazaro, S. M., and Saquet, A. A. (1997). Cold storage of persimmons *(Diospyros kaki L.)* cultivars Fuyu and Rama Forte. *Ciencia-Rural, 27,* 561 - 565.

Brito, B., Rodriguez, M., Samaniego, I., Jaramillo, M. I., and Valliant, F. (2006). Characterizing polysaccharides in cherimoya (*Annona cherimola Mill*) pure and their enzymatic liquefaction. *Europe Food Resource Technology, 115*(4),377-378.

Brooker, D. B., Bakker, A. F. W., and Hall, C. W. (1974). Drying cereal grains. *The AVI publishing company, Inc*, Westport,Co,USA,265.

Burke, J. L., Waghorn, G. C., Brookes, I. M., and Attwood, G. T. (2000). Formulating total mixed rations from forages- defining the digestion kinetics of contrasting species. *Proceedings of New Zealand Society of Animal Production 60*,9-14.

Butool, S., and Butool, M. (2013). Nutritional quality on value addition to jack fruit seed flour. *International Journal of Science and Research, 4* (4),2406-2411.

Candrawinata, V. I., Golding, J. B., Roach, P. D. and Stathopoulos, C. E. (2014). Total phenolic content and antioxidant activity of apple pomace aqueous extract: effect of time, temperature and water to pomace ratio. *International Food Research Journal, 21*(6), 2337-2344.

Caprez, A., Arrigoni, E., Amado, R., and Neucom, H. (1986). Influence of different types of thermal treatment on the chemical composition and physical properties of wheat bran. *Journal Cereal Science, 4*, 233–239.

Chaparzadeh, N., and Yavari, B. (2013). Antioxidant responses of Golden delicious apple under cold storage conditions. *Iranian Journal of Plant Physiology,4* (1), 907-915.

Chauhan, K., Sharma, S., Chawla, E., and Chauhan, B. (2010). Development of food products on corporating dry powdered figs to explore their hypercholestrolemic potential. *Food Science Research Journal, 2*(1), 196-201.

Chawla, A., Kaur, R., and Sharma, A. K. (2012). *Carissa spinarum* Linn. : A Review on its pharmacognostical, phytochemical and pharmacological aspects. *International Journal of Pharmaceutical and Phytopharmacological Research,1*(4),215-232.

Cheftel, J. C., Cheftel, H., and Besancon, P. (1989). Methods de conservation. In: Cheftel, J. C., Cheftel, H., Besancon, P., (Ed). Introduction a la bioquimica tecnologia de los alimentos. *Zaragoza: Acribia, cap,7,*173-299.

Chen, M. L., and Morris, W. C. (1990). Effect of heat treatments on the chemical analysis of dietary fiber. *Journal of Food Science, 55,* 1647-1650.

Cheng, M. (2011). Effects of drying temperature on the flavonoid, phenolic acid and antioxidative capacities of the methanol extract of citrus fruit (*Citrus sinensis* L.) peel. *International Journal of Food Science and Technology, 46*(6),1179-1185.

Chinma, C. E., Igbabul, B. D., and Omotayo, O. O. (2012). Quality characteristics of cookies prepared from unripe and defatted sesame flour blends. *American Journal of Food Technology,7*(7),398-408.

Chinyere, G.C. and Obasi, N. A. (2013). Vitamins and phytochemical contents in four leafy vegetable subjected to different processing methods. *African Journal of Biotechnology,12* (26),4168-4173.

Chism, G. W., and Haard, N. F. (1996). Characteristics of edible plant tissues. In: Food Chemistry. OR *Fennema New York*: *Dekker,* 943-1011.

Chobanian, A. V., Bakris, G. L., Black, H. R., Cushman, W. C., Green, 1. L. A., Izzo, J. L. J. et al. (2003). National Heart, Lung and Blood Institute Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure; National High Blood Pressure Education Program Coordinating Committee. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA, 289,* 2560-72.

Chomnawang, C., Nantachai, K., Yongsawatdigul, J., Thawornchinsombut, S., and Tungkwa-chara, S. (2007). Chemical and biochemical changes in hybrid catfish fillet stored at 4°C and its gel properties. *Food Chemistry, 103*,420–427.

Choo, C. L., and Aziz, N. A. (2010). Effects of banana flour and β- glucan on the nutritional and sensory evaluation of noodles. *Food Chemistry, 119*, 34–40.

Choudhary, S., Pathak, A. K., Khare, S., and Kushwah, S. (2011). Evaluation of antidiabetic activity of leaves and fruits of *Ficus religiosa* Linn. *International Journal of Pharmacy and Life Sciences,2* (12),1325-1327.

Chuen, Y. S., and Aziz, N., A. A. (2009). Chemical and physical properties of muffin prepared from different levels of mango (*Mangifera indica)* variety Chokanan pulp flour. Food Technology Division, School of Industrial Technology, University Sains Malaysia,11800 Minden, Penang, Malaysia.

Chumyam, A., Wangchai, K., Jungklang, J., and Faiyue, B. (2013). Effects of heat treatments on antioxidant capacity and total phenolic content of four cultivars of purple skin eggplants. *Science Asian*, *39*,246-251.

Clary, C. D., Meza, M. E., Wang, S., and Petrucci, V. E. (2007). Improving grape quality using microwave vacuum drying associated with temperature control. *Journal of food science,72*(1),23-28.

Crizel, T. M., Rios, A. O., Thys, R. C. S., and Flores, S. H. (2015). Effects of orange by-product incorporation on the functional and technological properties of pasta. *Food Science Technology, campinas, 35*(3), 546-551.

Dalal, R. P. S., Thakur, N. A. and Singh, A. (2010). Nutritional value of Karonda *(Carissa carandas* Linn*).* A non- conventional fruit under semi- arid condition of Punjab. *Indian Journal of Agroforestry,12*(2),102-104.

Damiani, C., Silva, F. A. D., Lage, M. E., Pereira, D. E. P., Becker, F. S. et al. (2013). Stability of frozen marolo pulp during storage. *Food Science Technology Campinas*, *33*(4),713-721.

Dangcham, S., Bowen, J., Ferguson, I. B., and Ketsa, S. (2008). Effect of temperature and low oxygen on pericarp hardening of mangosteen fruit stored at low temperature. *Postharvest Biology and Technology 50*,37–44.

Darjazi, B. B. (2011). Morphological and pomological characteristics of fig (*Carissa spinarum*) cultivars from varamin, Iran. *African Journal of Biotechnology, 10* (82), 19096-19105.

Davey, M. W. V., Montagu, M., Inzé, D., Sanmartin, M., Kanellis, A. et al. (2000). Plant L-ascorbic acid: Chemistry, function, metabolism, bioavailability and effects of processing. *Journal of the Science of Food and Agriculture*, *80*(7), 825–860.

De- Ancos, B., Gonzáles, E. M., and Cano, M. P. (2000a). Ellagic acid, vitamin C and total phenol contents and radical scavenging capacity affected by freezing and frozen storage in raspberry fruit. *Journal Agriculture Food Chemistry*, 48,4565-4570.

Diaz, P. O., Hernansezl, J. J. I., Avevedol, E. A., Ambrizl, S. L. R., Pardo, M. E. S. et al. (2014). Chemical, starch digestibility and sensory characteristics of durum wheat/ unripe whole banana flour blends for spaghetti formulation. *Food and Nutrition Sciences, 5*, 264-270.

Din, K. (2008). Physico-chemical properties fruit Karonda *(Carissa carandas)* Dans fat works Pastilnya, (QK495K452008 FRB).

Donovan, J. L., Meyer, A. S., and Waterhouse, A. L. (1998). Phenolic composition and antioxidant activity of prunes and prune juice (*Prunus domestica*). *Journal of Agriculture and Food Chemistry*,*46*(4),1247-1252.

Duen, M., Alonso, J. J., Buelga, C. S., and Bailo, T. E. (2008). Anthocyanin composition in (*Carissa spinarum*). *Journal of Food Composition and Analysis, 21*, 107–115.

Dunas, W., Jin, S., Zhao, G., and Sun, P. (2015). Microwave-assisted extraction of anthocyanin from Chinese bayberry and its effects on anthocyanin stability. *Food Science Technology, Campinas, 35*(3),524-530.

El- Sharnouby, G. A., Aleid, M. S., and Otaibi, M. M. (2012). Nutritional quality of biscuit supplemented with wheat bran and date palm fruits (*Phoenix dactylifera* L.). *Food and Nutrition Sciences, 3*, 322-328.

Elhana, N. H. A. (2008). Microwave drying of apple. Misr. *Journal of Agriculture, 25*(3),980-1003.

Elizabeth, K. G., and Poojara, R. H. (2014). Organoleptic attributes of garden cress seed incorporated snacks suitable for adolescents. *International Journal of Food and Nutritional Sciences,3*(6),126-129.

Embaby, H. E. S. (2011). Effect of heat treatment on certain antinutrient and *vivo* protein digestibility of peanut and sesame seeds. *Food Science Technology Research, 17*(1),31-38.

Ertekin, C., Gozlekci, S., Heybeli, N., Gencer, A., Adak, N., and Sengul, B. (2014). Drying of strawberry with infrared dryer. *International Conference of Agriculture Engineering,* C0689,1-7.

Eze, J., and Akubor, P. (2012). Effect of drying methods and storage on the physicochemical properties of Okra. *Journal of Food Processing and Technology*,3,8,177.

Famurewa, J. A. V. and Olumofin, K. M. (2015). Drying kinetics and influence on the chemical characteristics of dehydrated okra (*Abelmoschuesculentus*) using cabinet dryer. *European Journal of Engineering and Technology,3*(2),7-19.

FAO. (2003). State of food insecurity in the world: Monitoring progress towards the World Food Summit and Millenium Development Goals. FAO, Rome.

FAO. (2014). State of food insecurity in the world 2003: Monitoring progress towards the World Food Summit and Millenium Development Goals. FAO, Rome.

Farsi, M. A., Alasalvar, C., Morris, A., Baron, M., and Shahidi, F. (2005). Comparison of antioxidant activity, anthocyanins, carotenoids and phenolics of three native fresh and sun dried

date(*Phoenix dactylifera L.*) varieties grown in Oman. *Journal of Agriculture and Food Chemistry,1*-9.

Fatima, A., Singh, P. P., Irchhaiya, and R., Agarwal, P. (2013). Effect of leaves of *Carissa spinarum* linn. on blood glucose and lipid profile in alloxan induced diabetic rats. *American Journal of Phytomedicine and Clinical Therapeutics,* 4,385-394.

Fedha, M. S., Mwasaru, M. A., Njoroge, C. K., Ojijo, N. O., and Ouma, G. O. (2010). Effect of drying on selected proximate composition of fresh and processed fruits and seeds of two pumpkin species. *Agriculture and Biology Journal of North America,1*(6),1299-1302.

Fennema (1976). Principles of food science. Food chemistry. New York: Marcel Dekker Inc.

Gajanana, T. M., Gowda, I. N. D., and Reddy, B. M. C. (2010). Exploring market potential and developing linkages– A case of underutilized fruit products in India. *Agricultural Economics Research Review,* 23, 437- 443.

Galoburda, R., Boca, S., Skrupskis, I., and Seglina, D. (2014). Physical and chemical parameters of strawberry puree. *Foodbalt,* 172-177.

Garcia, J. M., Infante, J. A., Guzman, N. E. R., Baca, P. R., Cadillo, M. G. C., and Laredo, R. F. G. (2013). Drying parameters of half-cut and ground figs (*Carissa spinarum L.)* var. Mission and the effect on their functional properties. *Journal of Engineering,*10830,1-8.

Garmakhany, A. D., Kashaninejad, M., Amiri, S. S., and Nikoo, M. A. R. (2013). Effect of moisture content on biophysical properties of pomegranate seeds. *Minerva Biotechnologica, 25* (1), 9-16.

Geeta, K., and Sharda, K. (2013). Nutritional evaluation of Giloe (*Tinospora cordifolia*) extract incorporated energy dense food product. *Indian Journal of Research Paripex, 2*(9),41-43.

Gezer, I., H. H., and Demir, F. (2002). Some physical properties of Hacihaliloglu apricot pit and kernel. *Journal of Food Engineering, 56,* 49–57.

Gilani, A. H., Mehmood, M. H., Janbaz, K. H., and Khan, A. U. (2008). Ethnopharmacological studies on antispasmodic and antiplatelet activities of *Ficus carica*. *Journal of Ethnopharmacology, 119*, 1-5.

Girija, k., Lakshman, K., Udaya , C., Sachi, G. S., Divya, T.(2011). Anti- diabetic and anti-cholesterolemic activity of methanol extracts of three species of *Amaranthus*. *Asian Journal of Tropical Biomedicine;2* (1), 133-138.

Giusti, M. M., and Wrolstad, R. E. (2001). Characterization and measurement of anthocyanins by UV-visible spectroscopy. Unit F1.2. In Current Protocols in Food Analytical Chemistry. New York*:* John Wiley and Sons, Inc.

Gorecka, D., Pacholek, B., Dziedzic, K., and Gorecka, M. (2010). Raspberry pomace as a potential fiber source for cookies enrichment. *ACTA, Scientarium Polonorium Technologia Alimenariat, 9*(4),451-462.

Guesmi, F., Ferchichi, A., Fares, K., and Touil, L. (2006). Identification and differentiation of *Carissa spinarum L.* cultivars using inter simple sequence repeat markers. *African Journal Biotechnology, 5*(15), 1370-1374.

Gupta, P., Bhatnagar, I., Kim, K. S., Verma, A. K., and Sharma, A. (2014). *In-vitro* cancer cell cytotoxicity and alpha amylase inhibition effect of seven tropical fruit residues. *Asian Pacific of Tropical Biomedicine*,*4*(2),S665-S671.

Gupta, S., and Prakash, J. (2011). Nutritional and sensory quality of micronutrient-rich traditional products incorporated with green leafy vegetables. *International Food Research Journal, 18,* 667-675 .

Guvenc, M., Tuzcu, M., and Yilmaz, O. (2009). Analysis of fatty acid and some lipophilic vitamins found in fruits of the *Carissa spinarum* variety picked from the Adiyaman district. *Research Journal of Biological Sciences*,*4* (3),320-323.

Hakkinen, S. H., and Torronen, A. R. (2000). Content of flavonols and selected phenolic acids in strawberries and *Vaccinium* species: influence of cultivar, cultivation site and technique. *Food Research International Journal,33*, 517–24.

Hakkinen, S., Heinonen, M., Karewlampi, S., Mykkanen, H., and Torronen, A. R. (2000). Influence of domestic processing and storage on flavonols contents in berries. *Journal of Agriculture Food Chemistry, 48* (7), 2960-2965.

Hanwate, B. D., Kadam, R. M., and Yadav, D. N. (2005). Utilization of Karonda (*Carissa caranda*) juice in the manufacture of flavoured milk. *Department of Animal Husbandry and Dairy Science,*21-22.

Harborne, J. B. (1973). Phytochemical methods. *Chapman and Hall Ltd. London,* 11-113.

Hardi, Z. U., Zukic, M., Komlenic, D. K., Sabo, M., and Hardi, J. (2007). Quality parameters of noodles made with various supplements. *Czech Journal of Food Science,25*(3),151-157.

Hassan, S.W., Umar, R.A., Maihanu, H. M., Matazu, I. K., Faruk, U.Z., and Sani, A.A. (2007). The effect of drying methods on the nutrients and non- nutrients composition of leaves of *Gynandropsis gynandra* (*Capparaceae*). *Asian Journal of Biochemistry,*2, 349-353.

Hayat, K., Zhang, X., Farooq, U., Abbas, S., Xia, S., Jia, C. et al. (2016). Effect of microwave treatment on phenolic content and antioxidant activity of citrus mandarin pomace. *Food chemistry, 123,*423-429.

Hazbavi, E., Khoshtaghaza, M. H., Mostaan, A., and Banakar, A. (2014). Effect of storage duration on some physical properties of date palm (cv. Stamaran). *Journal of the Saudi Society of Agricultural Sciences, XXX,* XXX-XXX.

Hedge, J. E., and Hofreiter, B. T. (1962). In carbohydrate chemistry its stability in model systems. New York Academic Press. *Journal of Food Science and Technology, 30* (4), 246-8.

Heshe, G. G., Haki, G. D. and Woldegiorgis, A. Z. (2015). Effect of refined milling on the nutritional value and antioxidant capacity of wheat types common in Ethiopia and a recovery attempt with bran supplementation in bread. *Journal Food Process Technology,6*,11.

Ho, L. H., and Dahari, N. C. (2016). Effect of watermelon rind powder on physicochemical, texture and sensory properties of wet noodles. CyTA-*Journal of Food*, 14(3),465-472.

Ho, L. H., Latif, N. W. B. A. (2016). Nutritional composition, physical properties, and sensory evaluation of cookies prepared from wheat flour and pitaya (*Hylocereus undatus*) peel flour blends. *Cogent Food and Agriculture*, 2, 1-10.

Holland, N., Menezes, H. C., and Lafuente, M. T. (2002). Carbohydrate as related to the heating induced chilling tolerance and respiratory rate of 'Fortune' mandarin fruit harvested at different maturity stages. *Postharvest Biological Technology, 25*, 181–191.

Hosseinaei, O., Wang, S., Enayati, A. A., and Rials, T. G. (2012). Effects of hemicellulose extraction on properties of wood flour- plastic composites. *Composite Part A , 43*,686-694.

Hui, Y. H., Puil, C., Isabel, G. L., Miang, H. L., Murrell, K. D. et al. (2004). Hand book of frozen foods. *Marcel Dekker Incorporated*, 74 – 75.

Hultman, L., and Rustard, T. (2004). Iced storage of Atlantic salmon (*Salmo salar*) effects on endogenous enzymes and their impact on muscle proteins and texture. *Food Chemistry, 87*,31–34.

Hussain, I., Amjad, S. A. M., and Ahmeed, R. (2015).Effect of modified sun drying techniques on fruit quality characters of dates harvested at rutab stage. *Journal of Agriculture Research,52*(3),415-423.

Ibitoye, W. O., Afolabi, M. O., Otegbayo, B. O., and Akintola, A. C. (2013). Preliminary studies of the chemical composition and sensory properties of sweet potato starch- flour blend noodles. *Official Journal of Nigerian Institute of Food Science and Technology,31*(2),48-51.

Ibrahim, K. M., Shawi, N. A., and Juboury, A. A. (2014). A Study on the Hypoglycemic effect of *Carissa spinarum* L. leaves aqueous extract against alloxan-induced diabetes in rabbits. *Medical Journal of Babylon, 6*,1-3.

Incedayi, B., Tamer, C. E., Sinir, G. O., Suna, S., and Copur, O. U. (2016). Impact of different drying parameters on colour, beta carotene, antioxidant activity and minerals of apricot *(Prunus armeniaca L.).Food Science and Technology, 36*(1), 171-178.

Intankar, P. R., Lokhande, S. J., Verma, P. R., and Arora, S. K. (2011). Antidiabetic potential of unripe *Carissa carandas* linn. fruit extract. *Journal of Ethanopharmacology, 135*,430-433.

Ioannou, I., Hafsam, I., Hamdi, S., Charbonnel, C., and Ghoul, M. (2012). Review of the effects of food processing and formulation on flavonoid and anthocyanin behavior. *Journal of Food and Engineering,111*, 208-217.

Irondi, A. E., Anokam, K. K., and Ndidi, U. S. (2013). Effect of drying methods on the phytochemicals composition and antioxidant activities of *Carica papayas* seed. *International Journal of Biosciences,3*(11),154-163.

Islam, M. S. (2011). Effects of the aqueous extract of white tea (*Camellia sinensis*) in a streptozotocin- induced diabetic model rats. *Phytomedicine*, 19, 25- 31.

Itankar, P. R., Lokhande, S. J., Verma, P. R., Arora, S. K., and Patil, A. T. (2011). Antidiabetic potential of unripe *Carissa carandas* Linn. fruit extract. *Journal of Ethanopharmacology,17*, 135(2),430-433.

Jahromi, G., Shahdadi, A., and Nasabpour, R. (2014). Composition of phenolic- compounds antioxidant activity and microbial quality of two varieties of fresh and frozen date-palm fruit during eight months storage in freezer. *International Journal of Farming and Allied Sciences, 3* (9),1025-1030.

Jan, I., and Rab, A. (2012). Influence of storage duration on physico-chemical changes in fruit of apple cultivars. *The Journal of Animal and Plant Science,22*(3),708-714.

Jauharah, M. Z., Rosli, W. I., and Robert, D. S. (2014). Physicochemical and sensorial evaluation of biscuit and muffin incorporated with young corn powder. *Sains Malaysian, 43*(1), 45-52.

Jayakumar, S. P., Seni, M., Jagadeesan, M., and Sundararajan, R. (2014). Antidiabetic and antioxidant effects of ethanolic extract of Anjir leaves *(Ficus carica)* in alloxan induced diabetic rat. *Asian Journal of Phytomedicine and Clinical Research, 2*(1), 1 - 10.

Jeong, S. M., Kim, S. Y., Kim, D. R., Jo, S. C., Nam, K. C. et al. (2004). Effect of heat treatment on the antioxidant activity of extracts from citrus peels. *Journal of Agriculture and Food Chemistry,52*,11, 3389-3393.

Jha, S. N., Kingsly, A. R. P., and Chopra, S. (2006). Physical and mechanical properties of mango during growth and storage for determination of maturity. *Journal of Food Engineering, 72*,73-76.

Jin, P., Wang, S. Y., Wang, C. Y., and Zheng, Y. (2011). Effect of cultural system and storage temperature on antioxidant capacity and phenolic compounds in strawberries. *Food Chemistry, 124*,262-270.

Johnson, J. T., Iwang, E. U., Hemen, J. T., Odey, M. O., Efiong, E. E., and Eteng, O. E. (2012). Evaluation of anti-nutrient of watermelon *Citrullus lanatus*. *Annals of Biological Research,3*(11),5145-5150.

Joseph, B., and Raj, S. J. (2011). Pharmacognostic and phytochemical properties of *Carissa spinarum* Linn- An overview. *International Journal of Pharm Tech Research, 3* (1),8-12.

Juan, J. M. G., Alberto, G. I., Nuria, E. R. G., Patricia, R. B., Maria, G. C. C. et al. (2013). Drying parameters of half-cut and ground figs *(Ficus carica)* var. Mission and the effect on their functional properties. *Journal of Engineering*, 1-8,710830.

Juhaimi, F. A., Uslu, N., Bozkurt, D., Ghafoor, K., Babiker, E. E. et al. (2015). Effects of oven and microwave drying on phenolic contents and antioxidant activities in four apple cultivars. *Quality Assurance and Safety of Crops and Foods, Article in Press*, 1757-837X.

Jung, S. T., Park, S. Y., Zachwieja, M. F., Barton, H., Piotrowicz, E. K. et al. (2005). Some essential phytochemical and the antioxidant potential in fresh and dried persimmon. *International Journal of Food Science and Nutrition, 65*(2),105-113.

Kadam, M. L., Salve, R. V., Mehrajfatema, Z. M., and More, S. G. (2012). Development and evaluation of composite flour for missi roti /chapatti. *Journal Food Processing Technology, 3*,134,2-7.

Kamiloglu, S., and Capanoglu, E. (2015). Polyphenol content in Figs (*Carissa spinarum* L.). Effect of sun drying. *International Journal of Food Properties, 18*,521–535.

Kamiloglu, S. (2012). Effect of sun- drying on polyphenols and in vitro bioavailability of Sarilop and Bursa Siyahi figs *(Carissa spinarum L.).* Istanbul Technical University. *Graduate School of Science Engineering and Technology,* 1-140.

Kamiloglu, S., Serali, O., Unal, N., and Capanoglu, E. (2013). Antioxidant activity and polyphenol composition of black mulberry *(Morus nigra L.)* products. *Journal of Berry Research,3*,41-51.

Kanuur, C., and Khandelwal, K. (2014). Pharmacognostical investigation and evaluation of *Carissa spinarum* fruit extract for adaptogenic activity. *International Journal of Pharmaceutical Sciences and Research,* 5 (5), 2022-2032.

Kar, D. M., Maharana, L., Pattnaik, S., and Dash, G. K. (2006). Studies on hypoglycemic activity of *Solanum xanthocarpum* Schrad. And wendl. fruit extract in rats. *Journal of Ethnopharmacology ,108*, 251 - 56.

Kashaninejad, M., Mortazavi, A., Safekori, A., and Tabil, L. G. (2006). Some physical properties of pistachio *(Pistacia vera L.)* nut and its kernel. *Journal Food Engineering*,72,30-38.

Kaur, A., and Kochhar, A. (2014).Sensory and nutritional evaluation of value added products using potato flour for nutritional and health benefits. *International Journal of Medical Sciences, 7*(1),1-6.

Kawka, A., Gorecka, D., and Gasiorowski, H. (1999). The effects of commercial barley flakes on dough characteristic and bread composition. *Food Science and Technology,2*(2).

Khan, M. N., Sarwar, A., Adeel, M., and Wahab, M. F. (2011). Nutritional evaluation of *Carissa spinarum* indigenous to Pakistan. *African Journal of Food Agriculture, Nutrition and Development, 11*(5),1684-5374.

Khan, M. N., Sarwar, A., Adeel, M., and Wahab, M. F. (2011). Nutritional evaluation of *Carissa spinarum* on the contents of sugars,organic acid and phenolic compounds. *Journal of Agriculture and Food Chemistry, 59,*11696 -11702.

Khan, A., and Vincet, J. F. V. (1996). Mechanical damage induced by controlled freezing in apple and potato. *Journal Texture Studies*, 27,143-153.

Khanal, R. C., Howard, L. R., and Prior, R. L. (2010). Effect of heating on the stability of grape and blueberry pomace procyanidins and total anthocyanins. *Food Research International,43,*1464-1469.

Khapre, A. P., Satwadhar, P. N., and Deshpande, H. W. (2015). Studies on standardization of fig fruits (*Ficus carica*) powder enriched cookies and its composition. *Asian Journal of Dairy and Food Research,4*, 71-74.

Khapre, A. P., and Satwadhar, P. N. (2010). Physico-chemical characteristics of fig fruits (*Ficus carica)* cv Dinkar and its cabinet dried powder. *Food Science Resources Journal,2*(1),23-25.

Kojic, A. B., Planinic, M., Tomas, S., Jokic, S., Bilic, M., and Velic, D. (2011). Effect of extraction condition on the extractability of phenolic compounds from lypophilised fig fruits (*Ficus carica). Polish Journal of Nutritional Science,61*(3),195-199.

Komolka, P., Gorecka, D., and Dziedzic, K. (2012).The effect of thermal processing of cruciferous vegetables on their content of dietary fiber and its fractions. *Acta Scientarium Polonorum Technologia Alimentaria,11*(4),347-354.

Krishan, P. G., Chang, K. C., and Brown, G. (1987). Effect of commercial oat bran on the composition of bread. *Cereal Chemistry,64*(1),55-58.

Krishanprabha, V., and Kiruthiga, V.(2015). Development and analysis of nutrients, antioxidants in sweet potato and pumpkin powder incorporated value added products. *International Journal of Advanced Research in Biological Sciences, 2*(4),65-71.

Kshetrimayum, R., Shukla, R. N., and Mishra, A. (2015). Study on drying and quality characteristics of tray and microwave dried guava slices. *International Journal of Science, Engineering and Technology, 3*(4),965-969.

Kulkarni, A.S., and Joshi, D.C.(2013). Effect of replacement of wheat flour with pumpkin powder on textural and sensory qualities of biscuit. *International Food Research Journal, 20*(2), 587-591.

Kulkarni, S. S., Deasai, A. D., Ranveer, R. C., and Sahoo, A. K. (2012). Development of nutrient rich noodles by supplementation with malted ragi flour. *International Food Research Journal,19(1*),309-313.

Kumar, S., Kumar, V., Parkash, M. (2012). Antidiabetic and hypolipidemic activities of kigelia pinnata flowers extract in a streptozotocin induces diabetic rats. *Asian Journal of Tropical Biomedicine;2* (7), 543-546.

Kumari, V. P., and Sangeeta, N. (2014). Process development and evaluation of quality characteristics of multilegume pasta. *Asian Journal Dairy and Food Research*, 33 (3) ,190-196.

Kwok, B. H. L., Durance, H. C., and Kitts, D. D. (2004). Dehydration techniques affects phytochemical contents and free radical scavenging activities of Saskatoon berries *(Amelanachier alnifolia Nutt.). Journal of Food Science,69*(3),122-126.

Laleh, G. H., Frydoonfar, H., Heidary, R., Jameei, R., and Zare, S. (2006). The effect of light, temperature, pH and species on stability of anthocyanin pigments in four *Berberis* Species. *Pakistan Journal of Nutrition, 5*(1), 90-92.

Lee, S. C., Kim, J. H., Jeong, S. M., Kim, D. R., Ha, J. U. et al. (2003). Effect of far- infrared radiation on the antioxidant activity of rice hulls. *Journal Agriculture Food Chemistry, 51,* 4400-4403.

Legesse, M. B., and Emire, S. A. (2012). Functional and physicochemical properties of mango seed kernels and wheat flour and their blends for biscuit production. *African Journal of Food Science and Technology*,3(9),193-203.

Leong, S. Y., and Oey, I. (2012). Effect of processing on anthocyanins, carotenoids and vitamin C in summer fruits and vegetable. *Food Chemistry,133,*1577-1587.

Lisa, A., and Felicetti, L. (2002). Fiber digestibility and nitrogen requirements of Blue Duikers. *Journal of Zoology Biology, 21*,123-134.

Lisa, L. P. (1997). Wild plant food in agricultural environment: A study of occurrence, management and gathering rights in North East Thailand. *Human Organization, 56,* 209-221.

Liu, S. C., and Tsai, C. W. (2012). Effect of heating time on the antioxidative capacities of citrus fruit *(Citrus sinesis)* by products. *Food Science Technology Resources,18*(4),505-513.

Lohchoompol, V., Srzednicki, G., and Craske, J. (2004). The change of total anthocyanin in blueberries and their antioxidant effect after drying and freezing. *Journal of Biomedicine and Biotechnology,5,*248-252.

Lopez, J., Galvez, A. V., Torres, M. J., Mondaca, L. R., Quispe, I. F., and Scala, K. D. (2013).Effect of dehydration temperature on physico-chemical properties and antioxidant capacity of goldenberry (*Physalis peruviana* L.). *Chilean Journal of Agricultural Research,73*,1-3.

Lopez, M. R. R., Diaz, P. O., Perez, L. A. B., Tovar, J., and Nicanor, A. B. (2011). Fiber concentrates from orange (*Citrus sinesis* L.) Bagase: Characteristics and application as backery product ingredients. *International Journal of Molecular Science*, 12, 2174-2186.

Lutz, M., Hernandez, J., and Henriquez, C. (2015). Phenolic content and antioxidant capacity in fresh and dry fruits and vegetables grown in Chile. *CyTA Journal of Food*, *13*(4), 541-547.

Macias, M. A., Martinez, A, C., Mounir, S., Gaitan, G. M., and Allaf, K. (2013). Comparative study of the effects of drying methods on antioxidant activity of dried strawberry (*Fragaria* Var. *Camarosa*). *Journal of Food Research*, *2*(2),92-107.

Mahapatra, A. K., Mishra, S., Basak, U. C., and Panda, P. C. (2012). Nutrient analysis of some selected wild fruits deciduous forests of India: an explorative study towards non conventional bio-nutrition. *Advance Journal of Food Science and Technology 4*(1),15-21.

Mahmoud, M. H., Qura, A. Z. E., Badawy, I. H., Yehya, A., Hady, A. et al. (2013). Hypocholesterolemic effect of antioxidant containing fruits in rats fed on high cholesterol and fat diet. *Journal of Applied Sciences Research, 9* (7), 4233-4244.

Malomo, S. A., Eleyinmi, A. F., and Fashakin, J. B. (2011). Chemical composition, rheological properties and bread making potentials of composite flours from breadfruit, breadnut and wheat. *African Journal of Food Science, 5*(7), 400 – 410.

Manach, C., Scalbert, A., Moorand, C., Remesy, C., and Jimenez, L. (2004). Polyphenols: food sources and bioavailability. *American Journal Clinical Nutrition,79,*727-747.

Mansour, E. H., Dworschak, E., Pollhamer, Z., Gergely, A., Matazu, I. K. et al. (1999). The effect of drying method on the nutrients and non-nutrients composition of the front of *Hibiscus esculentus*(Okra). *Nigeria Journal Renewable Energy, 11,* 9-13.

Mansour, E. H., Dworschak, E., Pollhamer, Z., Gergely, A., and Hovari, J. (1999). Pumpkin and canola seed proteins and bread quality. *Acta Alimentaria*,28,59-70.

Matazu, I.K. and Haroun, A. A. (2004). The effect of drying method on the nutrients and non-nutrients composition of the fruits of *Hibiscus esculentus* (Okra). *Nigerian Journal Renewable Energy*, 11, 9-13.

Matsuo, T., and Itoo, S. (1978). The chemical structure of kaki - Tannin from immature fruit of the persimmon *(Diospyros kaki L.). Agricultural Biological Chemistry, 42,*1637 - 1643.

Mc Clement, D. J. (2003). Analysis of Food Products. Accessed July 26,2012. http:// people.u.mass.edu/-mcclemen/581Ash$Minerals.html.

Mc Donald, J. k., Caflin, N. A., Sommano. S., and Cocksedge, R. (2006). The Effect of post analysis of food Products. Accessed July26,2012.http://people.umass.edu/mcclemen/581Ash and minerals.html.

Mechlouch, R. F., Elaskesh, E. O., Elfalleh, H. H. W., and Thabet, A. A. G. (2015). Changes in the physico-chemical properties of palm date using different drying methods. *University, Bulletin,17*(1),59-78.

Meda, V., Gupta, M., and Opoku, A. (2008). Drying kinetics and quality characteristics of microwave–vacuum dried Saskatoon berries. *Journal of Microwave Power and Electromagnetic energy, 42*(4),42-44.

Mehraj, H., Sikder, R. K., Haider, M. N., Hussain, M.S., and Uddin, A. F. M. J. (2013). Fig (*Ficus carica*). A new crop in Bangladesh. *International Journal of Buisness, Social and Scientific Research, 1*(1),2309-7892.

Mehta, S. (1995). *Evaluation of different cultivars of Anola (Emblica officinalis Garten) for processing* . MSc. Thesis.CCS HAU, Hisar.

Mhalaskar, S. R., Lande, S. B., Satwadhar, P. N., Deshpande, H. W., and Babar, K. P. (2012). Development of technology for fortification of fig (*Ficus carica*) fruit into its value added product- fig toffee. *International Journal of Processing and Post Harvest Technology,3* (121),176-179.

Michael, O. A., Gernah, D. I., and Igbabul, D. (2013). Physico-chemical and sensory evaluation of wheat bread supplemented with stabilized undefatted rice bran. *Food and Nutrition Sciences*, 4, 43-48 .

Mihajer, S., Taha, R. M., and Mohajer, M. (2016). Effects of cryopreservation and relative humidity on viability and nutritional composition of sainfoin (*Onobrychis vicifolia scop*.). *Journal of Animal and Plant Science, 26* (2),116-122.

Miletic, N., Popovic, B., Mitrovic, O., Kandic, M., and Leposavic, A. (2014). Phenolic compounds and antioxidant capacity commonly consumed in Serbia. Czech. *Journal of Food Science,32* (4),360-368.

Ministry of Health and Family Welfare. (2008). Department of Ayurveda yoga and neuropathy, Unani siddha homoeopathy, *New Delhi, First edition (AYUSH),VI* (1),340.

Mishra, G., Mishra, A. A., and Shukla, R. N. (2014). Development of pulse, banana and pineapple pomace based weaning food and its quality evaluation during storage. *International Journal of Development Research,* 4 (6),1257-1262.

Mishra, D. K., Dolan, K. D., and Yang, L. (2008). Confidence intervals for modeling anthocyanin retention in grape pomace during non isothermal heating. *Journal of Food Science, 73,* E9–E15.

Mishra, R. M., and Gupta, P. (2005). Frugivory and seed dispersal of *Carissa spinarum (* L.*)* in a tropical deciduous forest of central India. *International Society for Tropical Ecology*,46(2),151-156.

Mithanka, D. M. T. (2012). Polyphenol content and antioxidant analysis of *Pseudolachinostylis Maprouneifolia Pax* Var Dikindtii used as livestock feed farmers from Eastern Botswana. *Journal of Pharmaceutical and Scientific Innovation,1*(5),51-57.

Mohammadian, M. A., Mobrami, Z., and Sajedi, R. H. (2011). Bioactive compounds and antioxidant capacities in the flavedo tissue of two citrus cultivars under low temperature. *Brazilian Society of plant physiology, 23*(3), 203-208.

Mohsenin, N. N. (1986). Physical Properties of Plant and Animal Materials, New York: Gordon and Breach Science Publishers.

Mohsenin, N. N. (1970). Physical Properties of Plant and Animal Materials. Gordon and Breach Science Publishers, New York, USA.

Moldovan, B., and David, L. (2014). Studied the temperature and preserving agents on the stability of cornelian cherries anthocyanins. *Molecules, 19*, 8177-8188.

Monica, A., Madeau, E., Piscopo, A. E., Sanguinetti, E., Caro, A. D., Poiana, M. E., Romeo, V. et al. (2009). *European Food Resources, 228*,441-448.

Mori, K., Yamamoto, N. G., Kitayama, M., and Hashizume, K. (2007). Loss of anthocyanins in red- wine grape under high temperature. *Journal of Experimental Botany, 58*(8),1935–1945.

Morris, A., Barnett, A., and Burrows, O. (2004). Effect of processing on nutrient content of foods. *Cajarticles, 37*,160-164.

Morton, J. (1987). Fruits of warm climates. (Book. Fl. Ig. Miami, 2005), 47-50.

Morton, J. F. (1987). Fruits of warm climates. Creative Resources Systems, *Inc. Winterville*, N.C.,USA,503.

Mrabet, A., Gutierrez, G. R., Bejarano, R. G., Arcos, R. R., Ferchichi, A., Sindic, M., and Araujo, A. J. (2015). Valorization of Tunisian secondary date varieties (*Phoenix dactylifera L*.) by hydrothermal treatments: New fiber concentrates with antioxidant properties. *LWT-Food Science and Technology, 60*,518-524.

Mule, P. R., Barbind, R. P., Korake, R. L., and Gavit, D. P. (2014). Proximate composition, sensory evaluation and production cost of fig milk shake prepared from buffalo milk. *Animal Science, 8*(2),43-47.

Mullen, W., Stewart, A. J., Michael, E., Jean, J., Gardner, P., Garry, G. D. et al. (2002). Effect of freezing and storage on the phenolic, ellagitannins, flavonoids and antioxidant capacity of red raspberries. *Journal of Agriculture and Food Chemistry, 50*,5197-5201.

Musa, A. (2013). Effect of freezing on some plant toxins and micronutrients in the leaves of *Amaranthus Cruenthus*. *Journal of Food Studies,2*(1),75-92.

Musa, K. H., Abdullah, A., Jusoh, K., and Subramaniam, V. (2011) Antioxidant activity of pink-flesh guava (*Psidium guajava* L.): effect of extraction techniques and solvents. *Food Analytical Method, 4*, 100–7.

Mutso, M., and Satrino, M. L. (2010). Fruit responses to postharvest heat treatment time: characterization of heat-treated strawberry (*Fragaria x ananassa*) cv. 'Candonga' fruits. *Agronomy Research 8*, (1), 815–826.

Nackilcioglu, E., and Hisil, Y. (2013). Research on the phenolic compounds in Sarilop (*Carissa spinarum* L.) fig variety. *GIDA, 38*(5), 267-274.

Nakamura (2008). Preliminary studies on the removal of astringency by freezing in Japnese persimmons. *Journal of the Japnese Society for Horticultural Science, 30*(1),73-76.

Nandan, U., and Bhardwaj, R. (2014). The role of underutilized fruits in nutritional and economic security of tribals: a review. *Critical Reviews in Food Science and Nutrition*,54 (7),880-890.

National Sample Survey Office. (2012). Ministry and Statistics and Programme Implementation, New Delhi Government of India.

Neal, M. C. (1965). In Gardens of Hawaii, University of Hawaii and Bishop Museum, Honolulu, Hawaii, USA, 40.

Nermin, B. (2008). Utilization of buckwheat flour in gluten-free noodles production. *Journal of Food, Agriculture environment, 62* (20),113-115.

Ngueguim, T. F., Dimo, T., Dzeufiet, D. P. D., Vouffo, B., Dongo, E., Renaud, B. et al. (2007). Antidiabetic activities of methanol-derived extract of *Dorstenia picta* twigs in normal and streptozotocin-induced diabetic rats. *Asian Journal of Traditional Medicines,2* (4), 140 - 148.

Nicoli, M. C., Anese, M., and Parpinel, M. (1999). Influence on processing on the antioxidant properties of fruits and vegetables. *Trends in Food Science and Technology,10*, 94-100.

Nieman, D. C., Butterworth, D. E., and Nieman, C. N. (1992) Nutrition. *WmC. Brown Publishers*, Dubugye, 237-312.

Nilsson, J. S., Stegmark, R., and Akesson, B. (2004). Total antioxidant capacity in different pea *(Pistum sativum)* varieties after blanching and freezing. *Food Chemistry,86,*501-507.

Nimkar, P. M., and Chattopadhyay, P. K. (2001). Some physical properties of green gram. *Journal of Agricultural Engineering Resources*, *80* (2), 183-189.

Nithiyanantham, S., Varadharajan, S., and Siddhuraju, P. (2012). Differential effects of processing methods on the total phenolic content, antioxidant and antimicrobial activities of three species of Solanum. *Journal of Food and Drug Analysis,20*(4),844-854.

Njiida, A. A. (2010). Chemical composition, fiber fraction and anti-nutritional substances of semi arid browse forages of North- Eastern Nigeria. *Nigerian Journal of Basic and Applied Science, 18* (2),181-188.

Noonan, S. C., and Savage, G. P. (1999).Oxalate content of foods and its effect on humans. *Asia Pacific Journal Clinical Nutrition,8,*64-74.

Nordin, N. I. A. A., Ariffin, H., Andou, Y., Hassan, M. A., Shirai, Y., Nishida, H. et al. (2013). Modification of oil palm mesocarp fiber characteristics using superheated steam treatment. *Molecules, 18*, 9132-9146.

Noutchogoue, V. K., Kapseu, C., Tchiegang, C., Piffaut, B., and Parmentier, M. (2005).Textural and Biochemical changes associated with the hardening phenomenon in aiele fruit (*Canarium Schweinfurthi Eng). Journal of Food Technology,3*(2),143-148.

Nwanekezi, E. C., and Agbugba, R. U. (2015). Effect of substitution of sucrose with date palm (*Phoenix dactylifera*) fruit on quality bread. *Food Processing and Technology,6*(9),484.

Nwaogwe, J. O., and Adejumo, B. A. (2015). Qualities of African breadfruit (*Treculia Africana*) seed flour influenced by thermal processing methods and duration. *International Journal of Technology Enhancement and Emerging Engineering Research, 3*(4),102-104.

Oancea, S., Moiseenco, F., and Traldi, O. P. (2014). Effects of freezing and oven drying of Romanian wild and cultivated red raspberries on total anthocyanins and total antioxidant capacity. *Romanian Biotechnological Letters, 19*(2), 9241-9247.

Obiegbuna, J. E., Akubor, P. I., Ishiwu, C. N., and Ndife, J. (2013). Effect of substituting sugar with date palm pulp meal on the physicochemical, organoleptic and storage properties of bread. *African Journal of Food Science*,7(6),113-119.

Oboh, G., Ademosun, A. O., Olasehinde, T. A., Oyeleye, S. I., and Ehiakhamen, E. O. (2015). Effect of processing methods on the antioxidant properties and inhibition of alpha amylase and alpha glucosidase by African pear (*Dacryodes edulis*) fruit. *Nutra foods*, *14*, 19-26.

Ogbadoyi, E. O., and Musa, A. (2013). Effect of freezing on some plant toxins and micronutrients in the leaves of *Amaranthus cruentus. Journal of Food Science,2* (1),75-92.

Ogunbanwo, S. T., Azinat, S., Olufunke, A., and Fadahunsi, I. F. (2013). Microbiological and nutritional evaluation of water melon juice (*Citrullus lanatus*). *Academia Arena,5*(3),36-41.

Ojinnaka, M. C., Anyanwu, F. A., and Ihemeje, A. (2013). Nutritional evaluation of cookies produced from African breadfruit (*Treculia africana)* starch and wheat flour. *International Journal of Agricultural and Food Science*, 3(3), 95-99.

Olajire, A. A., and Azeez, L. (2011). Total antioxidant activity, phenolic, flavonoid and ascorbic acid contents of Nigerian vegetables. *African Journal of Food Science and Technology, 2*(2), 022-029.

Omer, U. C., and Canan, E. T. (2014). Fruit processing. Strategies for quality assessment. *Food Engineering Series*, DOI 10.1007/978-1-4939-1378-7-2.

Oyaizu, M. (1986). Studies on products of browning reaction: antioxidative activities of products of browning reaction prepared from glucosamine. *Jap*nese *Journal ofNutrition,44*, 307-315.

Ozcan, M., Arslan, D., and Unver, A. (2004). Effect of drying methods on the mineral content of basil (*Ocimum basilicum L.*). *Journal of Food Engineering, 69,* 375-379.

Oztekin, S., Erdem, T., and Karaaslan, S. (2011). Effect of hot air and microwave drying on some physical properties of laurel berry. *African Journal of Agricultural Research*, 6(12), 2676-2679.

Pacco, H. C., and Menegalli, F. (2004). Drying of sliced figs of 'Gigante de Valinhos' variety (*Carissa spinarum*). In Silva, M. A. and Rocha, S.C.S. (eds.) *Drying. Proceeding of the 14 th International Drying Symposium*, Sao Paulo, Brazil, 1851- 1858.

Pacco, H. C., Vigneault, C., Castro, L. R., Menegalli, F. C., and Cortez, L. A. B. (2007). Temperature effect on drying kinetics of 'Gigante de Valinhos' figs. *Journal of Food and Environment, 5*(2),70-75.

Padulosi, S., Hoeschle- Zeledon, I., and Bordoni, P. (2008). Minor crops and underutilized species: lessons and prospects In: N. Maxted, B.V. Ford-Lloyd, S.P. Kell, J.M. Iriondo, M.E. Dulloo, J. Turok eds. *Crop wild relatives, conservation and use.* Wallingford, UK: CAB International.

Pandey, A. K., Ojhav, V., Yadav, S., and Sandhu, S. K. (2011). Phytochemical evaluation and radical scavenging activity of *Bauhinia variegate, Saraca asoka* and *Terminalia arjuna* barks. *Resource Journal Phytochemistry,2*,89-97.

Pandey, A. K., Dubey, A. K., Singh, R. K., and Vida, E. (2014). Addressing the problem of micronutrient malnutrition in Neh region- underutilized vegetables as a source of food. *International Journal of Food and Nutritional Science, 3*(3),75-83.

Papu, S., Singh, A., Javir, S., Sweta, S., Arya, A. M., and Singh, B. R. (2014). Effect of drying characteristics of garlic – a review. *Journal Food Process Technology,5*(4),1-6.

Pardeshi, I. L., Bhuskade, S. A., and Kalmegh, V. B. (2013). Development of cold extruded ready to cook (*Vigna radiate L.)* nuggets. *Journal of Food Research and Technology,1*(1),21-28.

Parmar, C., and Kaushal, M. K. (1982). *In: Wild Fruits.* Kalyani Publishers, New Delhi, India,15-18.

Patel, D. K., Kumar, R., Prasad, S. K., Sairam, K., and Hemalatha, S. (2011). Antidiabetic and *in vitro* antioxidant potential of *Hybanthus enneaspermus* (Linn) F. Muell in streptozotocin-induced diabetic rats. *Asian Pacific Journal of Tropical Biomedicine*,1,316-22.

Pathak, P. K., Preeti, D., and Kumar, S. (2009). Effect of post-harvest treatments on shelf-life of aonla (*Emblica officinalis*) fruits damaged during harvesting. *Journal of Food Science Technology, 46*, 283–285.

Patras, A., Brunton, N. P., Donnell, C. O., and Tiwari, B. K. (2010). Effects of thermal processing on anthocyanin stability in foods; mechanisms and kinetics of degradation. *Trends in Food Science and Technology 21*,3-11 .

Perez, C., Dominquez, E., Canal, J. R., Campillo, J. E., and Tarres, M. D. (2000). Hypoglycemic activity of aqueous extract from *Carissa spinarum* fig tree leaves in streptozotocin diabetic rats. *Pharm Biology*,38(3),181-186.

Pewlong, W., Sajjabut, S., Eamsiri, J., and Chookaew, S. (2014). Evaluation of antioxidant activities, anthocyanins, total phenolic content, vitamin C content and cytotoxicity of *Carissa carandas* Linn. *Food and Applied Biosciences,13*(1),509-517.

Piga, A., Del, C. A., and Corda, G. (2003). From plums to prunes: Influence of drying parameters on polyphenols and antioxidant activity. *Journal of Agriculture and Food Chemistry, 51*,3675-3681.

Pimia, R. P., Hakkinen, S. T., Aarni, M., Suortti, T., Lampi, A. M., Eurola, M. et al. (2003). Blanching and long term freezing affect various bioactive compounds of vegetables in different ways. *Journal Science Food Agriculture,83*,1389-1402.

Pinki and Awasthi, P. (2014). Sensory and nutritional evaluation of value added cakes formulated by incorporating beetroot powder. *International Journal of Food and Nutrition Science,3*(6),145-148.

Planinic, M., Aliakbarian, B., Perego, P., Greganic, K., Tomas, S., and Kojic, A. B. (2015). Influence of temperature and drying time on extraction yield of phenolic compounds from grape pomace variety "Portogizac". *Chemical and Biochemical Engineering Quarterly,29*(3),343-350.

Poiana, M. E., Moigradean, D., and Alexa, E. (2010). Influence of home- scale freezing and storage on antioxidant properties and colour quality of different garden fruits. *Bulgarian Journal of Agriculture Science, 16* (2),163-171.

Pradhan, R. C., Naik, S. N., Bhatnagar, N., and Vijay, V. K. (2009). Moisture dependent physical properties of jatropa fruit. *Industrial Crops and Products, 29,* 341-347.

Pragati, D., and Dhawan, S. S. (2003). Effect of drying methods on nutrition composition of dehydrated aonla fruit (*Emblica officinalis Garten*) during storage. *Plant Foods for Human Nutrition, 58,* 1–9.

Pragati, S., Dahiya, S., and Dhawan, S. S. (2003). Effect of drying methods on nutritional composition of dehydrated anola fruit (*Emblica officinalis Garten*) during storage. *Plant Foods for Human Nutrition, 58*,1-9.

Prakash, D., Upadhyay, G., and Pushpangadna, P. (2011). Antioxidant potential of some under-utilized fruits. *Indo-Global Journal of Pharmaceutical Sciences, 1*(1), 25-32.

Pratyush, K., Masih, D., and Sonkar, C. (2015). Development and quality evaluation of pumpkin powder fortified cookies. *International Journal of Science, Engineering and Technology, 3*(4),1034-1038.

Price, M. L., Socoyoc, S. V. and Butler, L. G. (1978). A Critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. *Journal Agriculture Food Chemistry,* 26, 1214-1218.

Price, K. R., and Rhodes, M. J. C. (1997). Analysis of the major flavonoid glycosides present in four varieties of onion and changing in composition resulting from autolysis. *Journal of Science, Food and agriculture,74*,331-335.

Rabeta, M. S. and Lin, S. P. (2015). Effect of different drying methods on the antioxidant activities of leaves and berries of *Cayratia trifolia*. *Sains Malaysian, 44*(2),275-280.

Raffo, A., Leonardi, C., Fogliano, V., Ambrosino, P., Salucci, M., Gennaro, L. et al. (2002). Nutritional value of cherry tomatoes (*Lycopersicon esculentum* cv. Naomi F1) harvested at different ripening stages. *Journal Agriculture Food Chemistry,50,* 6550–6.

Rahman, S., M., Islam, M., R., Rahman, S., Mosaiab, T., Ahmed, F. K., Nusratun, N., Ahsan, S. et al. (2011). Antihyperglycemic studies with methanol Extract of *Annona reticulata* L. (Annonaceae) and *Carissa carandas* L. (Apocynaceae) leaves in swiss albino mice. *Advances in Natural and Applied Sciences, 5*(2),218-222.

Rai, N., Asati, B. S., Patel, R. K., and Yadav, D. S. (2005). Underutilized horticultural crops in North Eastern region. *ENVIS Bulletin: Himalayan Ecology, 13*(1),1-11.

Raj, A., and Masih, D. (2014). Physico chemical and rheological properties of wheat flour muffin supplemented with orange peel powder. *International Journal of Science and Research,3*(8),2319-7064.

Raji, A. O., Akinoso, R., and Raji, M. O. (2016). Effect of freeze- thaw cycles on the nutritional quality of some selected Nigerian soups. *Food Science and Nutrition, 4*(2),163-180.

Ramaswamy, H. S., and Tung, M. A. (1981). Thermophysical properties of apples in relation to freezing. *Journal of Food Science, 46,*724-728.

Rani, B., and Kawatra, A. (1994). Fiber constituents of some foods. *Plant Foods for Human Nutrition,45,*343-347.

Rashidi, A. A., and Noureddini, M. (2011). Hypoglycemic effect of the aromatic water of leaves of *Carissa spinarum* in normal and streptozotocin induced diabetic rats. *International Journal of Current Pharmaceutical Research,1,*372-379.

Ratti, C. (1994). Shrinkage during drying of foodstuffs. *Journal of Food Engineering, 23*(1),91-105.

Raupp, D. S., Rodrigues, E., Rockenbach, I. I., Carbonar, P. F. C., and Borasto, R. F. (2011). Effect of processing on antioxidant potential and total phenolic in beet(*Beta vulgaris L.). Cien. Technology Aliment. Campinas*,*31*(30),688-693.

Razavi, S. M. A., Pourfarzad, A., Sourky, H., and Jahoromy, S. H. R. (2010).The physical properties of fig *(Ficus carica)* as a function of moisture content and variety. *The Philippine Agricultural Scientist,41*,896-904.

Redddy, D. K., Jangabelli, M., and Singh, J. K. (2014). Utilization of an underexploited fruit (*Ficus carica*) as a preserved product. *Journal of Agroecology and Natural Resource Management,1*(2),78-81.

Rehman, S., Nandeem, M., Ahmad, F., Mushtaq, Z. (2013). Biotechnological production of xylitol rom banana peel and its impact on physicochemical properties of rusks. *Journal Agriculture Science Technology,15*,747-756.

Reyes, Y. C., Alvarez, L. D., Baez, D. A., Esquivel, O. O., and Moreno, A. O. (2013). Polyphenol oxidase inactivation by microwave oven and its phenolic profile of loquat (*Eriobotrya Japonica)* fruit. *Food and Nutrition Science*,4 (9B),87-94.

Rickman, J. C., Barrett, D. M., and Bruhn, C. M. (2007). Nutritional comparison of fresh,frozen and canned fruits and vegetables. Part1. Vitamins C and B and phenolic compounds. *Journal of the Science of Food and Agriculture,87*, 930-944.

Rickman, J. C., Bruhn, C. M., and Barrett, D. M. (2007). Nutritional comparison of fresh, frozen and canned fruits and vegetables II. Vitamin A and carotenoids, vitamin E, minerals and fiber. *Journal of Science of Food and Agriculture*, 0022-5142.

Rithiruangdej, P., Parnbankled, S., Donchedee, S., Wongsagonsup, R. (2011). Physical, chemical, textural and sensory properties of dried wheat noodles supplemented with unripe banana flour. *Kasetstar Journal (Natural Science),45*(3),500-509.

Rodríguez, R., Jiménez, A., Fernández-Bolaños, J., Guillén, R., and Heredia, A. (2006). Dietary fiber from vegetable products as source of functional ingredients. *Trends Food Science Technology, 17*, 3-15.

Romjaun, Z. Z., and Prakash, J. (2013). Development and assessment of fiber- enriched muffins. *Advances in Food Science,* 35(4), 159165.

Rosell, C. M., Rojas, J. A., and Benedita, B. C. (2011). Influence of hydrocolloids on dough rheology and bread quality. *Food Hydro-colloid,15*,75-81.

Rossetti, L., Fronzo, R. A., and Gharezi, R. (1990). Effect of metformin treatment on insulin action in diabetic rats: *in vivo* and *in vitro* correlations. *Metabol*, 39, 425-435.

Rosy, K., Gupta, A., and Sarita, S. (2015). Development and sensory optimization of low cost micronutrient rich nutritious product by using locally available food resources. *International Journal of Food and Nutritional Science,5*(1).

Rout, S. P., Kar, D. M., Mohapatra, S. B., and Swain, S. P. (2013). Anti-hyperglycemic effect *Annona Reticulata* L. leaves on experimental diabetic rat model. *Asian Journal of Pharmaceutical and Clinical Research, 6*(1),56-60.

Rozier, A., Lean, M. E. J., McDonald, M. S., and Black, C. (1995). Quantitative analysis of the flavonoid content of commercial tomatoes, onion, lettuice and celery. *Journal of Agriculture Food Chemistry, 42*, 281-285.

Rukayah, A. (1992). Buahbuahan Nadir Semonanjung Malaysia, Dewan Bahasadan Pustaka, Kuala Lumpur, Malaysia.

Rupasinghe, H. P. V., Wang, L., Huber, G. M., and Pittis, N. L. (2008). Effect of baking on dietary fiber and phenolics of muffins incorporated with apple skin powder. *Food Chemistry, 107*,1217-1224.

Ryder, J. M., Fletcher, G. C., Stec, M. G. and Seelye, R. J. (1993). Sensory, microbiological and chemical changes in hake stored in ice. *International Journal of Food Science Technology,28,* 169-180.

Sachin, A., Shreesh, K. O., and Divya, V. (2009). Characterization of streptozotocin induced diabetes mellitus in swiss albino mice. *Global Journal of Pharmacology, 3* (2),81-84.

Sadiq, I. S., Izugaize, T., Shiaibu, M., Dogoyaro, A. L., Garba, A. et al. (2013). The nutritional evaluation and medicinal value of date palm (*Phoenix dactylifera*). *International Journal of Modern Chemistry,4*,147-154.

Sae-kang, V., and Suphantharika, M. (2006). Influence of P^H and xanthan gum addition on freeze thaw stability of tapioca starch pastes. *Carbohydrate polymer,* 65,371-380.

Safy, F. S. E. (2014). Drying characteristics of laquot slices using different dehydration methods by comparative evaluation. *World Journal of Dairy and Food Sciences, 9* (2), 272-284.

Sakhale, B. K., Chalwad, R. U., and Pawar, V. D. (2012). Standardization of process for preparation of fig- mango mixed toffee. *International Food Research Journal,19*(3), 889-891.

Salgado, S. M., Guerra, N. B., and Filho, A. B. (1999). Frozen fruit pulps: Effects of the processing on dietary fiber contents. *Revista de Nutrico,50*,281-285.

Salim, N., Quatmane, A., Latrache, H., Ennhali, S., Zinelabidine, L. H. et al . (2014). Bioactive components and antioxidant activity of Morrocan Paprika (*Capscium annuum L.)* under different storage time and conditions. *Turkish Journal of Agricultural and Natural Sciences*, 1734-742.

Salmanian, S., Mahoonak, S. A. R., Alami, M., and Ghorbani, M. (2014). Phenolic Content, antiradical, antioxidant and antibacterial properties of Hawthorn (*Crataegus elbursensis*) seed and pulp extract. *Journal of Agricultural Science and Technology, 16*(2), 343-354.

Sandhu, M. K. (1990).“Fig’’ in fruits tropical and subtropical, T.K. Bose and Mitra, S. K, Eds, *Naya Prokash, Calcutta, India,* 650-663.

Sangeeta, S., and Mahanta, C. L. (2013). Effect of steaming, boiling and microwave cooking on the total phenolics, flavonoids and antioxidant properties of different vegetables of Assam, India. *International Journal of Food and Nutritional Science,2*(3)47-52.

Sanwal, R., and Chaudhary, A. K. (2011). Wound healing and antimicrobial potential of *Carissa spinarum* Linn. in albino mice. *Journal Ethnopharmacology,*135(3),792-6.

Sarkis, J. R., Jaeschke, D. P., Tessaro, I. C., and Marczak, D. F. (2013). Effects of ohmic and conventional heating on anthocyanin degradation during the processing of blueberry pulp. *Food Science and Technology, 51,* 79-85.

Saunders, R. M. (1990). "The Properties of Rice Bran as a Food Stuff," *Cereal Foods World, 35,* (7), 632-639.

Scheirber, A., Keller, P., and Carle, R. (2001). Determination of phenolic acids and flavonoids of apple and pear by high- performance liquid chromatography. *Journal of Chromatography A, 910,* 265-273.

Schmidt, B. M., Erdman, J. W., and Lila, M. A. (2005). Effects of food processing on blueberry antiproliferation and antioxidant activity. *Journal of Food Science,70* (6), S389-S394.

Schutz, H. G., and Cardello, A. V. (2001). A labeled affective magnitude (LAM) scale for assessing food liking/disliking. *Journal of Sensory Studies, 16,* 117–159.

Scibisz, I., and Mitek, M. (2007).The changes of antioxidant properties in high bush blueberries (*Vaccinium corymbosum* L.). During freezing and long –term frozen storage. *Acta Scientarium Polonrum Technologia Alimentaria, 6* (4),75-82.

See, E. F., Nadiah, W. A., Aziah, N. A. A. (2007). Physico chemical and sensory evaluation of breads supplemented with pumpkin flour. *Asian Food Journal,14*(2),123-130.

Seeminska, M.D., Najda, A., Dyduch, J., Gantner, M., and Klimek, K. (2015). The content of secondary metabolites and antioxidant activity of wild strawberry fruit (*Freagaria vesca* L.). *Journal of Analytical Methods in Chemistry, 83,*1238,1-8.

Seleem, H. A. (2015). Effect of blending doum (*Hyphaene thebacia*) powder with wheat flour on the nutritional value and quality of cake. *Food and Nutrition Science,6*,622-632.

Shaheel, S. K., Swami, D. V., Prasanna, B. K., and Krishna, U. K. (2015). Effect of blending of karonda (*Carissa caranda*) juice with guava, papaya and pineapple juice on its quality and organoleptic evaluation. *Plant archives,15*,187-192.

Sharifian, F., Motlagh, A. M., and Nikbakht, A. M. (2012). Pulsed microwave drying kinetics of fig fruits(*Carissa spinarum L*). *Australian Journal of Crop Science,6*(10),1441-1447.

Sharma, A., and Gupta, A. P. (2013). Evaluation of antioxidant activity and validated method for analysis of polyphenols from non – edible parts of Indian tropical fruits by using microwave assisted extraction and LC-MS/MS. *International Journal of Bio Science and Pharma,4,*(1),227-241.

Sharma, S. and Chopra, R. (2015). Formulation, chemical and textural analysis of biscuits prepared with malted green gram (*Vigna radiata*). *International Journal of Agricultural and Food Science,* 5(3),98-103.

Sharma, V., and Chawla, P. (2011). Development and nutrient evaluation of oat supplementated products for old age people with constipation. *Ethno Medicine*,5(3),161-164.

Sharnouby, G. A., Aleid, M. S., and Otaibi, M. A. (2012). Nutritional quality of biscuit supplemented with wheat bran and date palm fruits (*Phoenix dactylifera* L.). *Food and Nutrition Science,3*,322-328.

Shen, Y., Fukushima, M., Ito, Y., Murak, E., Honsono, T., Seki, T., Ariga, T. (2010). Verification of the antidiabetic effects of cinnamon (*Cinnamomum zeylancium*) using insulin uncontrolled type 1 diabetic rats and cultured adipocytes. Biosciences Biotechnology Biochemistry,74, 2418- 2425.

Shivasharanappa, K., and Londonkar, R . (2014). Evaluation of total phenolic content and free radical scavenging activity of *Ficus glomerata Roxb. International Journal of Pharmaceutical and Clinical Research, 6*(2), 133-137.

Shobaki, F. A., Bahay, A. M., and Esmail, R. S. A. (2010). Effect of fig fruits (*Ficus carica)* and its leaves on hyperglycemia in alloxan diabetic rats. *World Journal of Diary and Food Sciences,5*(1),47-57.

Sikora, E., Bieniek, M. I., and Borczak, B. (2013). Composition and antioxidant properties of fresh and frozen stored blackthorn fruits (*Prunus Spinosa L.). Acta Scientarium Polonorum Technologia,12*(4),365-372.

Silva, E. P., Cardoso, A. F. L., and Fante, C. (2013). Effect of postharvest temperature on the shelf life of gabiroba fruit (*Campomanesia pubescens*). *Food Science and Technology,33*(4),632-637.

Simonyan, K. J., Yiljep, Y. D., Oyatoyan, O. B., and Bawa, G. S. (2009). "Effects of Moisture Content on Some Physical Properties of *Lablab purpureus* (L.) Sweet Seeds". *Agricultural Engineering International,* 1279,(XI).

Singh, A., Grover, K., and Sharma, N. (2014). Nutritional evaluation of value added products using dehydrated greens for security of haematinic nutrient. *Food Science Research Journal,5* (2),168-173.

Singh, L., Yadav, N., Kumar, A. R., Gupta, A. K., Chacko, J. et al. (2007). Preparation of value added products from dehydrated bathua leaves (*Chenopodium album Linn*.). *Natural Product Radiance,6*(1),6-10.

Singh, S., Bala, N., Verma, A., and Srivastava, S. (2015). Development of noodles using banana peels as a functional ingredient. *International Journal of Pure Applied and Bio Science, 3* (1),87-91.

Singh, P., and Sharma, H. R. (2003). Nutritional and organoleptic evaluation of *Colocasia* leaf rolls supplemented with different protein sources. *Journal of Human Ecology,*14(6),467-469.

Singh, S., Singh, A. K., Joshi, H. K., Bagle, B. G., and Dhandar. D. G. (2009). Evaluation of packages for transportation and storability of aonla (*Emblica officinalis*) under semi-arid environment of Western India. *Journal of Food Science Technology, 46,*127–131.

Singleton, V. L., Orthofer, R., and Raventos, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-ciocalteau reagent. *Methods in Enzymology*, *299*,152-178.

Siriwattananon, L., and Maneerate, J. (2016). Effect of drying methods on dietary fiber content in dried and vegetable from non-toxic agricultural field. *International Journal of Geomate,11*(28),2896-2900.

Skrede, G. (1996). Fruits. In *Freezing Effects on Food Quality*; Jeremiah, L. E., Ed.; Dekker: New York.

Skupien, K. (2006). Evaluation of chemical composition of fresh and frozen blueberry fruit (*Vaccinium corymbosum* L.*). Acta. Sci.Pol. Hortorum Cultus,5*(1),19-25.

Slatnar, A., Klancar, U., Stampar, F., and Veberic, R. (2011). Effect of drying of figs (*Carissa spinarum* L.*)*on the contents of sugars, organic acid and phenolic compounds. *Journal of Agriculture Food Chemistry,9* (59),21,11696-702.

Sobota, A., and Luczak, J. (2010). Badania skladu chemicnego makaronow instant, Bromat. *Chem. Toksykol., XLIII*(4),515-522.

Solomon, A., Golubowicz, S., Yablowicz, Z., Grossman, S., Bergman, M., Gottlieb, H. E., Altman, A., Kerem, Z. et al. (2006). Antioxidant activities and anthocyanin content of fresh fruits of common fig *(Carissa spinarum L.). Journal of Agricultural and Food Chemistry, 54*(20),7717-7723.

Sonasong, P., Srzednicki, G., and Lohachoompol, V. (2010). Effects of preconditioning on quality of dried blueberries, 10th International Working Conference on Stored Product Protection, Julius-Kühn-Archiv, 425, 264-269.

Soni, N., Mehta, G. S., and Gupta, R. K. (2014). Estimation of nutritional, phytochemical, antioxidant and anti-bacterial activity of dried *Ficus carica*. *Journal of Pharmacy and Phytochemistry*, *32* (2), 158-165.

Sozzi, G. O., Abrajan-Villasenor, M. A., Trinchero, G. D., and Fraschina, A. A. (2005). Post harvest response of 'Brown Turkey' figs *(Carissa spinarum* L.*)* to the inhibition of ethylene perception . *Journal of the Science of Food and Agriculture,85*,2503-2508.

Stanley, M., Prince, P., Kamalakkannan, N., Venugopal, P., and Menon,V. P. (2004). Antidiabetic and antihyperlipidemic effect of alcoholic *Syzigium cumini* seeds in alloxan induced diabetic albino rats. *Journal Ethanopharmacology,91*,209-213.

Statin, C., Dineshkumar, P., and Nithiyananthan, K. (2012). Evaluation of antidiabetic activity of methanolic leaf extract of *Carissa spinarum* in alloxan- induced diabetic rats. *Asian Journal of Pharmaceutical and Clinical Research, 5* (3),85-87.

Stumvoll, M., Nurjhan, N., and Perriello, G. (1995).Metabolic effects of metformin in non-insulin-dependent diabetes mellitus. *The New England Journal of Medicine*, 333,550-554.

Sudha, M. L., Baskaran, V., and Leelavathi, K. (2007). Apple pomace as a source of dietary fiber and polyphenols and its effect on the rheological characteristics and cake making. *Food* Chemistry, *104*(2), 686-692.

Sudha, N. L., Vertrimani, L., and Leelavathi, K. (2007). Influence of fiber from different cereals on the rheological characteristics of wheat flour dough and biscuit quality. *Food Chemistry,100*,1365-1370.

Sultana, B., Anwar, F., Ashraf, M., and Saari, N. (2012). Effect of drying techniques on the total phenolic contents and antioxidant activity of selected fruits. *Journal of Medicinal Plants Research, 6* (1),161-167.

Sultana, A., Rahman, T. R., Islam, M., Rahman, M., and Alim, M. A. (2014). Evaluation of quality of chapatti enriched with jackfruit seed flour and bengal gram flour. *Journal of Environmental Science, Toxicology and Food Technology, 8(*5),73-78.

Sunmola, A. I., David, M. G., Olanrewaju, and Chizea, O. T. V. (2011). Biochemical effect of some food processing methods on the health promoting properties of under-utilized *Carissa papaya* seed. *Journal of Natural Products, 4*,17-24.

Surekha, N., and Naik, R. S. (2014). Development of value added khakara from barn yard millet consumer acceptability, nutritional and shelf- life evaluation. *Asian Journal of Home Science*,9(1),60-65.

Swami, G., Nagpal, N., Rahar, S., and Singh, P. (2010). Effect of aqueous leaves extract of *Carissa* linn. on blood glucose levels of normoglycemic and alloxan- induced diabetic wister rats. *International Journal of Current Pharmaceutical Research*, *2*(3),65-67.

Swanston, F. S. K., Day, C., Bailey, C. J., and Flat, P. R. (1990). Traditional plant treatment for diabetes. Studies in normal and streptozotocin diabetic mice. *Diabetologia*, 33,462-4.

Szczesniak, A. S. (1998). *Effect on storage on texture*. In I. A. Taub and R.P. Singh. Food storage stability . Boca Raton: CRC Press.

Szkudlarz, S. M., Bajerska, J., Wojtasiak, R. Z., and Gorecka, D. (2013). White grape pomace as a source of dietary fiber and polyphenols and its effect on physical and nutraceutical characteristics of wheat biscuits. *Journal Science Food and Agriculture,93*,389-395.

Taneya, M. L. J., Biswas, M. M. H., and Din, S. U. (2014). The studies on the preparation of instant noodles from wheat flour supplementing with sweet potato flour. *Journal of Bangladesh Agriculture University,12*(1),135-142.

Tanwar, B., Andallu, B., and Modgil, B. (2014). Influence of processing on physicochemical, nutritional and phytochemical composition of *Carissa spinarum* products. *Asian Journal Dairy and Food Resources,33*(1),37-43.

Thakur, M. (2014). Underutilized food crops: treasure for the future India. *Food Science Resource Journal*, 5(2),174-183.

Thimmaiah, S. K. (1999). Standard Methods of Biochemical Analysis, Kalyani Publishers.

Thomas, L. R., William, E., Connor, D. S., and Warner, S. (2015). The interaction of dietary fibers and cholesterol upon the plasma lipids and lipoproteins, sterol balance and bowel function in human subjects. *The journal of clinical investigation,60*,1429-1437.

Thoravaldson, K., and Skjoldebrand, C. (1998).Water diffusion in bread during baking. *Lebensmittel Wissenchatt and Technologies,31*,658-663.

Tiwari, B. K., Brennan, C. S., Jaganmohan, R., Surbhi, A. and Alagusundaram, K. (2011). Utilization of pigeon pea (*Cajanus cajan L*) by product in biscuit manufacture. *LWT-Food Science and Technology,44,*153-159.

Turkmen, N., Sari, F., Sedat, Y., and Velioglu, S. (2005). The effect of cooking methods on total phenolics and antioxidant activity of selected green vegetables. *Food Chemistry, 93*,713-718.

Uchenna, O. A., Nkiruka, I. V., Eze, E. P., and Chinazaekpere, O. C. (2013). Nutrient, phytochemical composition and sensory evaluation of formulated diabetic snacks made from Nigeria foods, *Afzelia Africana* and *Detarium Microcapium* seed flour. *Pakistan Journal of Nutrition, 12*(2),108-113.

Uchenna, O.A., Nikiruka, I. V., Eze, E. P., and Chinazaekpere, O. C. (2013). Nutrient, phytochemical composition and sensory evaluation of formulated diabetic snacks made from Nigeria foods, *Afzelia Africans* seed flour and *Detarium Microcapium* seed flour. *International Journal of Basic and Applied Sciences,13*(2),40-44.

Udomkun, P., Argyropoulous, D., Nagle, M., and Mahayothee, B. (2015). Sorption behavoiur of papayas as affected by compositional and structural alterations from osmotic pretreatment and drying. *Journal of Food Engineering,157*,14-23.

Updegroff, D.M. (1969). *Anal. Biochemistry,* 32, 420.

Van der Piji, L. (1972). Principles of dispersal in higher plants . Springer- Verlag, New York.

Van, K. H. H., de Boer, B. C. J., and Tijuburg, L. B. M . (2000). Carotenoid bioavailability in humans from tomatoes processed in different ways determined from the carotenoids response in the triglyceride- rich lipoprotein fraction of plasma after a single consumption and in plasma after four days of consumption. *Journal Nutrition,130*,1189-1196.

Van, P. J., and Robertson, J. B. (1977).What is fiber and fiber in food? *Nutrition Review,35*, 12.

Vankatartanam, L. (1988). Packing of figs. A souvenir on packing of fruits and vegetables in India; Agriculture Horticultural Society Public Gardner: Hyderabad, India.

Vasisthala, H., and Srivastava, N. A. (2013). Effect of soaking and cooking on dietary fiber components of different type of chickpea genotypes. *Journal of Food Science Technology,50* (3),579-584.

Vazhacharickal, P. J., Mathew, J. J., Kumar, N. K., and Sebastin, M. (2015). A study on the vitamin C contents of various neglected and underutilized fruits from western ghat region in Kerala. *International Journal of Food, Agriculture and Veterinary Sciences, 5*(1),94-105.

Verma, A., and Singh, V. (2014). Nutritional value and organoleptic evaluation of mushroom powder fortified Indian recipe: Besan laddu. *Asian Journal of Home Science,* 9(1),78-81.

Verma, I., and Gupta, R. K. (2015). Estimation of phytochemical, nutritional, antioxidant and antibacterial activity of dried fruit of sacred figs (*Ficus religiosa*) and formulation of value added product(Hard candy). *Journal of Pharmacognosy and Phytochemistry,4*(3),257-267.

Vidal, V., and Frias, C. (1991). Legumes processing effects on dietary fiber components. *Journal Food Science, 56*,1350-1352.

Vinod, D., Nandkule, D. M., Chitra, S., and Devendrasing, D. P. (2015). Development and quality evaluation of Jackfruit seed and soy flour noodles. *International Journal of Science, Engineering and Technology, 3*(3),802-806.

Vinson, J. A. (1999). Functional food properties of figs. *Cereal Foods World, 44*(2),82-87.

Vinson, J. A., Zubik, L., Bose, P., Samman, N., and Proch, J. (2005). Dried fruits: excellent *in vitro and in vivo* antioxidants. *Journal of American College of Nutrition, 24* (1),44-50.

Waghray, K., Gulla, S., and Bhanuteja, K. (2011). Sensory attributes of wheat (*Triticum species*) flour based chapatti incorporated with soy flour (*Glycine max*) and dates (*Pheonix dactylifera*). *Journal of Dairying, Foods and Home Science, 30* (4), 262 – 266.

Wang, R., Ding, S., Zhao, D., Wang, Z., Wu, J., and Hu, X. (2016). Effect of dehydration methods on antioxidant activities, phenolic content, cyclic nucleotides and volatiles of jujube fruits. *Food Science and Biotechnology*, *25*(1),137-143.

Wang, C. Y., Chen, C., T., and Wang, S. Y. (2009). Changes of flavonoid content and antioxidant capacity in blueberries after illumination with UV-C. *Food Chemistry, 117*,426–431

Wang, G., Wang, H., Song, Y., Jia, C., Wang, Z. et al. (2004). Studies on anti-HSV effect of *Carissa spinarum* leaves. *Journal of Chinese Medicinal Materials*, 27,754-6.

Wang, S. Y., Zheng, W., and Galletta. G. J. (2002) Cultural system affects fruit quality and antioxidant capacity in strawberries. *Journal Agriculture Food Chemistry, 50,* 6534–42.

Wani, R. A., Prasad, V. M., Hakeem, S. A., Sheema, S., Anguchuk, S. *et al.* (2013). Shelf life of Karonda jams (*Carissa caranda*) under ambient temperature. *African Journal of Agriculture Research, 8* (21),2447-2449.

Wetwitayaklung, P., Sarunyakasitharin, K., and Phaechamud, T. (2008). Total phenolic content and antioxidant activity of fresh and preserved fruits of *Ellaeocarpus hygrophilus Kurz*. *Thai Pharmaceutical Health Science Journal,4* (1),21-28.

Whitton, P. D., and Hems, D. A. (1975). Glycogen synthesis in perfused liver of streptozotocin diabetic rats. *Biochemical Journal*,21,150-153.

Wich, A., and Prasad, M. (2012). Drying of Karonda (*Carissa spinarum*) pomace and its tablet product. *KKU Science Journal, 40* (3),887-889.

Williams, J. T., and Haq, N. (2002). Global research on underutilized crops - an assessment of current activities and proposals for enhanced cooperation.

Wilson, V., Shetye, S. S., Kaur, K., and Shetty, S. (2016). Study of synergistic effects on antioxidant activity and antimicrobial activity of polyherbal formulations containing *Ficus* species. *International Journal of Pharmacy and Pharmaceutical Sciences, 8*(4),51-53.

Wojdylo, A., Figiel, A., and Oszmianski, J. (2007). Influence of temperature and time of apple drying on phenolic compounds content and their antioxidant activity. *Polish Journal of Food and Nutrition Sciences,57*,(4), 601-605.

Wojdylo, A., Figiel, A., Lech, K., Nowicka, P., and Oszmianski, J. (2014). Effect of convective and vacuum- microwave drying on the bioactive compounds, colour and antioxidant capacity of sour cherries. *Food Bioprocess Technology,7*, 829-841.

Wojdylo, A., Figiel, A., and Oszmianski, J. (2009). Effect of drying methods with the application of vacuum microwaves on the bioactive compounds, colour and antioxidant activity of strawberry fruits. *Journal Agriculture Food Chemistry*,*57*(4),1337-1343.

World Health Organization. (2003). Diet, nutrition and prevention of chronic disease, World Health Organization, *Genevia,* 89.

Wrolstad, R. E. (2004). Interaction of natural colour with other ingredients: anthocyanin pigments-bioactivity and colouring properties. *Journal of Food Science,69,* C419-425.

Wu, X., Gu, L., Holden, J., Haytowitz, D. B., Gebhardt, S. E., Beecher, G. et al. (2004) Development of a database for total antioxidant capacity in foods: a preliminary study. *Journal Food Composition Anal., 17,* 407–22.

Xu, G., Ye, X., Chen, J., and Liu, D. (2007). Effect of heat treatment on the phenolic compounds and antioxidant capacity of citrus peel extract. *Journal of agriculture and Food Chemistry,55,*330-335.

Yadav, D.N., Gaikwad, R. P., Kadam, R. M., Bhambure, C. V., and Joshi, S. V. (2005). Incorporation of Karonda (*Carissa carandas*) pulp in ice-cream. *Department of Animal Husbandry and Dairy Science,*21-22.

Yamaguchi, T., Taeko, M., Rie, K., Hiroko, M. F., Junji, T., Hitoshi, T. et al. (2001). "Radical-scavenging activity of vegetables and the effect of cooking on their activity." *Food Science and Technology Research*, 7(3), 250-257.

Yan, L. Y., Teng, L. T., and Jhi, T. J. (2006). Antioxidant properties of guava fruit: comparison with some local fruits. *Sunway Academic Journal*, *3*, 9–20.

Yanardag, R., Ozsoy- Sacan, O., and Bolkent, S. (2005). Protective effects of metformin treatment on the liver injury of the streptozotocin-diabetic rats. *Human and Experimental Toxicology*, 24,129-135.

Yin, M. C., and Cheng, W. S. (1998). Antioxidant activity of several allium members. *Journal Agriculture Food Chemistry*, *46*, 4097-101.

Yoshioka, H., Tsuyumu, S., and Takayanagi, K. **(**1990). Radical formation during the processing of green tea. *Agricultural and Biological Chemistry*, *54*,203-204.

Yun, Z., Gao, H., Liu, P., Liu, S., Luo, T., Jin, S., Xu, Q. et al. (2013). Comparative proteomic and metabolomic profiling of citrus fruit with enhancement of disease resistance by postharvest heat treatment. *BMC Plant Biology*,13, 44.

Yusufu, M. I., and Obiegbuna, J. E. (2015). Effect of processing methods on the phytochemical content and consumer acceptability of two selected green leafy vegetables. *Agricultural Science Research Journal, 5*(7),105-110.

Zabidi, M. A., and Yunus, A. M. (2014). Effect on physicochemical and sensory attributes of bread substituted with different levels of matured soursop *(Anona muricata*) flour. *World Academy of Science, Engineering and Technology, 8*(7),740-744.

Zaenuri, L. A., Susilawati, T., Sumitro, S. B., and Wahyuningsih, S. (2014). Effects of additional crude extract of fig fruit (*Carissa spinarum*) into Tris egg yolk based extender on quality of buck semen. *Journal of Biology, Agriculture and Healthcare, 4*(9), 21-27.

Zaidel, D. N. A., Makhtar, N. A., Jusoh, Y. M. M., and Muhamad, I. I. (2015). Efficiency and thermal stability of encapsulated anthocyanins from red dragon fruit (*Hylocereus polyrhizus* (Weber) Britton and Rose) using microwave-assisted technique. *Chemical Engineering Transactions,43*,1-6.

Zavala, J. F. A., Wang, S. Y., Wang, C. Y., and Aquilar, G. A. (2004). Effect of storage temperature on antioxidant capacity and aroma compounds in strawberry fruit. *Lebensm-Wiss.U-Technology,37*,687-695.

Zilic, S., Dodig, D., Sermesic, M. M., Kandic, V., Kostandinovic, M. et al. (2011). Small grain cereals compared for dietary fibre and protein contents. *Genetika,43*(2),381-395.

Zivkovic, M., Rakic, S., Maletic, R., Povrenovic, D., Nikolic, M. et al. (2011). Effect of temperature on the physical changes and drying kinetics in plum (*Prunus domestica L.)* Pozegaca variety. *Chemical Industry and Chemical Engineering Quaterly,17*(3),283-289.

Zolfaghari, M., Sahari, M. A., Barzegar, M., and Samadloiy, H. (2010). Physicochemical and enzymatic properties of five kiwi fruit cultivars during cold storage. *Food Bioprocess Technology*, *3*, 239-246.

CERTIFICATE

I certify that Ambika Chauhan has prepared her thesis titled **" Influence of processing on nutritional and phytochemical composition of Fig (*Ficus carica*) and Karonda (*Carissa spinarum*) "** for the award of Ph.D degree of Lovely Professional University**,** under my guidance and supervision. This present work is mainly the result of her continuous efforts and original investigation under my sincere guidance and supervision.

The research work report is suitable for Ph.D degree award submission in Nutrition and Dietetics.

Beenu

Dr. Beenu Tanwar

Assistant Professor
Department of Dairy Technology
MIDFT, Dudhsagar Dairy
Mehsana, Gujarat

1. INTRODUCTION

World Health Organization (2003) reported that fruits are rich in fiber, antioxidants, organic acids, vitamins, phenolic contents (Salmanian *et al.,* 2014) and considered to be a protective foods (Nicoli *et al.,*1999). They are used as a source of traditional medicine (Jain *et al.,* 2013) to cure many health problems (Mahapatra *et al.,* 2012) and contributes as a main source of livelihood for the poor people (Gajanana *et al.,* 2010).

Underutilized fruits or neglected crops are not cultivated commercially, not grown and rarely found in the market (Agent, 1994). They are nutritionally beneficial for the people and play an important role in human health. These fruit species may be distributed globally, but still find some restriction in their consumption and production system (Williams *et al*., 2002). Several underutilized fruits are unfamiliar, unknown and less eaten. However, underutilized fruits have not yet received much awareness as antioxidant sources compared to commercial fruits. These fruits are neglected due to ignorance factor, lack of information, unavailability, deficient in these fruits promotional campaigns, difficulty in storage and harvesting (Badola and Aitken, 2010). Now, these fruits may be included in the health promotion campaigns (Rukayah, 1992). Different types of underutilized fruits are grown in India like aonla, tamarind, karonda, fig, citron, jackfruit etc. Some fruits, which are still underutilized and proves effective to satisfied nutrition demand. Recent research has been mentioned *Ficus carica* and *Carissa spinarum* are considered for the research purpose due to their higher nutritional value and medicinal uses (Baliga *et al.*, 2011).

Ficus carica is commonly known as "Fig" (Jander and Machado, 2008). *Ficus carica* called fig in English and anjir in Hindi (Wealth of India, 1999). It is riped from late of July to late of September (Anon, 2011). It is a deciduous and cultivated fruit tree from the family Moraceae. It is richest source of mineral elements, calcium and fiber content (Vinson, 1999). Dried fig can be stored for 6-8 months (Venkatartnam, 1988).

Carissa spinarum is an evergreen shrub and fruits got mature in late April. It is cultivated mainly in parts of dry foothills of the Punjab, also in Himalayan tract (India) and also on the coast of the Southern Andaman Islands (Parmar and Kaushal, 1982). Riped fruit has dark black colour. It is mostly cultivated in garden, as hedges for its edible berries (Van der Piji,1972). They

are highly nutritious and good source of protein. So, it is mainly offered for sale at certain places (Parmar and Kaushal, 1982).

Some of the locally available fruits which are very cheap as compared to unseasonable, imported fruits (Grabowski *et al.*,2003). Fruits are highly perishable in nature (Pathak *et al*., 2009), have short life span (7-10 days of post harvest life); (Sozzi *et al.,* 2005) and it affects the storage ability, physiological, nutritional and chemical properties of fruits (Orsat *et al.*,2006).

To minimize the effect of degradation, processing is considered to be a most effective tool. Several processing methods (freezing, sun drying and microwave drying) have been introduced with the aim to increase the shelf life of fruits. Sun drying and microwave drying method are proved to be a most important drying practice for the fruits (Matazu and Haroun, 2004). These methods are mainly used to produce heat to remove moisture content. Moisture content is removed by evaporation with heating process and played very important role to affect the nutrient content of fruits in different ways. It helps to increase or decrease the concentration of some nutrients (Hassan *et al*., 2007).

This study is mainly to carried out to observe the effects of these processing methods on the nutrients of fruits and to determine the most suitable method for nutrient retension rather than to increase their shelf life. So, the aim of this study is to focus on the influence of processing on nutritional and phytochemical composition of underutilized fruits i.e. fig and karonda.

These fruits, mainly in raw form are astringent in taste and accepted less. Nowadays, these fruits are commonly used to prepared value added products, which improves nutritional value and acceptance level of the products (Goyal *et al.*, 2008; Singh *et al*.,2009).

LIST OF FIGURES

5.20	B1(100% green gram nugget, B2= 15 % Karonda, B3= 30% Karonda, B4= 45 % Karonda)	185

LIST OF TABLES

3. OBJECTIVES OF THE STUDY

1. To evaluate proximate, nutritional, physical and phytochemical composition of fresh fig and Karonda fruits.
2. To assess the influence of processing methods viz. sun drying, microwave drying and freezing on physicochemical, nutritional and phytochemical composition of selected fruits.
3. To evaluate the effect of fruit extract of *Ficus carica* and *Carissa spinarum* on blood glucose level of normoglycemic and diabetic wistar rats
4. To develop various value added products from the selected fruits and analyze their nutritional composition during 6 months of storage.

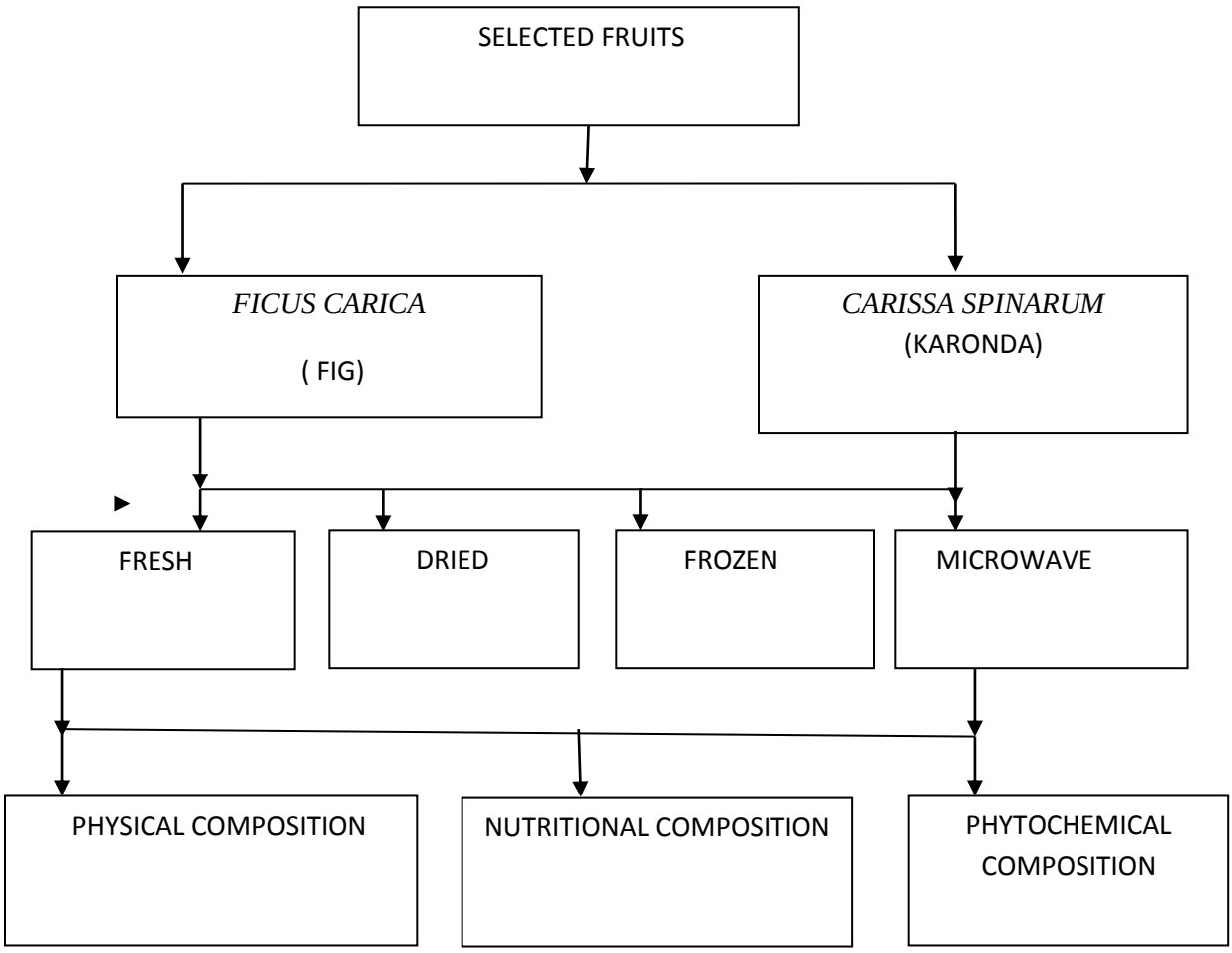

Fig. 4. 1 Flow chart for processing methods

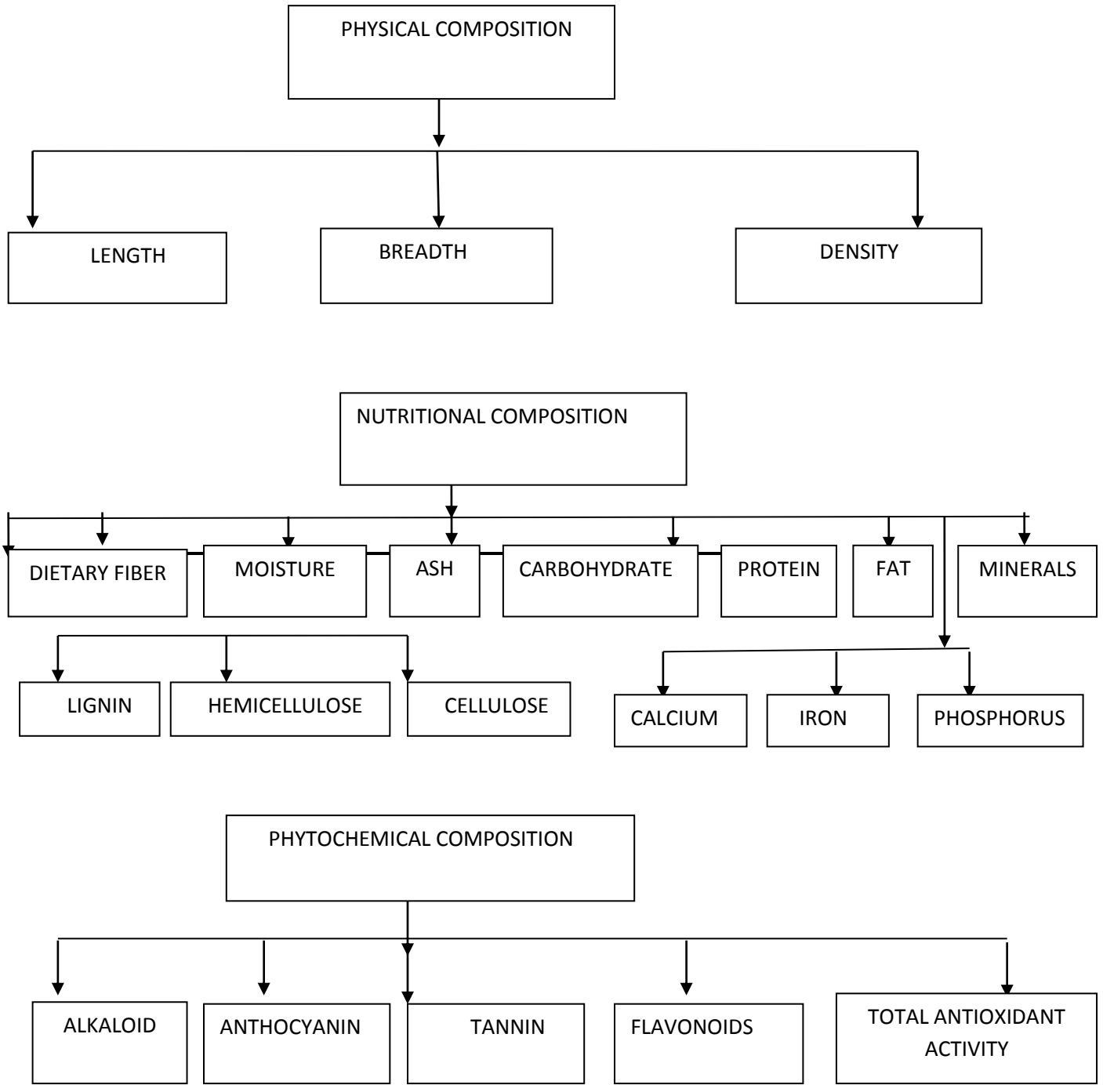

Fig. 4. 1 Flow chart for processing methods

4. RESEARCH METHODOLOGY

The present study was carried out in the Department of Food Technology and Nutrition, School of Agriculture and Food Technology, Lovely Professional University, Phagwara, Punjab. The research methodology and procedures to achieve the set objectives have been described under the following subheads:

4.1 Sample selection

4.2 Sample preparation

4.2 (a) Drying techniques

4.2 (b) Sorting

4.2 (c) Washing

4.2.(d) Sun drying

4.2 (e) Freezing

4.2 (f) Microwave drying

4.3 Physical composition

4.3 (a) Length and width

4.3 (b) Density

4.4 Nutritional composition

4.4 (a) Moisture content

4.4 (b) Ash content

4.4 (c) Carbohydrate content

4.4 (d) Fat content

4.4 (e) Protein content

4.4 (f) Dietary fiber

4.4 (g) Hemicellulose

4.4 (h) Neutral detergent fiber

4.4 (i) Acid detergent fiber

4.4 (j) Cellulose content

4.4 (k) Lignin content

4.5 Extraction preparation

4.5 (a) Total phenolic content

4.5 (b) Total flavonoid content

4.6 Antioxidant activity

4.6 (a) DPPH assay

4.6 (b) FRAP assay

4.7 Tannin content

4.8 Alkaloid content

4.9 Anthocyanin content

4.10 Mineral composition

4.11 Experimental design

4.11 (a) Experimental animals

4.11 (b) Preparation of extracts

4.11 (c) Method for acute toxicity test

4.11 (d) Preparation of interventions

4.11 (e) Animals and induction of diabetes mellitus

4.11 (f) Multiple dose of hypoglycemic study

4.11 (g) Experimental plan

4.12 Value added product development

4.12 (a) Procurement for raw materials

4.12 (b) Fruit powder preparation

4.12 (c) Experimental plan

4.12 (d) Organoleptic evaluation

4.13 Statistical analysis

4.1 Sample selection

Ripened whole fresh *Ficus carica* and *Carissa spinarum* were collected from orchard of a local cultivar from Bilaspur, Himachal Pradesh, (India) during 2014 - 2015.

4.2 Sample Preparation

4.2 (a) Sorting

Fresh, non insected fruits were selected for the study purpose. Discolored fruits were removed before washing.

4.2 (b) Washing

Selected fruits were washed by using distilled water and cleaned properly to remove dust particles. These fruits were dried properly and weighed accurately to and divide into four equal slots. First slot was for fresh (without any treatment), second slot (sun dried), third slot (freezing) and fourth slot was (microwave dried).

4.1 (c) Drying methods

Fruits were exposed to the methods given below:

4.2 (d) Sun drying

Fruits were distributed separately, on the stainless steel trays and dried under direct sunlight for 5 days between 15 July to 20 July, 2015 and stored in cellophane bag for further use.

4.2 (e) Frozen storage

In frozen, the selected whole fresh fruits were packed in polyethylene bags, sealed and safely collected in a freezer at -20°C for 20 days.

4.2 (f) Microwave drying

Selected fresh fruits were placed in a Pyrex petri dish in a single layer and heated for 3 minutes and 15 seconds by using microwave (Sharp R-248e; 800W). Dried fruits were cooled normal temperature. After that again weight was taken to measured the weight loss. After the treatment of different processing methods, selected fruits were used for further analysis.

4.3 Physical composition

4.3 (a) Length and Width

Ten fruits were randomly selected for the measurement of length by using a vernier calliper with 0.01 mm reading accuracy (Mohsenin,1970).

4.3 (b) Density

Randomly ten fruits were selected for mass and measured accurately by using an accurate (0.01) electrical balance (Balasubramanian, 2001). For the measurement of density fruit was weighed and toluene was used to dropped them. The density was calculated by using displacement method. Toluene was used to measure the density of fruits instead of water (Mohsenin, 1986; Gezer *et al.* 2002). Bulk density was calculated with a definite volume beaker. The fruits were poured from 15 cm height into a beaker and excess fruits were discarded. Weighed when it was filled. The bulk density explained as the ratio mass and total volume of the sample (Aydin, 2002).

4.4 Nutritional composition

4.4 (a) Moisture content (AOAC, 2010)

Procedure The moisture content was determined by using oven dried method. 3 gram fruit sample was weighed and taken in a pre heated petri dish. Dried petri dish was kept in oven at temperature 45°C for 3 hrs. It was taken out from pre heated oven then kept in a dessicator for 30 minutes to cool and attained constant weight. Samples were weighed again with petri dish after cooling. Weight loss was represented the moisture content.

Calculation

weight (g) of fruit sample before drying (W1)

weight (g) of fruit sample after drying (W2)

$$\text{Moisture}(\%) = \frac{(W1 - W2)}{W1} X\ 100$$

4.4 (b) Ash content (AOAC, 2010)

Total 3 gm fruit sample was weighed and put in previously pre dried silica crucible. Placed the crucible with lid in the furnance at heating temperature at 550 °C overnight to burn off all

impurities, which were presented on the surface of crucible. After that ashed sample were taken out from the muffle furnance and cooled in a dessicator for 2 hrs. Cooled samples were weighed again and calculated the per cent of ash content given below.

Calculation

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of fruit sample}} X\ 100$$

4.4 (c) Carbohydrate (Hedge and Hofreiter, 1962)

Reagents

5ml of 2 N HCL

Anthrone reagent: Dissolved 200 mg anthrone in 100 ml of ice-cold 95% H_2SO_4.

Standard glucose: Stock- Dissolved 100 mg in 100 ml water.

Working standard: 10 ml of stock diluted to 100 ml with distilled water. Added few drops of toluene and stored in a refrigerator.

Procedure

Take a boiling tube and weighed 100 mg fruit sample in it. Tubes were boiled for three hours in a boiling water bath with 5 ml of 2.5 N HCl. Wait for some time to cooled them at normal temperature. Neutralized it by using sodium carbonate powder until the froth ceases. Made up the volume to 100 ml and centrifuged these tubes. Supernatant was easily collected and taken 0.5, 1 ml aliquots and used it for further analysis. Prepared standards by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of standard solution '0' serves as blank. Made up the volume to 1 ml with distilled water. Anthrone reagent (4 ml) was added and heat them in a boiling water bath for eight minutes. Absorbance was taken at 630 nm. Drawn a standard graph on the X-axis versus absorbance on the Y-axis. From the graph calculated the total carbohydrate present in the sample tube.

Calculation $x = \frac{\text{mg of glucose}}{\text{vol.of fruit sample}}\ X\ 100$

4.4 (d) Fat (AOAC, 2010)

Reagent

Petroleum ether – 250 ml

Procedure

Soxhlet extraction method was used for the fat determination. Bottle was placed with the lid in the incubator at temperature 105 °C overnight. Weighed about 3gm of fruit sample into wraped paper filter. Fruit sample was wrapped in a extraction thimble and transferd into a soxhlet. Filled 250 ml of petroleum ether into the bolltle and fixed it with heating mantle. Connected the soxhlet apparatus and turned on the water to cool them and heated the sample for 14hrs by switched on the heating mantle. Evaporated solvent by using the vacum condenser. Bottle was dried completely at temperature 80°C - 90 °C to evaporate the solvent. Cooled it in a dessicator, after drying. Dried content was weighed with the bottle.

Calculation

$$\text{Fat (\%)} = \frac{\text{Weight of fat}}{\text{weight of fruit sample}} X\ 100$$

4.4 (e) Protein (AOAC, 2010)

Reagents

Kjedahl catalyst- Mixed 1 part of coppersulphate and 9 part of potassium sulphate

Conc.sulphuric acid – 200 ml

NaOH - 40%

HCl - 0.2 N

H_3BO_3 - 4%

Indicator solution- Mixed 200 ml of 0.2 % bromocresol green (in 95% ethanol) in 100 ml of 0.1% methyl red (in 95% ethanol)

Procedure

1gm weight sample was taken in a digestion flask. Then added 200ml of conc. sulphuric acid and 5gm Kjedhal catalyst in it. Prepared a tube which contained heated above mentioned chemical except sample as blank. Inclined position was used for the flask to heat it gently unit frothing ceases. Boiled contineously till solution was cleared. Then, 60 ml of distilled water was added in it and cooled it. Flask was connected immediately to the digestion bulb on condenser

and condenser tip was immersed in the standard acid. Mixed few indicator drops in a receiver. Flask was shaked to mix all contents properly untill, NH_3 was distilled. Removed receiver and washed the tip of condenser. Titratration was done by using the excess standard acid distilled with standard NaOH solution.

Calculation

$$\text{Protein (\%)} = \frac{(\text{A}-\text{B})XNX1.400\ 7X6.25}{\text{W}}$$

Where, A= Vol. (ml) of 0.2 N HCl used sample titration

B = Vol. (ml) of 0.2 N HCl used blank titration

N= Normality of HCl

W= Weight (g) of sample

14.007= Atomic weight of nitrogen

4.4 (f) Dietary fiber content (Van and Robertson, 1977)

4.4 (g) Hemicellulose = NDF-ADF

4.4 (h) Neutral detergent fiber (NDF)

Reagents

Neutral detergent solution
Sodium borate decahydrate -6.81g
Disodium ethylene diamine neutral -18.61 g
Sodium lauryl sulfate neutral – 30g
2- ethoxyethanol – 10 ml
Disodium phosphate anhydrous – 4.5g

Procedure

Dried sample was grinded well to pass through 1 mm screen. Weighed 1 gm of grinded sample in a crucible. Mixed solution of neutral detergent 100 ml into 0.5 gm of sodium sulfite in a crucible at normal temperature. Mixed few drops of n-octanol. After heat treatment refluxed it for 60 minutes from onset of boiling. Filtered properly, boiling water used to wash it three times. After that again wash it with cold acetone. Then, dried for 8 hours at heating

temperature 105 °C. Then kept in a dessicator to cool and weighed. Made ash in a muffle at temperature 550 °C for 2 hours. Cooled it in a dessicator and weighed.

Calculation

$$\text{NDF}\ (\%) = \frac{(\text{weight of crucible} + \text{weight of residue}) - \text{weight of crucible}}{\text{weight of sample}} \text{X}100$$

4.4 (i) Acid detergent fiber (ADF) (AOAC, 1975)

Reagents

Acid detergent solution- 75 ml

Buffer solution (P^H 1.5-2.0): 0.2M HCl -260 ml

0.2 M KCL - 1000ml

Hexadecyltrimethylammonium bromide-20gm dissolved in 1 liter of buffer solution.

Procedure

Dried sample was fine grinded and passed through 1mm screen. Weighed 1 gm of grinded sample. Added 75 ml of acid detergent solution into a Berzelius beaker and heated the sample on a hot plate for 5 minutes. Covered gently with the condenser and refluxed for 1 hour. Beaker was removed for refluxing apparatus and vacuum-filtered hot solution through tared gooch crucible by using 50-60ml hot water with 30 ml acetone. Vacuum has been used to dry fiber by sucking. Then crucible and fibre was dried overnight at temperature 110°C in oven. Percentage of fiber was calculated at dry basis.

Calculations

$$\text{ADF}\ \% = \frac{(\text{weight of crucible} + \text{weight of residue}) - \text{weight of crucible}}{\text{weight of sample}}\ \text{X}100$$

Cellulose= Neutral detergent fiber – Acid detergent fiber

4.4 (j) Cellulose content (Updegroff, 1969)

Reagents

Nitric reagent - Mixed 150 ml (80% acetic acid) and 15 ml (conc. nitric acid)

Anthrone reagent- Dissolved 200 mg anthrone in 100 ml conc. sulphuric acid.

Prepared fresh and chilled for 2 hours before use.

Sulphuric acid- 67%

Procedure

Taken a test tube with 1gm weighed sample. Added 3 ml of nitric acid and mixed in a vortex mixer. After that test tube was heated in a hot water-bath at temperature 100°C for half an hour. Cooled them and centrifuged for 20 minutes and supernatant was removed. Washed residue with distilled water. Mixed 10 ml (67% sulphuric acid) and allowed to stand for 1 hour. After that 1 ml of above solution was taken and diluted it to 100 ml. Then, 1 ml from that dilute solution was also taken and further added 10 ml of anthrone reagent in it. Boiling water bath was used to heat the tubes for ten minutes. Cooled and absorbance was taken at 630 nm. Anthrone reagent and distilled water was used as a blank. Weighed 100 mg cellulose and proceeded was taken in a test tube and all above mentioned steps for standard. Instead of just taken 1 ml of the diluted solution mentioned above taken a series of volumes and colour developed.

Calculation

Drawn the standard graph and cellulose sample was calculated.

4.4 (k) Lignin content (Burke *et al.* 2000)

Reagents

Acid detergent solution-75 ml

Buffer solution (P^H 1.5-2.0): 0.2M HCl -260 ml

0.2 M KCL - 1000ml

Hexadecyltrimethylammonium bromide-20gm dissolved in 1 liter of buffer solution.

Procedure

Dried sample was grinded fine to pass through 1mm screen. Weighed 1 gm of grinded sample . Berzelius beaker was used for the mixing of acid detergent solution and heated the sample on a hot plate for 5 minutes. Beaker was covered with the condenser and refluxed gently for 1 hours. Beaker was removed for refluxing apparatus and through tared gooch crucible was used to vacuum filter with 50-60ml hot water and with 30 ml acetone. Fiber has been sucked dried by using the vacuum. After that crucible and fiber was dried overnight at temperature 110°C in oven. Mixed 1.5 ml of 12 M H_2SO4 to all tubes contained residue fiber and digested at temperature 30°C for 30 minutes. After digestion the acid – insoluble residue was collected by using whatman filter paper with Buckner funnel (45mm) by filteration. Then, washed with water and two times with acetone and sample was dried at temperature 100 °C overnight. Weighed the filter and residue. Made ash at heating temperature 450°C for 6 hours. Weighed again after ashing . Lignin content was determined by the difference in the weight of the residue before and after ashing.

4.5 Extraction preparation

Methanol was used for the extraction of solvent. Taken a conical flask (covered it with aluminum foil) and filled it with 1 gm of weighed sample with 80 per cent methanol. After that agitated it in a orbital shaker at 50°C with 200rpm for two hours (Heidolph Unimax 1010, Schwabach, Germany). Mixture was filtered through a whatman filter paper No.4. Cleared solution was taken for the analysis (Emmy *et al.* 2009).

4.5 (a) Total phenolic content (Thimmaiah, 1999)

Reagents

Fruit powder juice (extract) -0.5 ml

Distilled water- 2.5 ml

Folin- Ciocalteu reagent- 0.5 ml

Sodium carbonate- 2ml

Conc. tannic acid -1000 µg/ml

Procedure

Folin –Ciocalteu (F- C) reagent was used to determine the phenolic content. Mixed 0.5 ml fruit extract in a beaker contained 2.5 ml of distilled water. Added 0.5 ml of Folin -Ciocalteau reagent (1:1) in it and incubated for 3 minutes. After that 2 ml (20% sodium carbonate) was mixed to each tube and kept for 1 minute in a hot boiling water bath. Wait to cool the tubes and taken absorbance at 650 nm. Tannic acid was used as standard. Graph was plotted by using different concentration of standard and absorbance therefore concentration of unknown was intercepted from graph.

4.5 (b) Total flavonoid content (Olajire and Azeez, 2011)

Reagents

Sample extracted - 1ml

Distilled water- 4 ml

Aluminum chloride – 0.3 ml of 10 %

Sodium nitrite- 0.3 ml of 5 %

Sodium hydroxide- 2ml of 1 M

Procedure

Total 1ml of extract solution was mixed in 4 ml (distilled water) and 0.3ml (5% sodium nitrite). Left it for 5 minutes and then mixed with 0.3ml 10% aluminum chloride in all mixture. Added 2ml of 1M NaOH in it after 6 minutes and volume make up to 10 ml with distilled water. After that absorbance was taken at 510 nm. Quercetin was used as a standard and graph was plotted against different concentration of standard and absorbance therefore concentration of unknown was intercepts from graph.

4.6 Antioxidant activity

4.6 (a) DPPH assay (Blois , 1958)

Reagents

DPPH solution- 50 µg/ml

Methanol- 50 µg/ml

Procedure

Antioxidant activity was determined by DPPH radical scavenging method. Extract was taken 50 μg/ml by pipette into DPPH solution conc. 50 μg/ml (1:1) for the initiation of reaction. Incubated it after 30 minutes and taken absorbance at 516 nm. DPPH solution 50 μg/ml was for standard and methanol was used for blank. The experiment was replicated with three independent assay.

Calculation

$$\text{Scavenging activity (\%)} = \frac{(Ac - As)}{Ac} X100$$

Where, Ac = Absorbance of the control

As=Absorbance of the sample

4.6 (b) Antioxidant activity

FRAP assay (Oyaizu,1986)

Reagents

Phosphate buffer- 1 ml

Potassium ferricyanide-1.0 ml

Trichloroacetic acid – 1.0 ml

Ferric chloride- 0.1 ml

Procedure

The antioxidant activity was determined by using (FRAP) ferric reducing assay. In this method 1 ml potassium ferricyanide (1.0 ml, 10 mg/ml) and phosphate buffer (1 ml, 0.2 M, pH 6.6) was mixed together and incubated for 20 minutes at temperature 50 °C. Mixed trichloroacetic acid (1.0 ml,100 mg/ml) with mixture and centrifuged for 5 minutes. Supernatant (1.0 ml) was mixed well by using distilled water (1.0 ml) and ferric chloride (0.1 ml, 1.0 mg/ml). Absorbance was taken at 700 nm.

Calculation

Scavenging activity (%) = $\frac{(A - B)}{A} X100$

4.7 Tannin content (Price *et al*. 1978).

Reagents

Concentrate HCL- 10 ml

Methanol- (1 %)

Vanillin reagent- (0.5% , 5 ml)

Catechin – 1 mg/ml

Procedure

Weighed 200 mg sample was taken in a test tubes. And extraction was done by using 10 ml (1% concentrated HCl) in methanol for 20 minutes. Mixed vanillin reagent (0.5%, 5 ml) to 1 ml extract and left it for 20 minutes at temperature 30°C. Then, taken absorbance at 500nm and result was expressed in catechin equivalents i.e. catechin (mg/100gm) which has been given a colour intensity equivalent to tannins after corrected the blank. Calculation of tannin content was done and results were expressed in mg/ 100 gm.

4.8 Alkaloid content (Herborne, 1973)

Reagents

Acetic acid – 100ml of 10 %

Ethanol – 100 ml

Conc. ammonium hydroxide- drop wise

Procedure

Weighed 5 gm of sample and kept into a 250 ml of beaker. Mixed 100 ml (10% acetic acid and ethanol). Beaker was covered tightly and left it for 4 hours. Filtered it properly and

concentrated it up to one-fourth of its original volume by using a boiling water bath. Concentrated ammonium hydroxide mixed dropwise in this extract till precipitation was completed. After settled down the whole solution, the precipitate was collected. Washed it with diluted ammonium hydroxide. Alkaloid was contained from the left residue after filteration. Dried it properly and weighed.

4.9 Anthocyanin content (Giusti and Wrolstad, 2001)

Reagents

Sample- 1ml

Potassium chloride-5ml

Sodium acetate-5 ml

Procedure

Anthocyanin quantification was done by using P^H- differential method. Taken extract was diluted in a solution of (1.0 M HCL,25 Mm KCL) P^H 1.0 and in a solution (0.4 M CH_3COONa) P^H 4.5. Absorbance was taken against distilled water at 510 nm and 700 nm.

Calculation

Diluted sample absorbance (A) as follows:

$A = (A_{510} – A_{700})$ pH 1.0 – $(A_{510} – A_{700})$ pH 4.5

Monomeric anthocyanin pigment (mg/L) = $x = \frac{(AXMWXDFX1000)}{\varepsilon X1}$

Where,

The molecular weight(MW)

The dilution factor (DF)

The molar absorptivity(ε)

Cyanidin-3-glucoside (pigment content) where MW = 449.2 and ε= 26,900

4.10 Mineral composition (AYUSH, 2008)

Calcium, Iron and Phosphorus

Reagents

Nitric acid- 10 ml

Procedure

Weighed 0.5 gm of coarse fruit sample in a casparian flask and mixed with 10 ml nitric acid. Covered it properly and left for overnight. After that, heated on a electric hot plate till the solution become cleared and transparent . Heat continuously till the solution became light yellow colour and white smoke dispersed. The solution was cooled and then transferred into 50 ml volumetric flask and diluted with the same solvent to the volume and mixed it properly. Prepared reagent blank solution with explained method. The mineral content was carried out from the cleared solution by Inductively coupled plasma- optical emission spectrometry (ICP-OES).

4.11 Experimental Design

4.11 (a) Experimental animals

Healthy male albino rats were 200gm -250gm body weight were mainly used for the study purpose. The rats were acclimatized in the animal house environment for seven days before starting the research work. The study was approved by Animals Ethics Committee in University (Regd. No. 954/PO/AC/06/CPCSEA).

4.11 (b) Preparation of extracts

Microwave dried fruits were selected for the study and converted into fine powder. Petroleum ether was used to remove fat from the powder material. Methanol and water mixture of 1:1 was used for the 72 hours extraction. Filtered extract was concentrated by rotary evaporator and vacuum dessicator was used to keep it. The calculated yield for the extract of *Ficus carica*

extract was 29 per cent and *Carissa spinarum* was 31.6 per cent and with respect to dried powder (Rout *et al.*2013).

4.11 (c) Method for acute toxicity test

Male rats (wistar albino) were fasted overnight and separated into two groups (n=3). Two groups were orally fed with the extract of *Ficus carica* and *Carissa spinarum* separately, in increasing dose of 1000 mg, 2500 mg and 5000 mg according to body weight of rats. And rats were observed continuously for 2 days for change noticed in their behaviour, neurologically, any toxicity sign and mortality. If any, so they were again observed for the next 7 days for any changes in their behavoiur and death. One- tenth and one fifth of the maximum safe dose of the extract were selected for the experiment which was used for acute toxicity (Rout *et al.*2013).

4.11 (d) Preparation of interventions

Selected fruit extract dosage according to body weight of rats i.e. 500 mg. Mixed it with distilled water by using Tween 20 at 25 per cent level. Tween 20 was used as suspending agent. The Metformin dose (50 mg/kg body weight) was also made by same method The sample used for test, solvent and Metformin drug were given orally to rats based on their level of dose according to their body weight (Rout *et al.*2013).

4.11 (e) Animals and induction of diabetes mellitus

Overnight fasted rats were administered (35mg/kg body weight) of single injection of Streptozotocin (STZ) interaperitoneally for the induction of diabetes (Gupta *et al*.2004). STZ solution was prepared by dissolving it into 0.9 per cent of ice cold saline instantly before use. Fasting blood sugar levels were observed (FBG>250 mg/dl)to be diabetic after a week of STZ administration and further used for the experiment (Sachin *et al*.2009).

4.11 (f) Multiple dose hypoglycemic study

Rats were divided into seven groups and each group contained six rats. Every group was either received solvent (2.5 ml), selected fruit extract doses and Metformin 50 mg/kg body weight of everyday 30 minutes before food throughout experimental period. All rats were continuously observed and blood sample was collected on 0,7 14 and 21 days. Blood sample was collected for the measurement of fasting blood sugar level (Ngueguim *et al.* 2007; Kar *et al.* 2006).

4.11 (g) Experimental plan

Seven groups of rats each group contained six rats and conducted a study for 21 days:

Group 1 Rats treated with basal diets (control group)

Group 2- Diabetic control group treated with drug streptozotocin, negative control group (Diabetic+ Streptozotocin)

Group 3- Diabetic rats treated with antidiabetic drugs i.e. metformin and supplemented with basal diet, positive control group (Diabetic + Metformin)

Group 4- Diabetic rats treated with 500 mg extract of *Ficus carica* according to body weight of rats supplemented with basal diet

Group 5- Diabetic rats treated with 500 mg extract of *Carissa spinarum* according to body weight of rats and supplemented with basal diet

Group 6- Normal rats treated with 500 mg extract of *Ficus carica* according to body weight of rats and supplemented with basal diet

Group 7- Normal rats treated with 500 mg extract of *Carissa spinarum* according to body weight of rats and supplemented with basal diet

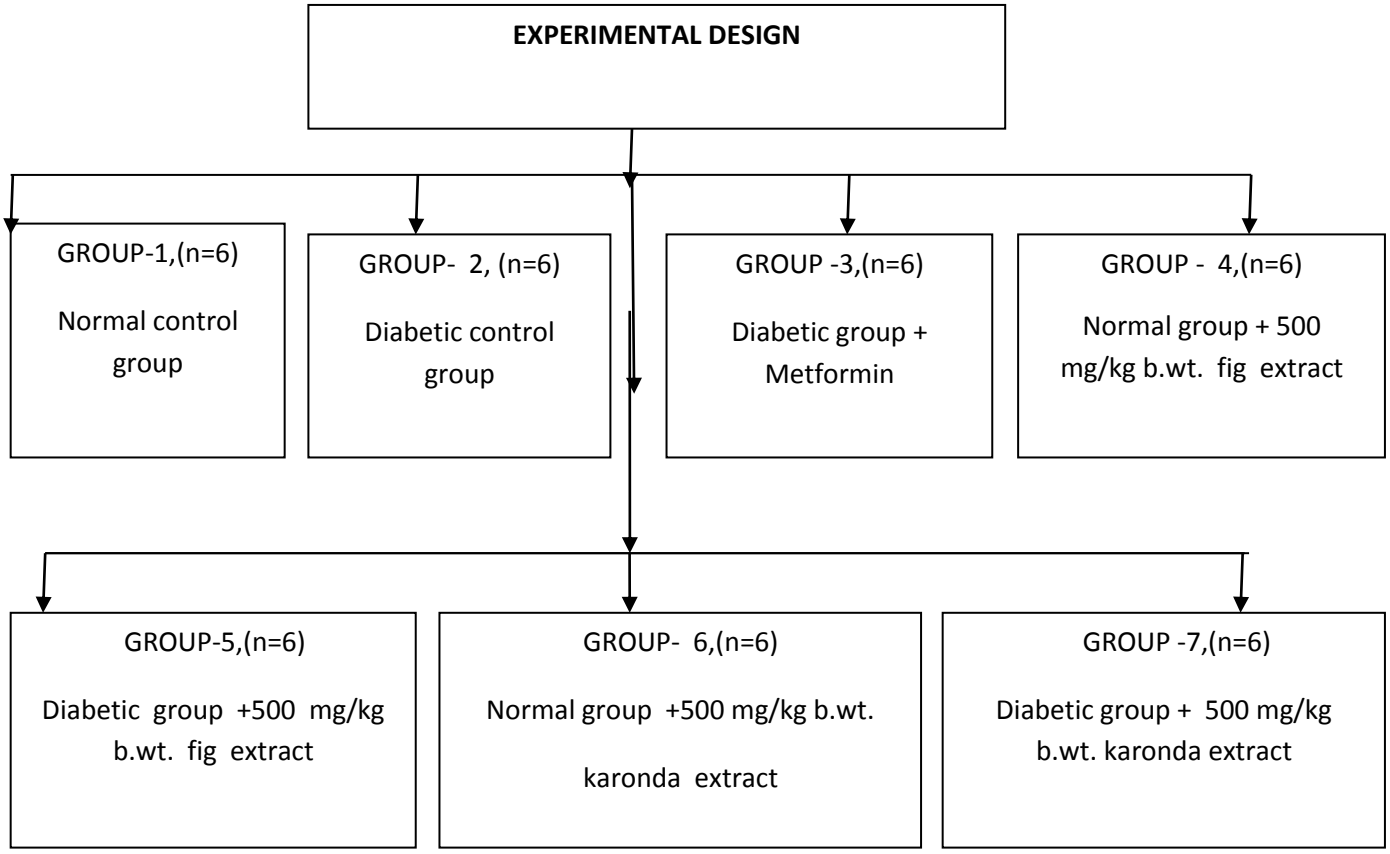

Fig. 4.2 Flow chart for value experimental design

4.12 Value added products development

4.12 (a) Procurement for raw materials

In order to develop (bun ,muffin, noodles and nuggets) value added products, the required materials were purchased from a local market in Jalandhar (wheat flour, R. oil, skimmed milk, honey, baking powder) etc.

4.12 (b) Fruit powder preparation

Fresh fruits were collected and spoiled fruits were removed before washing. Distilled water was used to wash these fruits three times to remove unwanted dirt particles then weighed and divided equally. Selected fruits were dried and distributed separately on the stainless steel trays and microwave dried for 3 minutes and 15 seconds (800W). Dried fruits were grounded fine in a grinding machine and sieved through 1mm sieve. All prepared mixture was stored in airtight container at room temperature and used for further analysis.

4.12 (c) Experiment design

The experimental design for the present research is depicted in **Table 4.1** and **Table 4.1.1** showed the different incorporation of fruits. In **Table 4.1.2** the different ingredients were used in making the buns were given in gm and **Fig 4.1** showed the flowchart for the preparation of buns.

Table 4.1 Experimental plan for bun

S. No.	Parameter	Level	Description
1.	Product	1	Bun
2.	Ingredient	5	Wheat flour, whole fresh fruit, R.oil, yeast powder and salt
3	Samples	8	B1, B2, B3, B4, T1, T2, T3 and T4 (Bun)
4.	Analysis	3	Nutritional analysis, Mineral analysis, sensory analysis

Table 4.2 Treatment description. Different combination of wheat flour, fresh fruit , R.oil, yeast powder and salt were used for the development of bun

Treatment	**Wheat Flour (WF), %**	***Ficus carica* (FC), %**	***Carissa spinarum* (CS), %**
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Where, B1 (Standard) =100% wheat flour bun, B2 = 15% *Carisssa spinarum*, B3= 30% *Carisssa spinarum*, B4= 45% *Carisssa spinarum*), T1= 100 % wheat flour bun , T2 = 15% *Ficus carica*, T3 = 30% *Ficus carica*, T4 = 45% *Ficus carica*

Table 4.3 Ingredients were used in the preparation of bun (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Wheat flour	100	85	70	55	100	85	70	55
2.	Fresh sample	0	15	30	45	0	15	30	45
3.	R.oil	1	1	1	1	1	1	1	1
4.	Yeast powder	2	2	2	2	2	2	2	2
5.	Salt	2	2	2	2	2	2	2	2

Bun Development (Alam *et al.* 2013)

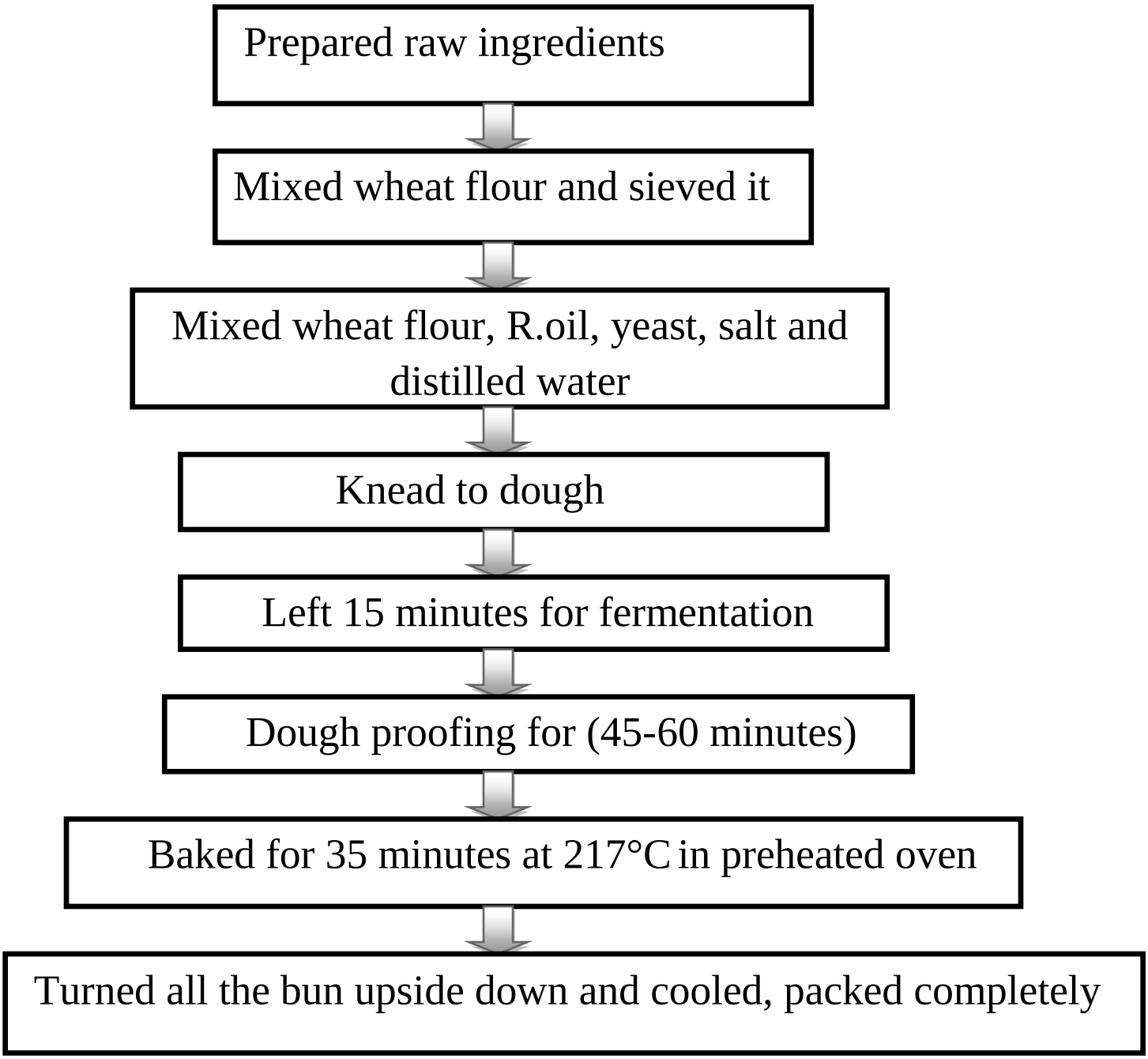

Fig. 4.3 Flow chart for the preparation of bun

Table 4.4 Experimental plan for muffin

S. No.	Parameter	Level	Description
1.	Product	2	Muffin
2.	Ingredient	6	Refined wheat flour, fresh fruit, R.oil, skimmed milk, honey, baking powder
3	Samples	8	B1, B2, B3, B4, T1, T2,T3and T4 (Muffin)
4.	Analysis	3	Nutritional analysis, Mineral analysis, sensory analysis

Table 4.5 Treatment description. Different combination of refined wheat flour, fresh fruit, R.oil, skimmed milk, honey, baking powder were used for the development of muffin

Treatment	**Wheat Flour (WF), %**	***Ficus carica* (FC), %**	***Carissa spinarum*(CS) %**
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Table 4.6 Ingredients were used in the preparation of muffin (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Refined wheat flour	100	85	70	55	100	85	70	55
2.	Sample/fruit powder	0	15	30	45	0	15	30	45
3.	R. oil	15	15	15	15	15	15	15	15
4.	Skimmed milk	25	25	25	25	25	25	25	25
5.	Honey	9	9	9	9	9	9	9	9
6.	Baking powder	1	1	1	1	1	1	1	1

Muffin Development (Uchenna *et al.* 2013)

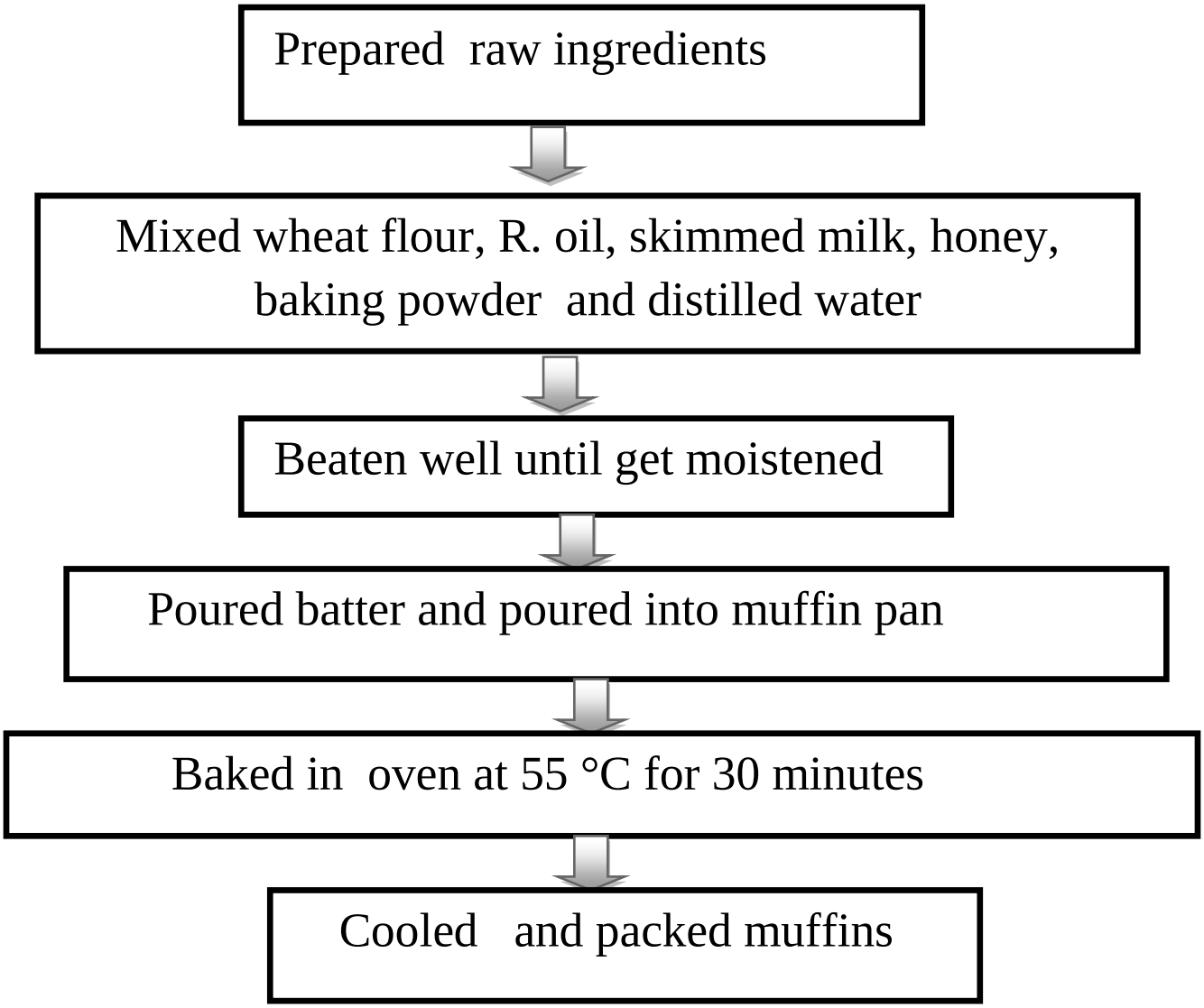

Fig. 4.4 Flow chart for the preparation of muffin

Table 4.7 Experimental plan for noodles

S. No.	Parameter	Level	Description
1.	Product	3	Noodles
2.	Ingredient	2	Wheatflour,fruit powder
3	Samples	8	B1, B2, B3, B4, T1, T2, T3 andT4 (Noodles)
4.	Analysis	2	Nutritional analysis, Mineral analysis

Table 4.8 Treatment description. Different combination of wheat flour, fruit powder was used for the development of noodles

Treatment	Wheat Flour (WF), %	*Ficus carica* (FC), %	*Carissa spinarum* (CS), %
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Table 4.9 Ingredients were used in the preparation of noodles (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Wheat flour	`100	85	70	55	`100	85	70	55
2.	Sample/fruit powder	0	15	30	45	0	15	30	45

Noodles Development (Ibitoye *et al.* 2013)

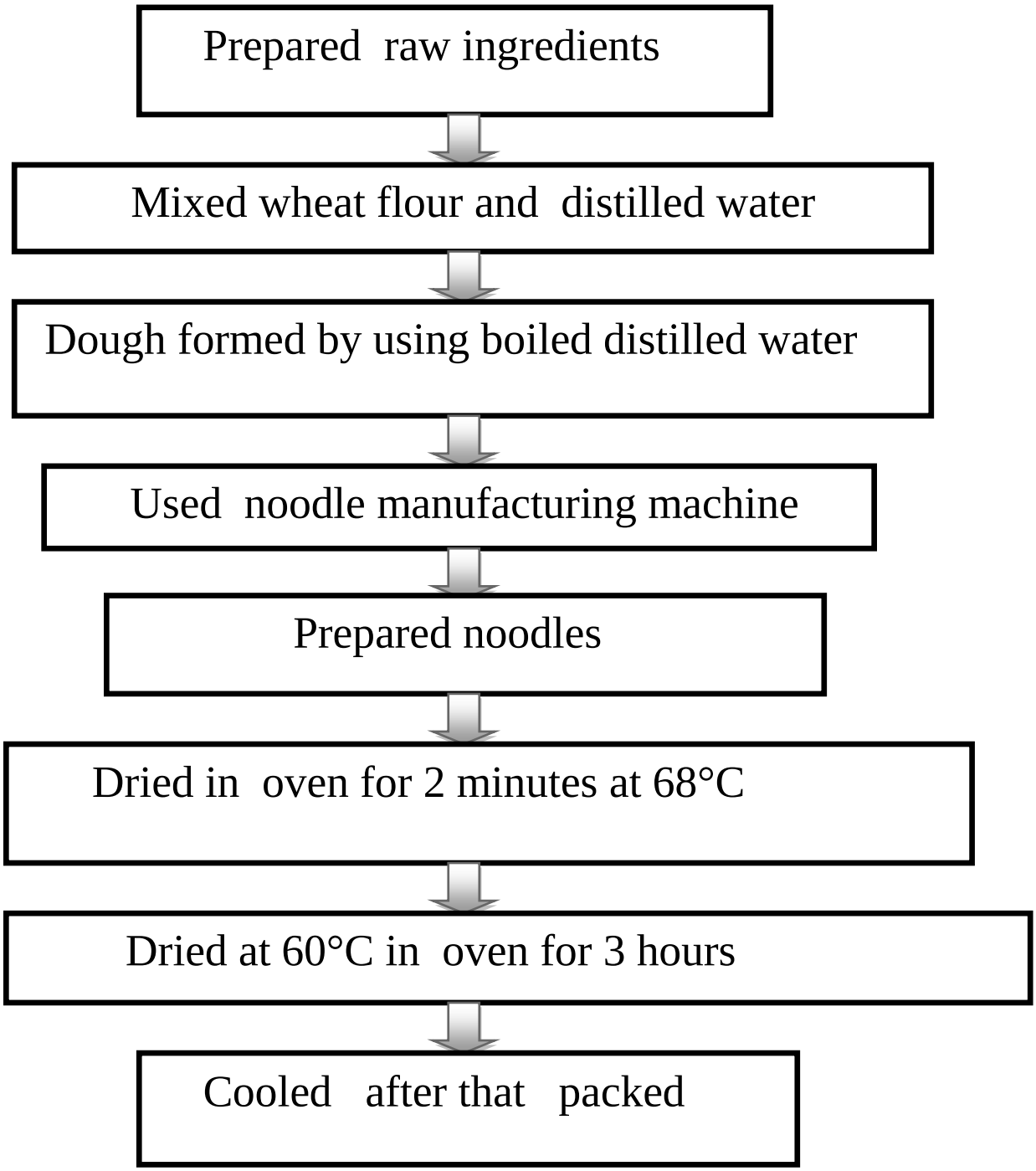

Fig. 4.5 Flow chart for the preparation of noodles

Table 4.10 Experimental plan for nuggets

S. No.	Parameter	Level	Description
1.	Product	4	Nuggets
2.	Ingredient	2	Moong flour, fruit powder
3	Samples	8	B1, B2, B3, B4, T1,T2,T3andT4 (Nuggets)
4.	Analysis	2	Nutritional analysis, Mineral analysis

Table 4.11 Treatment description. Different combination of moong flour, fruit powder was used for development of nuggets

Treatment	**Wheat Flour (WF), %**	***Ficus carica* (FC), %**	***Carissa spinarum* (CS), %**
B1	100	0	0
B2	85	0	15
B3	70	0	30
B4	55	0	45
T1	100	0	0
T2	85	15	0
T3	70	30	0
T4	55	45	0

Table 4.12 Ingredients used in the preparation of nuggets (in gm/100gm)

S.No.	Ingredients	B1	B2	B3	B4	T1	T2	T3	T4
1.	Moong flour	100	85	70	55	100	85	70	55
2.	Sample/fruit powder	0	15	30	45	0	15	30	45

Nugget Development (Pandey *et al.* 2012)

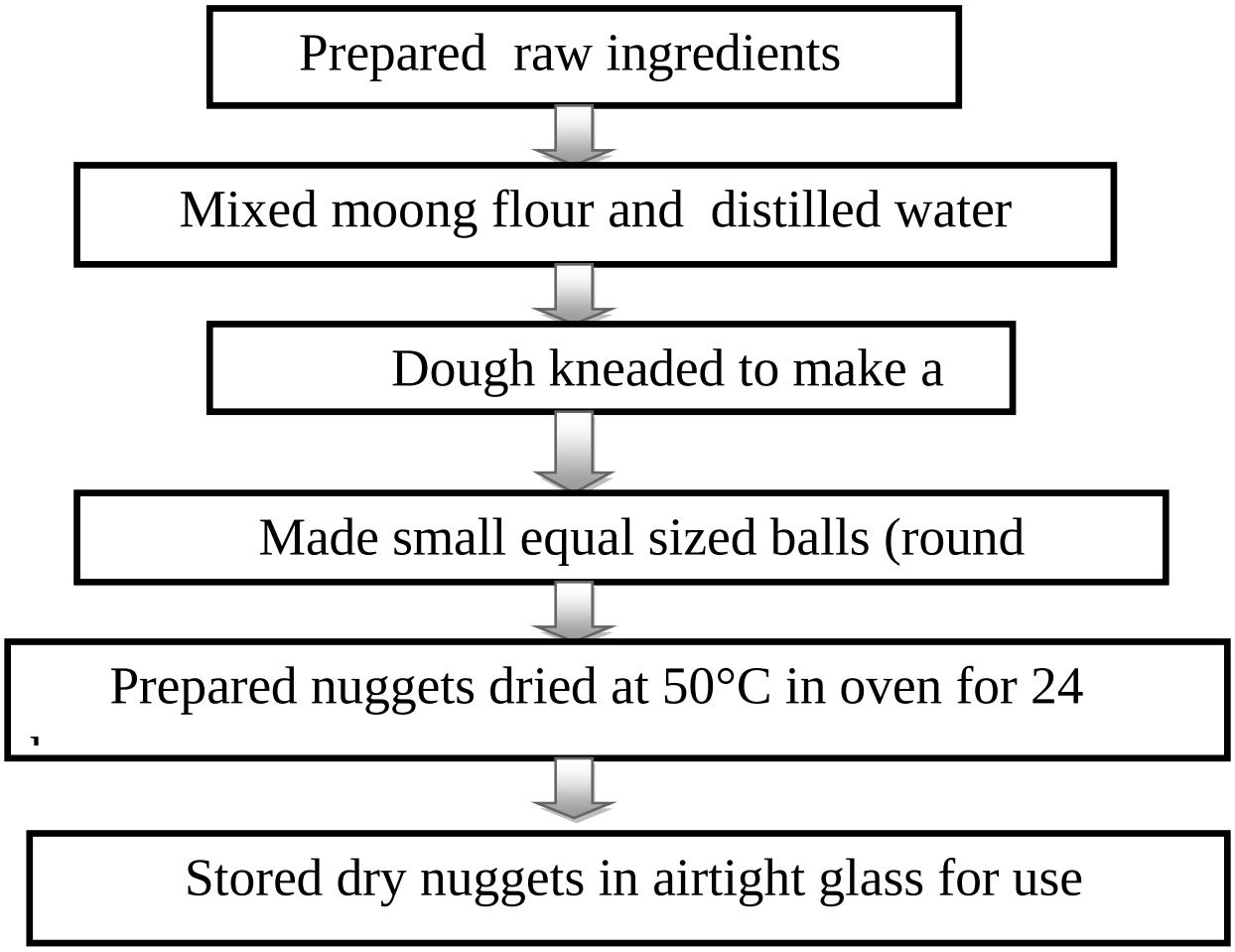

Fig. 4.6 Flow chart for the preparation of nuggets

4.12 (d) Organoleptic evaluation

Bun and muffin samples were evaluated for the appearance, colour, texture, flavor and overall acceptability by using 9 – point hedonic scale (Schutz and Cardello, 2001).

4.13 Statistical analysis

Experiments were performed in triplicates. These results were analyzed by using Graph pad prism 5 software for ANOVA (one-way analysis of variance) with Tukey's test for the determination of significant difference between the mean at 5 per cent level and statistically measured at significant level ($p < 0.05$).

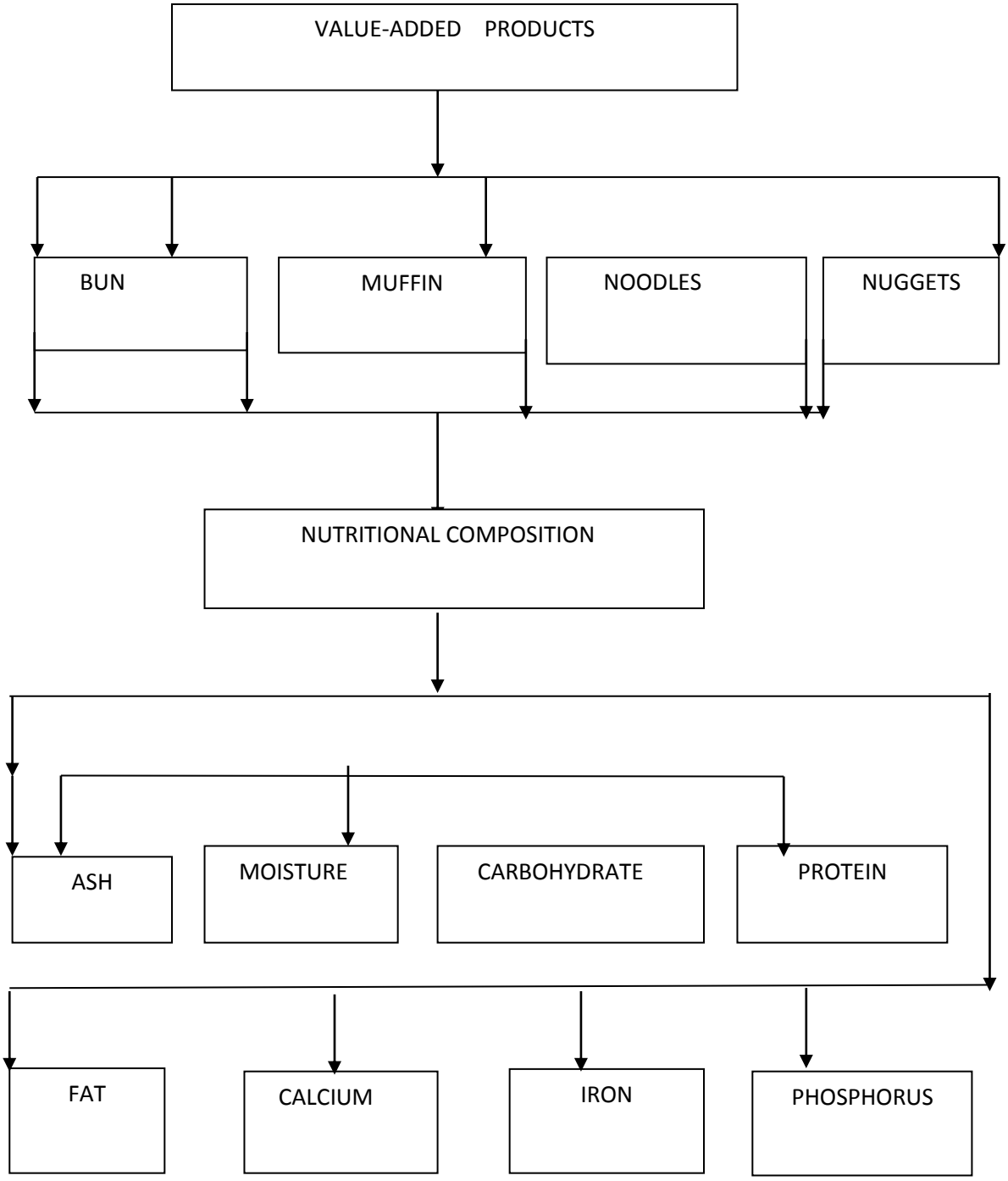

Fig. 4.7 Flow chart for value added products

5. RESULTS AND DISCUSSION

The present study was carried out in the Department of Food Technology and Nutrition, School of Agriculture and Food Technology, Lovely Professional University, Phagwara, Punjab during the year 2012- 2016. The results are discussed in the following subheads:

5.1 Analysis of *Ficus carica* (fig)

5.1 (a) Physical properties of fig

5.1 (b) Nutritional composition of fig

5.1 (c) Dietary composition of fig

5.1 (d) Phytochemical composition of *Ficus carica* (Total phenolic content)

5.1 (e) The total flavonoid content of fig

5.1 (f) Antioxidant activity (DPPH) of fig

5.1 (g) Antioxidant activity (FRAP) of fig

5.1 (h) Anti- nutritional content and anthocyanin content of fig

5.1 (i) Mineral composition of fig

5.2 Analysis of *Carissa spinarum* (Karonda)

5.2 (a) Physical properties of Karonda

5.2 (b) Nutritional composition of Karonda

5.2 (c) Dietary composition of Karonda

5.2 (d) Phytochemical composition of *Carissa spinarum* (Total phenolic content)

5.2 (e) The total flavonoid content of Karonda

5.2 (f) Antioxidant activity (DPPH) of Karonda

5.2 (g) Antioxidant activity (FRAP) of Karonda

5.2 (h) Anti- nutritional content and anthocyanin content of Karonda

5.2 (i) Mineral composition of Karonda

5.3 Experimental design

5.3 (a) Effect of fig (*Ficus carica*) methanolic extract on fasting blood glucose level in diabetic and non diabetic rats

5.3 (b) Effect of fig (*Ficus carica*) methanolic extract on body weight in diabetic and non diabetic rats

5.4 Experimental design

5.4 (a) Effect of Karonda (*Carissa spinarum*) methanolic extract on fasting blood glucose level in diabetic and non diabetic rats

5.4 (b) Effect of Karonda (*Carissa spinarum*) methanolic extract on body weight in diabetic and non diabetic rats

5.5 Formulation of value added product with substitution of fig

5.5 (a) Bun

5.5 (b) Nutritional composition

5.5 (c) Dietary fiber

5.5 (d) Mineral composition

5.5 (e) Organoleptic analysis

5.6 Muffin

5.6 (a) Nutritional composition

5.6 (b) Dietary fiber

5.6 (c) Mineral composition

5.6 (d) Organoleptic analysis

5.7 Noodles

5.7 (a) Nutritional composition

5.7 (b) Dietary fiber

5.7 (c) Mineral composition

5.7 (d) Organoleptic analysis

5.8 Noodles

5.8 (a) Nutritional composition

5.8 (b) Dietary fiber

5.8 (c) Mineral composition

5.8 (d) Organoleptic analysis

5.9 Formulation of value added product with substitution of Karonda

5.9 (a) Bun

5.9 (b) Nutritional composition

5.9 (c) Dietary fiber

5.9 (d) Mineral composition

5.9 (e) Organoleptic analysis

5.10 Muffin

5.10 (a) Nutritional composition

5.10 (b) Dietary fiber

5.10 (c) Mineral composition

5.10 (d) Organoleptic analysis

5.11 Noodles

5.11 (a) Nutritional composition

5.11 (b) Dietary fiber

5.11 (c) Mineral composition

5.11 (d) Organoleptic analysis

5.12 Noodles

5.12 (a) Nutritional composition

5.12 (b) Dietary fiber

5.12 (c) Mineral composition

5.12 (d) Organoleptic analysis

5.1 Analysis of *Ficus carica* (fig)

5.1 (a) Physical properties of fig

The effect of processing methods on the physical properties of fig is depicted in Table 6.1. The length of fresh fig was found to be 15.46 mm. Similar results, i.e. 20 mm to 36 mm were reported by Darjazi *et al*. (2011) in fresh fig fruit. A statistically significant increase ($p< 0.05$) in length was observed in fresh fig sample, the increasing order being MDS<SD <FRS<FS.

Table 5.1 Effect of processing methods on physical properties of fig

Drying methods	FS	SD	FRS	MDS
Length(mm)	15.46 ± 0.05^{a}	14.26 ± 0.05^{b}	14.46 ± 0.05^{c}	14.16 ± 0.05^{bd}
Width(mm)	18.14 ± 0.00^{a}	17.46 ± 0.05^{b}	17.86 ± 0.05^{c}	17.16 ± 0.05^{cd}
Density(gm/cc)	0.95 ± 0.00^{a}	0.93 ± 0.02^{a}	0.94 ± 0.01^{a}	0.91 ± 0.00^{ab}

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample

Length of sun dried fig was found to be 14.26 mm. Length decreased by 7.76 %, in sun dried fig as compared to fresh ones. Length of microwave dried fig was found to be 14.16 mm. Length decreased by 8.40 %, in microwave dried fig as compared to fresh ones. Similar results have been reported by Hazbavi *et al.* (2014), wherein they reported 3.06 % decrease in length in date palm fruit by thermal processing. Similar decrease in length has been reported by Zivcovic *et al*. (2011) in thermal dried plum. This may be attributed to the fact that thermal process leads to decrease in length of fruits as moisture content is reduced (Kashaninejad *et al*.2006) and also due to the shrinkage of fruits (Jha *et al*.2006).

Length of frozen fig was found to be 14.46mm. Length decreased by 6.46 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 4.80 % decrease in length in frozen dates. This decrease in length by frozen storage might be due to the period of cold storage (Al- Yahayai and Al- Kharusi,2012).

The width of fresh fig was found to be 18.14 mm. Similar results, i.e. 21mm to 48 mm was reported by Darjazi *et al*. (2011) in fresh fig fruit. A statistically significant increase ($p<0.05$) in width was observed in fresh fig sample, the increasing order being MDS<SD <FRS<FS.

Width of sun dried fig was found to be 17.46 mm. Width decreased by 3.74 % in sun dried fig as compared to fresh ones. Width of microwave dried fig was found to be 17.16 mm. Width decreased by 5.40 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Hazbavi *et al.*(2014), where they found 1.45 % decrease in width in thermal processed date palm fruit. Similar decrease in width has been reported by Zivcovic *et al*. (2011) in heat treated plum. This decrease in width by thermal process might be due to the reduction of moisture content (Kashaninejad *etal.*2006) and also due to the shrinkage of fruits (Jha *et al.*2006; Hazbavi *et al*, 2014). Width of frozen fig was found to be 17.86 mm. Width decreased by 1.54 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), wherein they reported 7.69 % decrease in width in frozen dates. This decrease in width by frozen storage might be due to the period of cold storage (Al- Yahayai and Al- Kharusi, 2012).

The density of fresh fig was found to be 0.95 gm/cc. Similar results, i.e. 1.46 gm/cc was reported by Razavi *et al*. (2010) in fresh fig fruit. A statistically significant increase ($p<0.05$) in density was observed in fresh sample, the increasing order being MDS<SD <FRS<FS. Density increased in fresh due to higher moisture content that leads to increase volume (Garmakhany *et al.* 2013). Density of sun dried fig was found to be 0.93 gm/cc. Density decreased by 2.10 % in sun dried fig as compared to fresh ones. Density of microwave dried fig was found to be 0.91 gm/cc. Density decreased by 4.21 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Pacco and Menegalli (2004), where they reported decrease in density in thermal dried fig fruit. This is may be attributed to the fact that thermal processing fig becomes more porous.

Density of frozen fig was found to be 0.94 gm/cc. Density decreased by 1.05 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Ramaswamy and Tung (1981), wherein they reported decrease in density by 6.74 % in frozen storage "Golden" apple.

5.1 (b) Nutritional composition of fig

The moisture content of fig fruit is depicted in Table 5.2. Moisture content of fresh fig was found to be 80.2 per cent. Similar results, i.e. 80.61 per cent was reported by Nakilcioglu and Hisil, (2013) in "Sarilop" fresh fig variety. The moisture content increased significantly ($p<0.05$) in frozen fig sample, the increasing order being MDS<SD<FS<FRS.

Table 5.2 Effect of processing methods on nutritional properties of fig

Drying methods	FS	SD	FRS	MDS
Moisture (%)	80.2 ± 0.00^{a}	25.86 ± 2.48^{b}	81.0 ± 1.97^{ac}	25.43 ± 3.23^{bc}
Ash (%)	4.00 ± 0.34^{a}	4.42 ± 0.19^{a}	4.20 ± 0.08^{a}	4.30 ± 0.23^{a}
Carbohydrate (%)	16.3 ± 0.18^{a}	65.15 ± 0.20^{b}	16.0 ± 0.03^{ac}	65.18 ± 0.08^{cd}
Fat (%)	0.53 ± 0.08^{a}	0.56 ± 0.00^{a}	0.51 ± 0.07^{a}	0.59 ± 0.03^{a}
Protein (%)	0.53 ± 0.15^{a}	3.01 ± 0.09^{a}	2.71 ± 0.32^{a}	3.18 ± 0.07^{a}

The moisture content of sun dried fig was found to be 25.85 per cent. Moisture content decreased by 67.75 % in sun dried fig as compared to fresh ones. Similar results have been reported by Siriwattananon and Maneerate (2016), in guava where they found 89.08% decrease in moisture content in sun dried fruit. Moisture content of microwave dried fig was found to be 25.43 per cent. Moisture content decreased by 68.29 % in microwave dried fig as compared to

fresh ones. Similar results have been reported by Nakilcioglu and Hisil (2013), wherein they reported 79.76% decrease in moisture content in fig fruit after thermal process. Similar decrease in moisture content (99.75%) has been reported by Lutz *et al.* (2015) in heat treated blackberry. Kshetrimayum *et al*. (2015), also reported 92.86 % reduction in moisture content in microwave dried guava slices. This reduction in moisture content by thermal process might be due to the rapid water loss (Mechlouch *et al.* 2015), heating temperature (Brooker, 1974) and higher absorption power (Meda *et al.* 2008).

Moisture content of frozen fig was found to be 81.0 per cent. Moisture content increased by 0.99 % in frozen fig as compared to fresh ones. Similar results have been reported by Aleid *et al*. (2014), where they reported 10.51% increase in moisture content in date during frozen storage and Damini *et al*.(2013), wherein they reported 2.45 % increase in the moisture content in frozen marolo pulp. Similar increase in moisture content (1.0 %) has been reported by Boca *et al.* (2014) in frozen strawberry puree. This may be attributed to the fact that frozen storage leads to increase in moisture content of fruits as destruction of cellular structure by syneresis (Sae-Kang and Suphantharika, 2006) that leads to release of intracellular water (Chefteh and Besancon, 1989) which is migrated out of the cell (Damiani *et al*.2013).

The ash content of fig fruit is depicted in Table 5.2. Ash content of fresh fig was found to be 4.00 per cent . Similar results, i.e. 5.74 per cent was reported by Chawla *et al*. (2012) in fresh fig fruit. Ash content increased non significantly ($p>0.05$) in all fig dried samples and the increasing order being FS<FRS<MDS<SD. The ash content of sun dried fig was found to be 4.42 per cent. Ash content increased by 10.5 % in sun dried fig as compared to fresh ones. Ash content of microwave dried fig was found to be 4.30 per cent. Ash content increased by 7.5 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Nordin *et al*. (2013), wherein they reported 12.53 % increase in ash content in palm during thermal process. This increase in ash content by thermal process might be due to the removal of moisture content (Lisa, 1997).

Ash content of frozen fig was found to be 4.20 per cent. Ash content increased by 5.0 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Zolfaghari *et al*. (2010), where they reported 8.3 % increase in ash content in kiwi fruit during frozen storage.

Similar increase in ash content 20 % has been reported by Ogunobanwo *et al*.(2013) in frozen water melon juice. This increase in ash content by frozen storage might be due to the presence of products which has chemical stability (Raji *et al.* 2016).

Fat content of fig fruit is depicted in Table 5.2. Fat content of fresh fig was found to be 0.53 per cent. Similar results, i.e. 0.34 per cent was reported by Mahmoud *et al*. (2013) in fresh fig fruit. A statistically non significant increase ($p<0.05$) in fat content in all dried fig samples and the increasing order being FRS<FS<SD<MDS.

The fat content of sun dried fig was found to be 0.56 per cent. Fat content increased by 5.66 % in sun dried fig as compared to fresh ones. Fat content of microwave dried fig was found to be 0.59 per cent. Fat content increased by 11.32 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Nwaigwe and Adejumo (2015), in African bread fruit where they found 2.10 % increase in fat content during thermal process. This may be attributed to the fact that thermal process leads to increase in fat content of fruits along with removal of moisture content (Morris *et al.* 2004). Fat content of frozen fig was found to be 0.51 per cent. Fat content decreased by 3.77 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 10.81 % decrease in fat content in frozen blackthorn fruit. This decrease in fat content by frozen storage might be due to oxidation (Ryder *et al*.1993) that leads to release oxidative enzymes from various rupture cellular organelles (Boonsumrej *et al.* 2007).

Carbohydrate content of fresh fig was found to be 16.3 per cent. Similar results, i.e. 17.1 per cent was reported by Guvenc *et al*. (2009) in fresh fig fruit. Significant difference ($p<0.05$) increased in carbohydrate content in all fig dried samples and the increasing order being FRS<FS<SD<MDS. The carbohydrate content of sun dried fig was found to be 65.15 per cent. Carbohydrate content increased by 299.69% in sun dried fig as compared to fresh ones. Carbohydrate content of microwave dried fig was found to be 65.18 per cent. Carbohydrate content increased by 299.87% in microwave dried fig as compared to fresh ones. Similar results have been reported by Guvenc *et al*. (2009) in fig fruit where they found 240.39 % increase in carbohydrate content during heat treatment and Clary *et al*. (2007), wherein they reported 265. 27% increase in carbohydrate content in microwave dried grapes. Similar increase in

carbohydrate content (13.15 %) has been reported by Nwaigwe and Adejumo (2015) in thermal treated African bread fruit. This increase in carbohydrate content by thermal process might be due to hydrolytic effect of carbohydrate stored in fruits (Akinhanmi *et al.* 2008).

Carbohydrate content of frozen fig was found to be 65.15 per cent. Carbohydrate content decreased by 1.84 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Galoburda *et al.* (2014), where they reported 55.2% decrease in the carbohydrate content in strawberry puree during frozen storage. Damiani *et al*. (2013), wherein they reported 16.11% decrease in carbohydrate content in frozen marolo pulp. Similar decrease in carbohydrate content (25.78%) has been reported by Zolfaghari *et al*. (2010), in frozen kiwi fruit. This may be attributed to the fact that frozen storage leads to decrease in carbohydrate content of fruits as increase in carbon consumption which is required for fruit respiration (Holland *et al*. 2002) and also due to the breakdown of cell structure during frozen storage (Cheftel and Besancon,1989).

The protein content of fig fruit is depicted in Table 5.2. Protein content of fresh fig was found to be 2.98 per cent. Similar results, i.e.1.30 per cent was reported by Guvenc *et al*. (2009) in fresh fig fruit. Protein content non significantly increased ($p>0.05$) in all fig dried samples and the increasing order being FRS<FS<SD<MDS. The protein content of sun dried fig was found to be 3.01 per cent. Protein content increased by 467.92 % in sun dried fig as compared to fresh ones. Protein content of microwave dried fig was found to be 3.18 per cent. Protein content increased by 500.00 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mahmoud *et al*.(2013) in fig fruit where they found 288.23 % increase in protein content during thermal process and Clary *et al*. (2007), wherein they reported 236.11 % increase in protein content in grapes during heat treatment. Similar increase in protein content (14.28 %) has been reported by Nwaigwe and Adejumo (2015) in African bread fruit during thermal process. This increase in protein content by thermal process might be due to the enhancement in dry matter contents by the concentration of soluble solids (Eze and Akubor, 2012).

Protein content of frozen fig was found to be 2.71 per cent. Protein content decreased by 411.32 % in frozen storage fig as compared to fresh ones. Similar results have been reported by

Sikora *et al.* (2013), where they reported 57.51% decrease in protein content in blackthorn fruit during frozen storage. Similar decrease in protein content (7.79 %) has been reported by Damiani *et al*. (2013) in frozen marolo pulp. This may be attributed to the fact that frozen storage decrease in protein content of fruits as reduction in proteins which are water and salt soluble (Chomnawang *etal.*2007), denaturation of proteins (Ryder *et al.* 1993) and destruction caused by enzymatic activity (Hultman and Rustard, 2004).

5.1 (c) Dietary composition of fig

The neutral detergent fiber (NDF) of fig fruit is depicted in Table 5.3. Neutral detergent fiber of fresh fig was found to be 12.73 per cent. Similar results, i.e. 12.49 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. A statistically significant ($p<0.05$) increase in NDF in all fig dried samples, the increasing order being FRS<FS<SD<MDS

Table 5.3 Effect of processing methods on dietary composition of fig

Drying methods	FS	SD	FRS	MDS
NDF (%)	12.73 ± 0.05^{a}	12.83 ± 0.05^{a}	12.53 ± 0.11^{b}	12.86 ± 0.05^{ac}
ADF (%)	0.40 ± 0.10^{a}	0.56 ± 0.11^{a}	0.38 ± 0.07^{a}	0.60 ± 0.05^{a}
Hemicellulose (%)	12.26 ± 0.05^{a}	12.30 ± 2.17^{a}	12.16 ± 0.05^{a}	12.33 ± 0.11^{a}
Cellulose (%)	15.91 ± 0.05^{a}	16.11 ± 0.07^{a}	15.90 ± 0.40^{a}	16.68 ± 0.05^{b}
Lignin (%)	1.72 ± 0.01^{a}	1.73 ± 0.01^{a}	1.70 ± 0.00^{a}	1.74 ± 0.01^{ab}

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The neutral detergent fiber of sun dried fig was found to be 12.83 per cent. NDF increased by 0.78 % in sun dried fig as compared to fresh ones. NDF in microwave dried fig was found to be 12.86 per cent. NDF increased by 1.02 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Clary *et al*. (2007), where they reported 58 % increase in dietary fiber content in microwave dried grapes. This increase in dietary fiber by thermal process might be due to the formation of Maillard reaction product (Chang and Morris, 1990; Vidal and Frias, 1991) and also due to the reduction in moisture content (Fennema, 1976), by leaching of soluble components to the solution that leads to form the heat resistant complexes between polysaccharides and other mechanism i.e. protein and phenolic content (Caprez *et al.* 1986; Rodriguez *et al.* 2006). Dietary fiber (hemicellulose, cellulose and lignin) also increased (Vasishtha *et al.* 2013) due to releasing of enzymatic fiber components from insoluble cell wall matrix (Hakkinen *et al.*2003).

Neutral detergent fiber of frozen fig was found to be 12.53 per cent. The NDF decreased by 1.57% in frozen storage fig as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 18.13 % decrease in dietary fiber in frozen blackthorn fruit and Salgado *et al.* (1999), wherein they reported reduction in dietary fiber in frozen tropical fruits. This decrease in NDF by frozen storage might be due to the reduction in of cell wall polysaccharides tissues that leads declined dietary fiber (Khan and Vincent, 1996).

Acid detergent fiber (ADF) of fig fruit is depicted in Table 5.3. Acid detergent fiber of fresh fig was found to be 0.40 per cent. Similar results, i.e. 0.74 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. The ADF increased non significantly ($p>0.05$) in dried fig samples, the increasing order being FRS<FS<SD<MDS. The acid detergent fiber of sun dried fig was found to be 0.56 per cent. ADF increased by 40 % in sun dried fig as compared to fresh ones. ADF in microwave dried fig was found to be 0.60 per cent. ADF increased by 50 % in microwave dried fig as compared to fresh ones. Acid detergent fiber in frozen fig was found to be 0.38 per cent. The ADF decreased by 5.0 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Mohajer *et al.* (2016), where they reported 32.66 % decrease in ADF in frozen sainfoin seed.

Hemicellulose content of fresh fig was found to be 12.26 per cent. Similar results, i.e. 12.09 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. A statistically non significant increase ($p>0.05$) in hemicellulose content in fresh fig samples, the increasing order being FRS<FR<SD<MDS. The hemicellulose content of sun dried fig was found to be 12.30 per cent. Hemicellulose content increased by 0.32 % in sun dried fig as compared to fresh ones. Hemicellulose content in microwave dried fig was found to be 12.33 per cent. Hemicellulose content increased by 0.57 % in microwave dried fig. Similar results have been reported by Komolka *et al*. (2012), where they reported 5 % increase in hemicellulose content in common cabbage by thermal processing. Hemicellulose content in frozen fig was found to be 12.16 per cent. The hemicellulose content decreased by 0.06 % in frozen storage fig.

Cellulose content of fig fruit is depicted in Table 5.3. Cellulose content of fresh fig was found to be 15.91 per cent. Similar results, i.e. 22.20 per cent was reported by Nzidda (2010) in " *Ficus polita*" a variety of fig fruit. The cellulose content increased significantly ($p<0.05$) in dried fig samples, the increasing order being FRS<FS<SD<MDS. The cellulose content of sun dried fig was found to be 16.11 per cent. Cellulose content increased by 1.25 % in sun dried fig as compared to fresh ones. Cellulose content in microwave dried fig was found to be 16.68 per cent. Cellulose content increased by 4.83 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015), where they reported 13.7% increase in cellulose content in date fruit during thermal process and Nordin *et al*. (2013), wherein they reported 3.31% increase in oil palm fruit during heat treatment. Cellulose content in frozen fig was found to be 15.90 per cent. The cellulose content decreased by 0.06 % in frozen storage fig as compared to fresh ones.

Lignin content of fresh fig was found to be 1.72 per cent. Similar results, i.e. 2.53 per cent was reported by Lisa and Felicetti (2002) in fresh fig fruit. The lignin content increased significantly ($p<0.05$) in dried fig samples, the increasing order being FRS<FS<SD<MDS. The lignin content of sun dried fig was found to be 1.73 per cent. Lignin content increased by 0.58 % in sun dried fig as compared to fresh ones. Lignin content in microwave dried fig was found to be 1.74 per cent. Lignin content increased by 1.16 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015) in date fruit where they

found 20.68 % increase in lignin content during thermal process. Similar increase in lignin content (38.79 %) has been reported by Nordin *et al*. (2013) in thermal processed oil palm fruit. This increase in lignin content by thermal process might be due to increase the activity of lignin synthesis enzymes i.e. phenylalanine ammonia lyase (Yun *et al*.2013). Hosseinaei *et al.* (2012) also reported that due to heat, complex structure of lignin is formed which makes it difficult for degradation. Lignin content in frozen fig was found to be 1.70 per cent. The lignin content decreased by 1.16 % in frozen fig as compared to fresh ones. Similar results have been reported by Dangcham *et al*. (2008), where they reported 65.07 % decrease in lignin content in mangosteen fruit at low temperature storage.

5.1 (d) Phytochemical composition of fig (Total Phenolic content)

Processing methods caused remarkable changes in the total phenolic content of fig fruit is depicted in **Figure 5.1**. Total phenolic content (TPC) of fresh fig was found to be 4.58 mg TAE/100gm. Similar results, i.e. 1.15 mg GAE/100gm to 6.98 mg GAE/100gm were reported by Nakilcioglu and Hisil, (2013) in "Sarilop" fresh fig varieties.

A statistically significant increase ($p<0.05$) in TPC was observed in all dried fig samples, the increasing order being FRS<FS <SD<MDS. Total phenolic content of sun dried fig was found to be 4.92 mg TAE/100gm. TPC increased by 7.42 %, in sun dried fig as compared to fresh ones. Al-Farsi *et al.* (2005), reported 22.5 % increase in TPC in dates after sun drying. Total phenolic content of microwave dried fig was found to be 4.94 mg TAE/100gm. TPC increased by 7.86 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Reyes *et al.* (2013) in loquat where they found 10.52 % increase in TPC in microwave dried fruit as compared to fresh ones and Hayat *et al*. (2010), wherein they reported increase from 4.3% to 45.61% in microwave dried pomace. This increase in TPC by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (HMP) by Maillard reaction (Donovan *et al.* 1998) and also due to the breakdown of cellular structure of cells, which makes the phenolic content more extractable (Van *et al.* 2000). Singleton *et al.* (1999) mentioned enhancement in phenolic content may be due to the formation of aglycons by reacting with Folin-Ciocalteau reagent.

Total phenolic content of frozen fig was found to be 4.52 mg TAE/100gm. Frozen stored fig fruits exhibited 1.31 % decrease in total phenolic content as compared to fresh ones. Similar results have been reported by Mullen *et al.* (2002), where they reported 21 to 28 % decrease in the TPC in raspberries during frozen storage as compared to fresh ones. Similar decrease in TPC (0.81%) has been reported by Scibisz and Mitek (2007) in frozen blueberries. This may be attributed to the fact that frozen storage leads to decrease in total phenolic content of fruits as polyphenol oxidase enzymes (PPO) are released by breaking cells and that leads to oxidation of polyphenolics to quinines (De Ancos *et al*. 2000a).

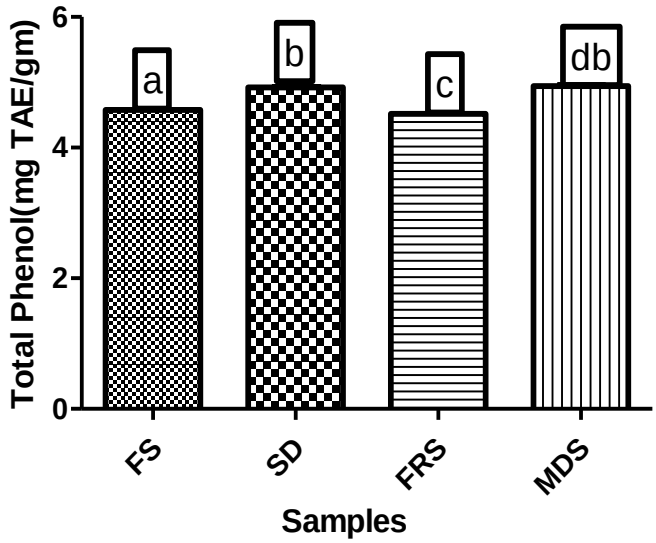

Fig. 5.1 Total Phenolic content of fig

Values are expressed in triplicates (mean ± SD)

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample

5.2 (e) Total Flavonoid content of fig

Flavonoid content of fig fruit is depicted in **Figure 5.2.** Total flavonoid content of fresh fig was found to be 0.21 mg QE/100gm. Similar results, i.e. 1.6 mg catechin equivalent/ 100gm

to 2.3 mg catechin equivalent /100gm were reported by Solomon *et al*. (2006) in "Brunswick " fresh fig varieties.

The total flavonoid content increased significantly ($p<0.05$) in fresh fig sample, the increasing order being SD<MDS<FS<FRS. The flavonoid content of sun dried fig was found to be 0.19 mg QE/100gm. Flavonoid content decreased by 9.52 % in sun dried fig as compared to fresh ones. Similar results have been reported by Wang *et al.* (2016) in jujube fruit where they found 26.75 % decrease in flavonoid content in sun dried fruit. Flavonoid content of microwave dried fig was found to be 0.20 mg QE/100gm. Flavonoid content decreased by 4.76 % in microwave dried fig as compared to fresh ones. Similarly reduction in total flavonoid content (33.3%) has been reported by Salim *et al.* (2014) in microwave dried pepper and Planinic *et al.* (2015), wherein they reported 15.3% reduction in flavonoid content in microwave dried grape fruit. Similar results have been reported by Macias *et al* .(2013), where they reported 23.13 % decrease in flavonoid content in strawberry fruit during thermal process. This decrease in flavonoid content by thermal process (Crozier *et al.* 1995; Price and Rhodes, 1997) might be due to the breakdown of some phytochemicals, which affects cell wall integrity and that leads to migration of some flavonoid components (Davey *et al.* 2000). Ioannou *et al.* (2012) also mentioned that heating process caused degradation might be due to parameters such as pH, oxygen, light, activity of polyphenoleoxidase enzymes and by hydrolysis of C- glycosides bonds, which are presented in flavonoids (Manach *et al.*2004). Flavonoid content of frozen fig was found to be 0.23 mg QE/100gm.

Flavonoid content increased by 9.52 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Mohammadian *et al*.(2011), where they reported 52.11% increase in flavonoid content in "*Citrus limon*" during frozen storage. This may be attributed to the fact that frozen storage leads to increase in flavonoid content of fruits as increase in quercetin derivatives during cold storage (Omer and Canan, 2014) that increases quercetin hydrolysis (Hakkinen *et al*.2000).

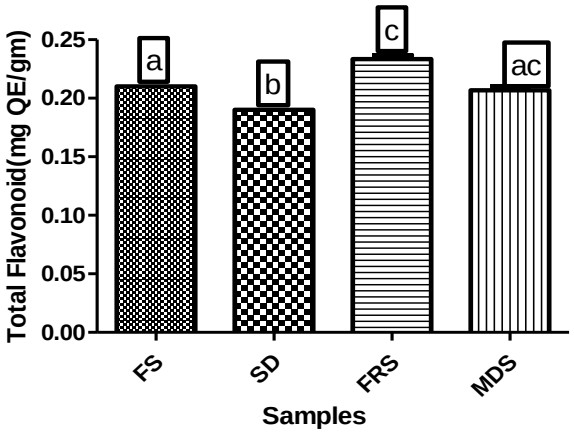

Fig. 5.2 Total Flavonoid content of fig

Values are expressed in triplicates (mean ± SD)

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.1 (f) Antioxidant activity of fig

Processing methods caused remarkable changes in antioxidant activity of fig fruit is depicted in **Figure 5.3.** Antioxidant activity of fresh fig was found to be 73.42 per cent. Similar results, i.e. 75.16 per cent was reported by Wilson *et al*. (2016) in " *Ficus religiosa*" a variety fig fruit.

Antioxidant activity significantly ($p<0.05$) increased in all dried fig sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity of sun dried fig was found to be 75.36 per cent. Antioxidant activity increased by 2.64 % in sun dried fig as compared to fresh ones. Antioxidant activity of microwave dried fig was found to be 75.84 per cent. Antioxidant activity increased by 3.29 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Mechlouch *et al.* (2015), where they found 95.32 % increase in antioxidant activity (DPPH) in microwave dried palm date and Juhaimi *et al*.(2015), wherein they reported 280.33 % increase in DPPH antioxidant activity in microwave dried apple. Similar increase in antioxidant activity from 0.27 % to 0.96 % has been reported by Jeong et al.(2004) in heat treated citrus peel extract. This increase in antioxidant activity (DPPH) by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (Raupp *et al*.2011), presence of

naturally occurring compounds such as Maillard reaction products (Yin and Chang,1998; Piga *et al*. 2003;Lee *et al*.2003), released of a free phenolic fraction (Yamaguchi *et al*. 2001), due to oxidative and hydrolytic enzyme (Farsi *et al*.2005), disruption of cell wall that leads to release and enhances antioxidant activity (Chumyan *et al*.2013).

Antioxidant activity of frozen fig was found to be 71.66 per cent. Antioxidant activity (DPPH) decreased by 2.39 % in frozen storage fig as compared to fresh ones. Similar results have been reported by De Ancos *et al.* (2000), where they reported 12 % decrease in antioxidant activity (DPPH) in frozen raspberry fruit and Pimia *et al*.(2003), wherein they reported 20 % decrease in antioxidant activity in frozen peas. Similar decrease in antioxidant activity (1.64 %) has been reported by Mohammadian *et al.*(2011) in frozen "*Citrus limon*. This may be attributed to the fact that frozen storage leads to decrease in antioxidant activity of fruits as disruption of cell structure (Sikora *etal*.2013) and cell wall that leads to release of the oxidative and hydrolytic enzymes that can destroy antioxidant in fruits (Chism,1996).

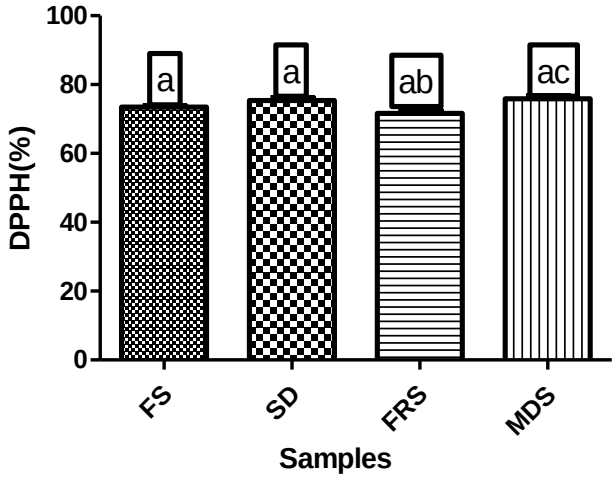

Fig. 5.3 Antioxidant activity (DPPH) of fig

Different superscripts in the same row are significantly different ($p<0.05$).

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.1 (g) Antioxidant activity of fig

Ferric reducing scavenging activity (FRAP) is depicted in **Figure 5.4.** Antioxidant activity of fresh fig was found to be 76.22 per cent. Shivasharanappa and Londonkar, (2014) reported lower antioxidant activity in"*Ficus glomerata*" variety of fig fruit, i.e. 29 per cent to 70 per cent as compared to our results. This difference might be due to many parameters such as fruit colour (Bey and Louaileche, 2015), extraction methods, solvent (Musa *et al.*2011), difference in cultivation (Wand *et al*. 2002; Hakkinen and Torronen, 2000), ripening period (Raffo *et al.* 2012), environmental factor (Wu *etal*.2014). Antioxidant activity non significantly ($p > 0.05$) increased in all dried fig sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity (FRAP) of sun dried fig was found to be 76.55 per cent. Antioxidant activity (FRAP) increased by 0.43 % in sun dried fig as compared to fresh ones. Antioxidant activity of microwave dried fig was found to be 78.54 per cent. Antioxidant activity increased by 3.04 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Piga *et al.* (2003), where they reported increase in antioxidant activity (FRAP) in plum fruit during thermal process. Higher antioxidant activity might be due to relative increase of FRAP value which determined the capacity of plant extract for the donation and acceptance of electrons (Yan *et al.* 2006). This increase in antioxidant activity by thermal process may be due to reduction in moisture content(Abou El-Hana, 2008), inhibition of oxidative enzymes and cell wall destruction which releases antioxidant compounds (Yamaguchi *et al.* 2001).

Antioxidant activity of frozen fig was found to be 75.76 per cent. Antioxidant activity (FRAP) decreased by 0.60 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Poiana *et al*.(2010), where they reported decrease from 6.5% to 12% in frozen strawberry fruit and Nilsson *et al.* (2004), wherein they reported decrease in antioxidant activity (FRAP) in frozen peas.

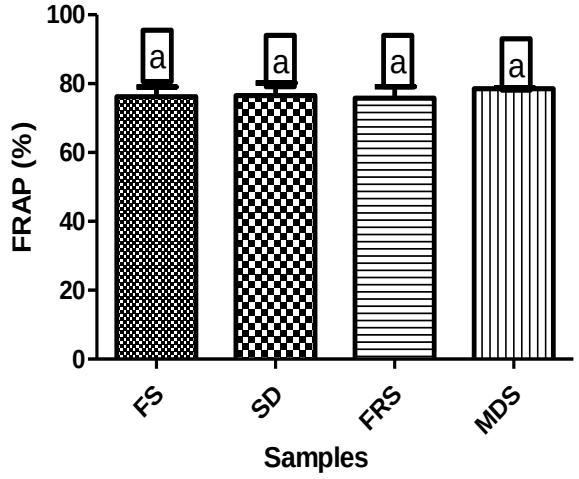

Fig. 5.4 Antioxidant activity (FRAP) of fig

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample

5.1 (h) Anti - nutritional content and anthocyanin content of fig

Tannin content of fresh fig was found to be 0.67 gm/100gm and depicted in Table 5.4. Similar results, i.e. 1.88 gm/100 gm was reported by Noonan and Savage (1999) in "*Ficus Benghalensis* " a variety of fig fruit. Tannin content increased significantly ($p<0.05$) in fresh fig samples, the increasing order being FRS<SD<MDS<FS.

Sun dried fig tannin content was found to be 0.61 gm /100gm. Tannin content decreased by 8.95 % in sun dried fig as compared to fresh ones. Tannin content of microwave dried fig was found to be 0.62 gm /100gm. Tannin content decreased by 7.46 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Pragati *et al.* (2003) in aonla fruit where they found 31.50% decrease in tannin content during thermal process and Nwaigwe and Adejumo (2015), wherein they reported 92.56 % decrease in tannin content in African bread fruit heat treatment. Similar decrease in tannin content (10.58 %) has been reported by Sunmola *et al.* (2011) in *Carica papaya* seed during thermal process. This decrease in tannin content by thermal process might be due to the oxidation of bioactive compounds (Yoshioka *etal.* 1990) and also due to the breakdown of cell structure which migrates the components that

are creating loss by leakage in the presence of oxygen and light (Scheieber *et al*.2001) and also due to various chemical reaction involving enzymes (polyphenoleoxidase) which are responsible to convert tannins into other products (Pragati *et al.* 2003; Mehta,1995).

Table 5.4 Effect of processing methods on anti - nutritional and anthocyanin content of fig

Drying methods	FS	SD	FRS	MDS
Tannin- (gm/100g)	0.67 ± 0.00^{a}	0.61 ± 0.00^{b}	0.60 ± 0.00^{bc}	0.62 ± 0.00^{bd}
Alkaloid- (gm/100g)	7.80 ± 0.04^{a}	7.76 ± 0.02^{a}	7.60 ± 0.1^{b}	7.79 ± 0.04^{ac}
Anthocyanin- (mg/100g)	4.78 ± 0.19^{a}	4.67 ± 0.00^{a}	4.89 ± 0.19^{a}	4.56 ± 0.50^{a}

Tannin content of frozen fig was found to be 0.60 gm /100gm. Tannin content decreased by 10.44 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 33.33 % reduction in tannin content in frozen dates. Similar decrease in tannin content in persimmons fruit has been reported by Nakamura (1961) during frozen storage. This decrease in tannin content by frozen storage might be due to the non-enzymatic activity in fruits (Al-Ogadi and Mutlak, 1986; Abu-Goukh *et al*. 2003), change occurs in chemical properties of tannin (Nakamura ,1961) that leads to coagulate soluble tannin into insoluble (Brackmann *et al.*1997; Matsu and Itoo,1978).

Alkaloid content of fig fruit is depicted in Table 5.4. Total alkaloid content of fresh fig was found to be 7.80 gm /100gm. Similar results, i.e. 9.6 gm/100gm was reported by Soni *et al*. (2014) in fig fruit. A statistically significant increase ($p<0.05$) in alkaloid content was observed in fresh fig samples, the increasing order being FRS<SD<MDS<FS. The alkaloid content of sun dried fig was found to be 7.76 gm /100gm. Alkaloid content decreased by 0.51 % in sun dried fig as compared to fresh ones. Alkaloid content of microwave dried fig was found to be 7.79 gm /100gm. Alkaloid content decreased by 0.12 % in microwave dried fig as compared

to fresh ones. Similar results have been reported by Nwaigwe and Adejumo (2015) in African bread fruit they found 20.75 % decrease in alkaloid content during heat treatment and Irondi *et al*. (2010), wherein they reported decrease in alkaloid content in *Carica papaya* by thermal process. This decrease in alkaloid content by thermal process might be due to the breakdown of cell structure which results migration of components, that leads to loss by various chemical reactions i.e. involving enzymes, light and heat (Atlabachew *et al*. 2013). Alkaloid content of frozen fig was found to be 7.60 gm /100gm. Alkaloid content decreased by 2.56 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Atlabachew *et al*. (2013), where they reported 56 % decrease in alkaloid content (cathinone) in frozen (*Catha Edulis* Forsk) leaves.

The anthocyanin content of fig fruit is depicted in Table 5.4. Total anthocyanin content of fresh fig was found to be 4.78 mg cyanidin-3-glucoside equivalents/100gm. Similar results, i.e. 0.1 mg cynide-3-glucose/100gm to 27.3 mg cynidin-3-glucoside equivalent /100gm were reported by Solomon *et al*. (2006) in "Mission" fresh fig varieties. Anthocyanin content increased non significantly ($p > 0.05$) in frozen fig samples, the increasing order being MDS<SD<FS<FRS.

The anthocyanin content of sun dried fig was found to be 4.67 mg cyanidin-3-glucoside equivalents/100gm. Anthocyanin content decreased by 2.30 % in sun dried fig as compared to fresh ones. Anthocyanin content of microwave dried fig was found to be 4.5 mg /100gm. Anthocyanin content decreased by 2.30 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Wojdylo *et al.* (2009) in strawberry where they found 12.9 % decrease in anthocyanin content in microwave dried fruit. Similar decrease in anthocyanin content (35.69 %) has been reported by Wojdylo *et al*. (2014) in microwave dried sour cherries. This decrease in anthocyanin content by thermal process (Juan *et al*.2013) might be due to different factors i.e. heat, oxygen, metal ion, co-pigmentation and pH (Mishra and Yang, 2008), polyphenol oxidase enzymes activity (Kwok *et al.*2004) and browning reaction (Wrolstad *et al.* 2004).

Total anthocyanin content of frozen fig was found to be 4.89 mg cyanidin-3-glucoside equivalents/100gm. Anthocyanin content increased by 4.60 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Scibisz and Mitek (2007), where they

reported 1.30 % increase in anthocyanin content in frozen blueberries. Similar increase in anthocyanin content (2.16 %) has been reported by Mullen *et al.* (2002) in frozen red raspberries. This increase in anthocyanin content might be due to ice crystal formation that favours to reallocation of water molecules in cell structure, that leads to enhance the release of membrane bound anthocyanin (Szczesniak, 1998; Leong and Oey, 2012) and also due to the cellular disruption in fruits (Skrede, 1996) which contributes to increase the cyanidin -3-galactoside content in fruits (Scibisz and Mitek, 2007).

5.1 (i) Mineral composition of fig

The mineral composition of fig fruit as depicted in Table 5.5. Calcium content of fresh fig was found to be 80.76 mg /100gm. Similar results, i.e.78 mg/100gm was reported by Khan *et al*. (2011) in fresh fig fruit.

Table 5.5 Effect of processing methods on mineral composition of fig

Drying methods	FS	SD	FRS	MDS
Calcium- (mg/100g)	80.6± 0.01 ^{a}	285.23±0.01 ^{b}	80.76± 0.01 ^{c}	302.86± 0.01^{cd}
Iron- (mg/100g)	12.01±0.01^{a}	12.66± 0.01 ^{b}	11.51 ±0.01^{c}	13.20 ±0.01^{dc}
Phosphorus- (mg/100g)	17.66± 0.01^{a}	106.16 ± 0.01^{cd}	17.41± 0.01^{c}	123.13± 0.01 ^{cd}

Calcium content increased significantly ($p<0.05$) in microwave dried fig sample, the increasing order being FS<FRS<SD<MDS. Mineral composition might be increased or decreased by different processing methods (Rickman *et al.* 2007). The calcium content of sun dried fig was found to be 285.23 mg /100gm. Calcium content increased by 253.18% in sun dried fig as compared to fresh ones. Calcium content of microwave dried fig was found to be 302.86 mg /100gm . Calcium content increased by 275.01 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Clary *et al.* (2007) in grapes where they found

157.81 % increase in mineral content in microwave dried fruit and Incedayi *et al.* (2016), wherein they reported 70.93 % increase in calcium content in microwave dried apricot fruit. This increase in calcium content by thermal process might be due to increasing of dry matter content. Ozcan *etal.* (2004) also reported that changes in the concentration of minerals are also depending on the method and the drying temperature used (Ozcan *et al.* 2004).

Calcium content of frozen fig was found to be 80.76 mg /100gm. Calcium content increased by 0.198 % in frozen storage fig as compared to fresh ones. Similar results were reported by Zolfaghari *et al*.(2010), where they reported 13.42 % increase in calcium content in frozen kiwi fruit of "Abbot" cultivar. Similar increase in calcium content (6.25%) has been reported by Bouzari *et al*.(2015) in frozen carrot.

Iron content of fresh fig was found to be 12.01 mg /100gm. Similar results, i.e. 10.09 mg/100gm was reported by Khan *et al*. (2011) in fresh fig. Iron content increased significantly ($p<0.05$)in microwave dried fig sample, the increasing order being FRS<FS<SD<MDS. The iron content of sun dried fig was found to be 12.66 mg /100gm . Iron content increased by 5.41% in sun dried fig as compared to fresh ones. Iron content of microwave dried fig was found to be 13.20 mg /100gm. Iron content increased by 9.90 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Clary *et al*. (2007) in grapes where they found 35.29 % increase in iron content during thermal process. Similar increase in iron content (395.06%) has been reported by Jung *et al*. (2005) in microwave dried persimmon fruit. Iron content of frozen fig was found to be 11.51 mg /100gm. Iron content decreased by 4.16 % in frozen storage fig as compared to fresh ones. Similar results have been reported by Zolfaghari *et al*.(2010) in kiwi fruit where they found 13.80 % decrease in iron content in frozen storage.

Phosphorus content of fresh fig was found to be 17.66 mg /100gm. Guvenc *et al*. (2009) was reported higher phosphorus content in fresh fig fruit i.e. 22 mg/100gm as compared to our results. This differences might be due variation in cultivars, storage period and genetic factor (Zolfaghari *et al.* 2010). Phosphorus content increased significantly ($p<0.05$) in microwave dried fig sample, the increasing order being FRS<FS<SD<MDS. The phosphorus content of sun dried fig was found to be 106.16 mg /100gm. Phosphorus content increased by 501.13 % in sun dried fig as compared to fresh ones. Phosphorus content of microwave dried fig was found

to be 123.13 mg /100gm. Phosphorus content increased by 597.22 % in microwave dried fig as compared to fresh ones. Similar results have been reported by Ozcan and Arslan, (2011) in tomato where they found 250% increase in phosphorus content during heat treatment . Phosphorus content of frozen fig was found to be 17.41 mg /100gm. Phosphorus content decreased by 1.42 % in frozen storage fig as compared to fresh ones. Similar decrease in phosphorus content 14.53 % has been reported by Zolfaghari *et al*.(2010) in frozen kiwi fruit and Ogbadoyi and Musa (2013), wherein they reported reduction in mineral content in frozen storage "*Amaranthus cruentus".* This may be attributed to the fact that frozen storage leads to decrease in iron content of fruits as high moisture content that leads to form ice crystals and causes leakage from the cell membranes (Baker and Gawish, 1997) that leads to reduction in mineral elements (Hui *et al*., 2004; McDonald *et al.,* 2006).

5.2 Analysis of *Carissa spinarum* (Karonda)

5.2 (a) Physical properties of karonda

The length of fresh karonda was found to be 7.46 mm. Similar results, i.e. 6 mm length was reported by Amreen *et al.* (2013) in fresh *Carissa spinarum* fruit. A statistically significant increase ($p<0.05$) in length was observed in fresh karonda sample, the increasing order being MDS<SD <FRS<FS.

Table 5.6 Effect of processing methods on physical properties of karonda

Drying methods	FS	SD	FRS	MDS
Length(mm)	7.46 ± 0.05^{a}	6.06 ± 0.05^{b}	6.36 ± 0.05^{c}	5.96 ± 0.05^{db}
Width(mm)	4.54±0.00a	3.76 ± 0.05^{b}	3.86 ± 0.05^{c}	3.26 ± 0.05^{cd}
Density(gm/cc)	0.64 ± 0.01^{a}	0.61 ± 0.00^{a}	0.62 ± 0.00^{ab}	0.60 ± 0.00^{a}

Where, Fresh- FS, Sun drying-SD, Freezed -FRS, Microwave drying-MDS

Length of sun dried karonda was found to be 6.06 mm. Length was decreased by 20.10 %, in sun dried karonda as compared to fresh ones. Length of microwave dried karonda was found to be 5.96 mm. Length decreased by 20.10 %, in microwave dried karonda as compared to fresh ones. Similar results have been reported by Oztekin *et al.* (2011), wherein they reported 0.70 % decrease in length in berry fruit by thermal processing. Similar decrease in length has been reported by Zivcovic *et al*. (2011) in thermal dried plum.

This may be attributed to the fact that thermal process leads to decrease in length due to the shrinkage of fruits (Hazbavi *etal*. 2014). Length of frozen karonda was found to be 6.36 mm. Length decreased by 14.74 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 4.80 % decrease in length in frozen dates. This decrease in length by frozen storage might be due to the period of cold

storage (Al- Yahayai and Al- Kharusi,2012). The width of fresh karonda was found to be 4.54 mm. Similar results, i.e. 6 mm width was reported by Amreen *et al.(*2013) in fresh *Carissa spinarum* fruit. A statistically significant increase ($p<0.05$) in width was observed in fresh karonda sample, the increasing order being MDS<SD <FRS<FS.

Width of sun dried karonda was found to be 3.76 mm. Width decreased by 17.18 % in sun dried karonda as compared to fresh ones. Width of microwave dried karonda was found to be 3.26 mm. Width decreased by 28.19 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Oztekin *et al.* (2011), wherein they reported 6.79 % decrease in width in berry fruit by thermal processing. Similar decrease in width has been reported by Zivcovic *et al*. (2011) in heat treated plum. This decrease in width by thermal process might be due to the reduction of moisture content (Kashaninejad *et al.*2006) and also due to the shrinkage of fruits (Jha *et al.*2006; Hazbavi *et al*, 2014). Width of frozen karonda was found to be 3.86 mm. Width decreased by 14.97 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), wherein they reported 7.69 % decrease in width in frozen dates. This decrease in width by frozen storage might be due to the period of cold storage (Al- Yahayai and Al- Kharusi, 2012).

The density of fresh karonda was found to be 0.64 gm/cc. Similar results, i.e. 0.82 gm/cc was reported by Din (2008) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically significant increase ($p<0.05$) in density was observed in all dried karonda samples, the increasing order being MDS<SD<FRS<FS. Density increased in fresh fruits due to higher moisture content that leads to increase volume (Garmakhany *et al.* 2013). Density of sun dried karonda was found to be 0.61 gm/cc. Density decreased by 4.68 % in sun dried karonda as compared to fresh ones. Density of microwave dried karonda was found to be 0.60 gm/cc. Density decreased by 6.25 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Pacco and Menegalli (2004), where they reported decreased density in thermal dried fruit. This may be attributed to the fact that fruit becomes more porous due to heating process.

Density of frozen karonda was found to be 0.62 gm/cc. Density decreased by 3.12 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Ramaswamy

and Tung (1981), wherein they reported decrease in density by 6.74 % in frozen storage "Golden" apple.

5.2 (b) Nutritional composition of karonda

The moisture content of karonda fruit is depicted in Table 5.7. Moisture content of fresh karonda was found to be 81.05 per cent. Similar results, i.e. 83.17 per cent was reported by (Morton, 1987) in "*Carissa carandas"* a variety of karonda. The moisture content increased significantly ($p<0.05$) in frozen karonda sample, the increasing order being MDS<SD<FS<FRS.

Table 5.7 Effect of processing methods on nutritional composition of karonda

Drying methods	FS	SD	FRS	MDS
Moisture(%)	81.05 ± 1.97^{a}	16.86 ± 0.75^{b}	82.06 ± 2.19^{ac}	16.83 ± 0.40^{bc}
Ash (%)	2.46 ± 0.06^{a}	2.51 ± 0.05^{a}	2.48 ± 0.07^{a}	2.50 ± 0.06^{a}
Carbohydrate (%)	18.66 ± 0.25^{a}	60.51 ± 0.00^{b}	18.16 ± 0.59^{ac}	61.81 ± 0.01^{cd}
Fat (%)	1.30 ± 0.01^{a}	1.50 ± 0.03^{b}	1.29 ± 0.02^{ac}	1.51 ± 0.01^{bc}
Protein (%)	2.07 ± 0.04^{a}	2.41 ± 0.33^{a}	2.04 ± 0.04^{a}	2.51 ± 0.33^{a}

The moisture content of sun dried karonda was found to be 16.86 per cent. Moisture content decreased by 79.19 % in sun dried karonda as compared to fresh ones. Similar results have been reported by Kamiloglu and Capanoglu (2015), in fig where they found 76% decrease in moisture content in sun dried fruit. Moisture content of microwave dried karonda was found to be 16.83 per cent. Moisture content decreased by 79.23 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015), wherein they reported 88.88% decrease in moisture content in okra after thermal process.

Similar decrease in moisture content (70.32 %) has been reported by Guvenc *et al.* (2009) in heat treated fig. Udomkun *et al*.(2015), also reported 98.06 % reduction in moisture content in thermal dried papaya. This reduction in moisture content by thermal process might be due to the rapid water loss (Mechlouch *et al.* 2015), heating temperature (Brooker, 1974) and higher absorption power (Meda *et al.* 2008).

Moisture content of frozen karonda was found to be 82.06 per cent. Moisture content increased by 1.24 % in frozen karonda as compared to fresh ones. Similar results have been reported by Aleid *et al*. (2014), where they reported 10.51% increase in moisture content in date during frozen storage and Damini *et al*.(2013), wherein they reported 2.45 % increase in the moisture content in frozen marolo pulp. Similar increase in moisture content (1.0 %) has been reported by Boca *et al.* (2014) in frozen strawberry puree. This may be attributed to the fact that frozen storage leads to increase in moisture content of fruits as destruction of cellular structure by syneresis (Sae-Kang and Suphantharika, 2006) that leads to release of intracellular water (Chefteh and Besancon, 1989) which is migrated out of the cell (Damiani *et al*.2013).

The ash content of karonda fruit is depicted in Table 5.7. Ash content of fresh karonda was found to be 2.46 per cent. Similar results, i.e. 2.53 per cent was reported by Mishra and Gupta (2005), in fresh *Carissa spinarum*. The result of ash content non significantly ($p>0.05$) increased in all karonda dried samples and the increasing order being FS<FRS<MDS<SD. The ash content of sun dried karonda was found to be 2.51 per cent. Ash content increased by 2.03 % in sun dried karonda as compared to fresh ones. Ash content of microwave dried karonda was found to be 2.50 per cent. Ash content increased by 1.62 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Guvenc *et al*. (2009), wherein they reported 379.16 % increase in ash content in fig during thermal process. Similar increase 1.48 % ash content in fig fruit during heat treatment has been reported by Mahmoud *et al.* (2013). This increase in ash content by thermal process might be due to the removal of moisture content (Morris *et al.* 2004).

Ash content of frozen karonda was found to be 2.48 per cent. Ash content increased by 0.81 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Zolfaghari *et al*. (2010), where they reported 8.3 % increase in ash content in kiwi fruit during

frozen storage. Similar increase in ash content (20 %) has been reported by Ogunobanwo *et al*.(2013) in frozen water melon juice. This increase in ash content by frozen storage might be due to the presence of products which has chemical stability (Raji *et al.* 2016).

Fat content of karonda fruit is depicted in Table 5.7. Fat content of fresh karonda was found to be 1.30 per cent. Similar results, i.e. 2.57 per cent was reported by Morton (1987) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically significant increase ($p<0.05$) in fat content in all dried karonda samples and the increasing order being FRS<FS<SD<MDS.

The fat content of sun dried karonda was found to be 1.50 per cent. Fat content increased by 15.38 % in sun dried karonda as compared to fresh ones. Fat content of microwave dried karonda was found to be 1.51 per cent. Fat content increased by 16.15% in microwave dried karonda as compared to fresh ones. Similar results have been reported by Mrabet *et al.* (2015), in date where they found 7.64 % increase in fat content during thermal process. This may be attributed to the fact that thermal process leads to increase in fat content of fruits along with removal of moisture content (Morris *et al.* 2004). Fat content of frozen karonda was found to be 1.29 per cent. Fat content decreased by 0.76 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Ogunbanwo *et al.* (2013), where they reported 50 % decrease in fat content in water melon juice and Raji *et al*. (2016) reported decrease 0.95% fat content in *Ewedu* soups during frozen storage. This decrease in fat content by frozen storage might be due to oxidation (Ryder *et al*.1993) that leads to release oxidative enzymes from various rupture cellular organelles (Boonsumrej *et al.* 2007).

Carbohydrate content of fresh karonda was found to be 18.66 per cent. Similar results, i.e. 15.16 per cent was reported by Ara *et al*. (2014) in fresh "*Carissa carandas"* a variety of karonda fruit. The carbohydrate content was significantly ($p<0.05$) increased in all karonda dried samples and the increasing order being FRS<FS<SD<MDS. The carbohydrate content of sun dried karonda was found to be 60.51 per cent. Carbohydrate content increased by 224.27% in sun dried karonda as compared to fresh ones.

Carbohydrate content of microwave dried karonda was found to be 61.81 per cent. Carbohydrate content increased by 231.24 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Guvenc *et al*. (2009) in fig fruit where they

found 240.39 % increase in carbohydrate content during heat treatment and Famurewa and Olumofin,(2015),wherein they reported 141.30 % increase in carbohydrate content in microwave dried okra. Similar increase in carbohydrate content (325.47 %) has been reported by Mahmoud *et al.* (2013) in thermal treated sycamore fruit. This increase in carbohydrate content by thermal process might be due to hydrolytic effect of carbohydrate stored in fruits (Akinhanmi *et al.* 2008).

Carbohydrate content of frozen karonda was found to be 18.16 per cent. Carbohydrate content decreased by 2.67 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Galoburda *et al.* (2014), where they reported 55.2% decrease in the carbohydrate content in strawberry puree during frozen storage. Damiani *et al*. (2013) also reported 16.11 % decrease in carbohydrate content in frozen marolo pulp. Similar decrease in carbohydrate content (25.78%) has been reported by Zolfaghari *et al*.(2010), in frozen kiwi fruit. This may be attributed to the fact that frozen storage leads to decrease in carbohydrate content of fruits due to the breakdown of cell structure during frozen storage (Cheftel and Besancon, 1989).

The protein content of karonda fruit is depicted in Table 5.7. Protein content of fresh karonda was found to be 2.07 per cent. Similar results, i.e. 3.64 per cent was reported by Mahapatra *et al*. (2012) in fresh " *Carissa spinarum"* fruit. The protein content increased non significantly ($p>0.05$) in all karonda dried samples and the increasing order being FRS<FS<SD<MDS. The protein content of sun dried karonda was found to be 2.41 per cent. Protein content increased by 16.42 % in sun dried karonda as compared to fresh ones. Protein content of microwave dried karonda was found to be 2.51 per cent. Protein content increased by 21.25 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Fedha *et al*.(2010) in pumpkin where they found 2.5 % increase in protein content during thermal process and Clary *et al*. (2007), wherein they reported 236.11 % increase in protein content in grapes during heat treatment.

Similar increase in protein content (258.55%) has been reported by Guvenc *et al*. (2009) in fig fruit during thermal process. This increase in protein content by thermal process might be due to

the enhancement in dry matter contents by the concentration of soluble solids (Eze and Akubor, 2012).

Protein content of frozen karonda was found to be 2.04 per cent. Protein content decreased by 1.44% in frozen storage karonda as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 57.51% decrease in protein content in blackthorn fruit during frozen storage. Similar decrease in protein content (4.22 %) has been reported by Ogunbanwo *et al*. (2013) in frozen water melon juice and Raji *et al*. (2016) reported decrease 3.83% protein content in *Ewedu* soups during frozen storage. This may be attributed to the fact that frozen storage decrease in protein content of fruits as reduction in proteins which are water and salt soluble (Chomnawang *et al.*2007), denaturation of proteins (Ryder *et al.* 1993) and destruction caused by enzymatic activity (Hultman and Rustard, 2004).

5.2 (c) Dietary composition of karonda

The neutral detergent fiber (NDF) of karonda fruit is depicted in Table 5.8. Neutral detergent fiber of fresh karonda was found to be 25.43 per cent. Similar results, i.e. 27.27 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit.

NDF was significantly ($p<0.05$) higher in all karonda dried samples, the increasing order being FRS<FS<SD<MDS. The neutral detergent fiber of sun dried karonda was found to be 25.56 per cent. NDF increased by 0.51 % in sun dried karonda as compared to fresh ones. NDF in microwave dried karonda was found to be 26.23 per cent. NDF increased by 3.14 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015), where they reported 6.54 % increase in dietary fiber content in microwave dried okra. Similar increase 102.2 % dietary fiber in *Musa paradisaca* during oven drying has been mentioned by Agoreyo *et al.* (2011) and Mahmoud *et al.* (2013) reported increase 1.48 % ash content in fig fruit during heat treatment. This increase in dietary fiber by thermal process might be due to the formation of Maillard reaction product (Chang and Morris, 1990; Vidal and Frias, 1991) and also due to the reduction in moisture content (Fennema, 1976), by leaching of soluble components to the solution that leads to form the heat resistant complexes between polysaccharides and other mechanism i.e. protein and phenolic content components (Caprez *et al.* 1986; Rodriguez *et al.* 2006). Dietary fiber (hemicellulose,

cellulose and lignin) also increased (Vasishtha *et al.* 2013) due to releasing of enzymatic fiber components from insoluble cell wall matrix (Hakkinen *et al.*2003).

Table 5.8 Effect of processing methods on dietary composition of karonda

Drying methods	FS	SD	FRS	MDS
NDF(%)	25.43± 0.05^{a}	25.56± 0.66^{a}	25.26±0.05^{b}	26.23± 0.05^{ac}
ADF(%)	16.03± 0.11^{a}	16.13± 0.66^{a}	15.96±0.49^{a}	16.50± 0.00^{a}
Hemicellulose (%)	9.40± 0.51^{a}	9.43±0.98^{a}	9.20±0.10^{a}	9.66±0.15^{a}
Cellulose(%)	14.05±0.13^{a}	14.67±0.54^{a}	12.97±0.00^{a}	14.89 ± 0.09^{b}
Lignin (%)	3.10± 0.05^{a}	3.20± 0.05^{a}	3.00± 0.10^{a}	3.33±0.05^{ab}

Neutral detergent fiber of frozen karonda was found to be 25.26 per cent. The NDF decreased by 0.66 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Sikora *et al.* (2013), where they reported 18.13 % decrease in dietary fiber in frozen blackthorn fruit and Salgado *et al.* (1999), wherein they reported reduction in dietary fiber in frozen tropical fruits and Raji *et al*. (2016) reported decrease 0.92% dietary fiber in *Ewedu* soups during frozen storage. This decrease in NDF by frozen storage might be due to the reduction in of cell wall polysaccharides tissues that leads declined dietary fiber (Khan and Vincent, 1996).

The acid detergent fiber (ADF) of karonda fruit is depicted in Table 5.8. Acid detergent fiber of fresh karonda was found to be 16.03 per cent. Similar results, i.e. 18.03 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. The ADF was non significantly ($p>0.05$) increased in dried karonda samples, the increasing order being

FRS<FS<SD<MDS. The acid detergent fiber of sun dried karonda was found to be 16.13 per cent. ADF increased by 0.62 % in sun dried karonda as compared to fresh ones. ADF in microwave dried karonda was found to be 16.50 per cent. ADF increased by 1.24% in microwave dried karonda as compared to fresh ones. Acid detergent fiber in frozen karonda was found to be 15.96 per cent. The ADF decreased by 4.80 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Mohajer *et al.* (2016), where they reported 32.66 % decrease in ADF in frozen sainfoin seed.

Hemicellulose content of fresh karonda was found to be 9.40 per cent. Similar results, i.e. 9.24 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically non significant increase ($p>0.05$) in hemicellulose content in fresh karonda samples, the increasing order being FRS<FS<SD<MDS. The hemicellulose content of sun dried karonda was found to be 9.43 per cent. Hemicellulose content increased by 0.31 % in sun dried karonda as compared to fresh ones. Hemicellulose content in microwave dried karonda was found to be 9.66 per cent. Hemicellulose content increased by 2.76 % in microwave dried karonda as compared to fresh ones. This increase in hemicellulose content by thermal process. Similar results have been reported by Komolka *et al*. (2012), where they reported 5 % increase in hemicellulose content in common cabbage by thermal processing. Hemicellulose content in frozen karonda was found to be 9.20 per cent. The hemicellulose content decreased by 2.12 % in frozen storage karonda.

Cellulose content of karonda fruit is depicted in Table 5.8. Cellulose content of fresh karonda was found to be 14.05 per cent. Similar results, i.e. 11.64 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. The cellulose content increased significantly ($p<0.05$) in dried karonda samples, the increasing order being FRS<FS<SD<MDS. The cellulose content of sun dried karonda was found to be 14.67 per cent. Cellulose content increased by 4.41% in sun dried karonda as compared to fresh ones. Cellulose content in microwave dried karonda was found to be 14.89 per cent . Cellulose content increased by 5.97 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015), where they reported 13.7% increase in cellulose content in date fruit during thermal process and Nordin *et al*. (2013), wherein they

reported 3.31% increase in oil palm fruit during heat treatment. Cellulose content in frozen karonda was found to be 7.68 per cent. The cellulose content decreased by 7.68 % in frozen storage karonda as compared to fresh ones.

Lignin content of fresh karonda was found to be 3.10 per cent. Similar results i.e. 6.39 per cent was reported by Rani and Kawatra (1994) in fresh "*Carissa carandas"* a variety of karonda fruit. The lignin content increased significantly($p<0.05$) in dried karonda samples, the increasing order being FRS<FS<SD<MDS. The lignin content of sun dried karonda was found to be 3.20 per cent. Lignin content increased by 3.22 % in sun dried karonda as compared to fresh ones. Lignin content in microwave dried karonda was found to be 3.33 per cent. Lignin content increased by 7.41 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Mrabet *et al*. (2015) in date fruit where they found 20.68 % increase in lignin content during thermal process. Similar increase in lignin content (38.79 %) has been reported by Nordin *et al*. (2013) in thermal processed oil palm fruit. This increase in lignin content by thermal process might be due to increase the activity of lignin synthesis enzymes i.e. phenylalanine ammonia lyase (Yun *et al*. 2013). Hosseinaei *et al.* (2012) also reported that due to heat, complex structure of lignin is formed which makes it difficult for degradation. Lignin content in frozen karonda was found to be 3.00 per cent. The lignin content decreased by 3.23 % in frozen karonda as compared to fresh ones. Similar results have been reported by Dangcham *et al*. (2008), where they reported 65.07 % decrease in lignin content in mangosteen fruit at low temperature storage.

5.2 (d) Phytochemical composition of *Carissa spinarum* (Total phenolic content)

Processing methods caused remarkable changes in the total phenolic content of karonda fruit is depicted in Figure 5.5. Total phenolic content (TPC) of fresh karonda was found to be 5.31 mg TAE/100gm. Similar results i.e. 4.67 mg GAE/100gm was reported by Pewlong *et al.* (2014) in "*Carissa carandas"* a variety of karonda fruit .

A statistically significant increase ($p<0.05$) in TPC was observed in all dried karonda samples, the increasing order being FRS<FS <SD<MDS. Total phenolic content of sun dried karonda was found to be 5.50 mg TAE/100gm. TPC increased by 3.57 %, in sun dried karonda as compared to fresh ones. Sangeeta and Mahanta (2013), reported 30.18 % increase in TPC in tomato after

microwave drying. Total phenolic content of microwave dried karonda was found to be 5.74 mg TAE/100gm. TPC increased by 8.09 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Chumyam *et al.* (2013) in purple skin eggplants where they found 155.42 % increase in TPC in microwave dried fruit as compared to fresh ones and Turkmen *et al.*(2005), wherein they reported 126 % increase TPC in microwave dried pepper. Similar increase 85.12% TPC in pear by thermal treatment has been reported by Oboh *et al.*(2015). This increase in TPC by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (HMP) by Maillard reaction (Donovan *et al.* 1998) and also due to the breakdown of cellular structure of cells, which makes the phenolic content more extractable (Van *et al.* 2000). Singleton *et al.* (1999) mentioned enhancement in phenolic content may be due to the formation of aglycons by reacting with Folin-Ciocalteau reagent.

Phenolic content of frozen karonda was found to be 5.11 mg TAE/100gm. Frozen stored karonda fruits exhibited 3.76 % decrease in total phenolic content as compared to fresh ones. Similar results have been reported by Mullen *et al.* (2002), where they reported 21 to 28 % decrease in the TPC in raspberries during frozen storage as compared to fresh ones. Similar decrease in TPC (0.81%) has been reported by Scibisz and Mitek (2007) in frozen blueberries. This may be attributed to the fact that frozen storage leads to decrease in total phenolic content of fruits as polyphenol oxidase enzymes (PPO) are released by breaking cells and that leads to oxidation of polyphenolics to quinines (De Ancos *et al*. 2000a).

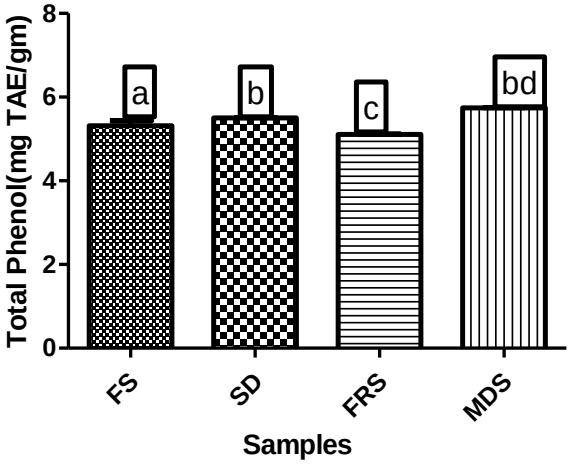

Fig. 5.5 Total Phenolic content of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS= Freezed sample, MDS=Microwave dried sample.

5.2 (e) Total flavonoid content of karonda

Flavonoid content of karonda fruit is depicted in Figure 5.6. Total flavonoid content of fresh karonda was found to be 0.44 mg QE/100gm. Similar results, i.e. 1.53 mg (rutin equivalent /100gm) was reported by Itankar *et al*.(2011) in "*Carissa carandas"* a variety of karonda. The total flavonoid content increased significantly ($p<0.05$) in fresh karonda sample, the increasing order being SD<MDS<FS<FRS. The flavonoid content of sun dried karonda was found to be 0.31 mg QE/100gm. Flavonoid content decreased by 29.54 % in sun dried karonda as compared to fresh ones. Similar results have been reported by Wang *et al.* (2016) in jujube fruit where they found 26.75% decrease in flavonoid content in sun dried fruit. Flavonoid content of microwave dried karonda was found to be 0.32 mg QE/100gm. Flavonoid content decreased by 27.27 % in microwave dried karonda as compared to fresh ones. Similar reduction in total flavonoid content (23.74%) has been reported by Sangeeta and Mahanta (2013) in microwave banana blossom and Planinic *et al.* (2015), wherein they reported 15.3% reduction in flavonoid content in microwave dried grape fruit. Similar results have been reported by Macias *et al* .(2013), where they reported 23.13 % decrease in flavonoid content in strawberry fruit during thermal process. This decrease in flavonoid content by thermal process (Crozier *et al.* 1995;

Price and Rhodes, 1997) might be due to the breakdown of some phytochemicals, which affects cell wall integrity and that leads to migration of some flavonoid components (Davey *et al.* 2000). Ioannou *et al.* (2012) also mentioned that heating process caused degradation might be due to parameters such as pH, oxygen, light, activity of polyphenoleoxidase enzymes and by hydrolysis of C- glycosides bonds, which are presented in flavonoids (Manach *et al.*2004).

Flavonoid content of frozen karonda was found to be 0.52 mg QE/100gm. Flavonoid content increased by 18.18 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Mullen *et al*. (2002), where they reported 21.07 % increase in flavonoid content in red raspberries during frozen storage. This may be attributed to the fact that frozen storage leads to increase in flavonoid content of fruits as increase in quercetin derivatives during cold storage (Omer and Canan, 2014) that increases quercetin hydrolysis (Hakkinen *et al*.2000).

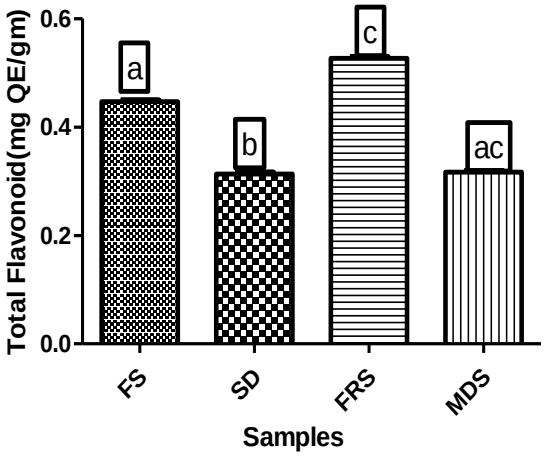

Fig. 5.6 Total Flavonoid content of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.2 (f) Antioxidant activity of karonda

Processing methods caused remarkable changes in antioxidant activity of karonda fruit is depicted in **Figure 5.7.** Antioxidant activity of fresh karonda was found to be 34.45 per cent. Similar results, i.e. 39.1 per cent was reported by Prakash *et al*. (2011) in "*Carissa carandas"* a variety of karonda fruit.

Antioxidant activity significantly ($p<0.05$) increased in all dried karonda sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity of sun dried karonda was found to be 34.47 per cent. Antioxidant activity increased by 0.05 % in sun dried karonda as compared to fresh ones. Antioxidant activity of microwave dried karonda was found to be 34.48 per cent. Antioxidant activity increased by 0.08 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Wojdylo *et al.* (2007), where they found 4.68 % increase in antioxidant activity (DPPH) in thermal dried apple and Chumyan *et al*. (2013), wherein they reported 266.12 % increase in DPPH antioxidant activity in microwave dried eggplants. Similar increase in antioxidant activity 138 % has been reported by Turkmen *et al*. (2005) in microwave heat treated pepper. Similar increase antioxidant activity 112.31% in berries has been reported by Rabeta and Lin (2015) and Sultana *et al.* (2012) also reported increase 3.57 % DPPH antioxidant activity in oven dried apricot. This increase in antioxidant activity (DPPH) by thermal process might be due to the formation of hydroxymethyl furfuraldehyde (Raupp *et al*.2011), presence of naturally occurring compounds such as Maillard reaction products (Yin and Chang,1998; Piga *et al*. 2003; Lee *et al*.2003), released of a free phenolic fraction (Yamaguchi *et al*. 2001), due to oxidative and hydrolytic enzyme (Farsi *et al*.2005), disruption of cell wall that leads to release and enhances antioxidant activity (Chumyan *et al*.2013).

Antioxidant activity of frozen karonda was found to be 30.83 per cent. Antioxidant activity (DPPH) decreased by 10.50 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by De Ancos *et al.* (2000), where they reported 12 % decrease in antioxidant activity (DPPH) in frozen raspberry fruit and Pimia *et al*. (2003), wherein they reported 20 % decrease in antioxidant activity in frozen peas. Similar decrease in antioxidant activity (1.64 %) has been reported by Mohammadian *et al.* (2011) in frozen "*Citrus limon*" .

This may be attributed to the fact that frozen storage leads to decrease in antioxidant activity of fruits as disruption of cell structure (Sikora *etal*.2013).

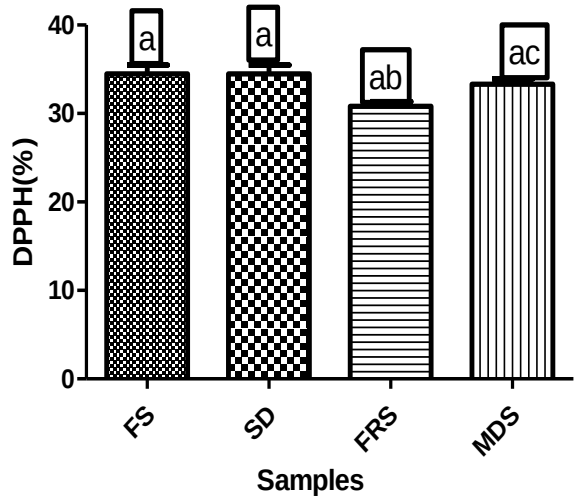

Fig. 5.7 Antioxidant activity (DPPH) of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.2 (g) Antioxidant activity of karonda

Antioxidant activity of karonda fruit is depicted in **Figure 5.8.** Antioxidant activity of fresh karonda was found to be 58.63 per cent. Prakash *et al.* (2011) reported lower antioxidant activity (48.2 %) in "*Carissa carandas*" a variety of karonda fruit as compared to our results. This difference might be due to many parameters such as fruit colour (Bey and Louaileche, 2015), extraction methods, solvent (Musa *et al.* 2011), cultivation location (Wand *et al.* 2002; Hakkinen and Torronen, 2000), ripening stage (Raffo *et al.* 2012), harvested condition and season (Wu *et al* .2014). Antioxidant activity increased non significantly ($p > 0.05$) in all dried karonda sample, the increasing order being FRS<FS<SD<MDS. Antioxidant activity (FRAP) of sun dried karonda was found to be 58.68 per cent. Antioxidant activity (FRAP) increased by 0.08 % in sun dried karonda as compared to fresh ones. Antioxidant activity of microwave dried karonda was found to be 58.79 per cent. Antioxidant activity increased by 0.27 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by

Rabeta and Lin (2015), where they reported increase 1040.12% antioxidant activity (FRAP) in berries during thermal process. Higher antioxidant activity might be due to relative increase of FRAP value which determined the capacity of plant extract for the donation and acceptance of electrons (Yan *et al.* 2006). This increase in antioxidant activity by thermal process may be due to reduction in moisture content(Abou El-Hana, 2008), inhibition of oxidative enzymes and cell wall destruction which releases antioxidant compounds (Yamaguchi *et al.* 2001).

Antioxidant activity of frozen karonda was found to be 55.36 per cent. Antioxidant activity (FRAP) decreased by 5.57 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Poiana *et al.*(2010), where they reported decrease from 6.5% to 12% in frozen strawberry fruit and Nilsson *et al.* (2004), wherein they reported decrease in antioxidant activity (FRAP) in frozen peas.

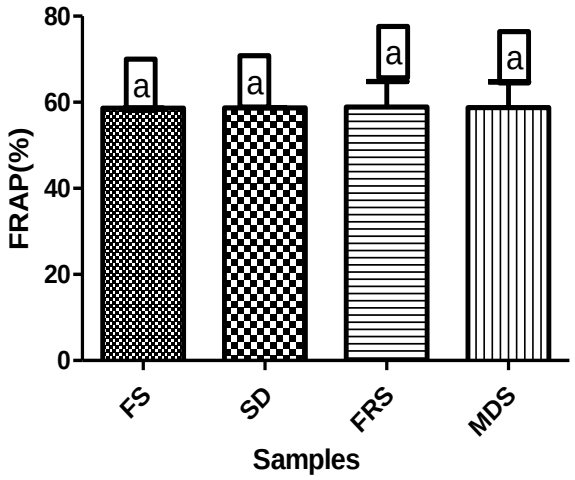

Fig. 5.8 Antioxidant activity (FRAP) of karonda

Where FS=Fresh sample, SD= Sun dried sample, FRS=Freezed sample, MDS=Microwave dried sample.

5.2 (h) Anti-nutritional content and anthocyanin content of karonda

Tannin content of fresh karonda was found to be 0.98 gm/100gm. Similar results, i.e. 1.02 gm/100gm was reported by Gupta *et al*. (2014) in "*Carissa carandas"* a variety of karonda fruit. Tannin content increased non significantly ($p>0.05$) increased in fresh karonda samples, the increasing order being FRS<SD<MDS<FS.

Table 5.9 Effect of processing methods on anti-nutritional and anthocyanin content of karonda

Drying methods	FS	SD	FRS	MDS
Tannin- (g/100g)	0.98± 0.01[a]	0.96± 0.01[a]	0.95±0.02 [a]	0.97± 0.00 [a]
Alkaloid- (g/100g)	1.94± 0.00 [a]	1.92±0 .01[a]	1.90±0.00[b]	1.92 ±0 .00[ac]
Anthocyanin- (mg/100g)	54.03± 0.00 [a]	53.43± 0.00[a]	55.20± 2.48 [a]	53.39± 5.02[a]

The tannin content of sun dried karonda was found to be 0.96 gm /100gm. Tannin content decreased by 2.04% in sun dried karonda as compared to fresh ones. Tannin content of microwave dried karonda was found to be 0.97 gm /100gm. Tannin content decreased by 1.02 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Chinyere and Obasi (2013) in leafy vegetable where they found 8.82 % decrease in tannin content during thermal process and Embaby (2011), wherein they reported 15.7 % decrease in tannin content in peanut seed during heat treatment. Similar decrease in tannin content (5.88 %) has been reported by Yusuf and Obiegbuna (2011) in *Vernonia amygdalina* leaf during thermal process. This decrease in tannin content by thermal process might be due to the oxidation of bioactive compounds (Yoshioka *et al.* 1990) and also due to the breakdown of cell structure which migrates the components that are creating loss by leakage in the presence of oxygen and light (Scheieber *et al*. 2001) and also due to various chemical reaction involving

enzymes (polyphenoleoxidase) which are responsible to convert tannins into other products (Pragati *et al.* 2003; Mehta,1995).

Tannin content of frozen karonda was found to be 0.95 gm /100gm. Tannin content decreased by 3.06 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Aleid *et al.* (2014), where they reported 33.33 % reduction in tannin content in frozen dates. Similar decrease in tannin content in persimmons fruit has been reported by Nakamura (1961) during frozen storage. This decrease in tannin content by frozen storage might be due to the non-enzymatic activity in fruits (Al-Ogadi and Mutlak, 1986; Abu-Goukh *et al*. 2003), change occurs in chemical properties of tannin (Nakamura ,1961) that leads to coagulate soluble tannin into insoluble (Brackmann *et al.*1997; Matsu and Itoo,1978).

Alkaloid content of karonda fruit is depicted in Table 5.9. Total alkaloid content of fresh karonda was found to be 1.94 gm /100gm. Similar results, i.e. 1.96 gm/100gm was reported by Gupta *et al*. (2014) in fresh "*Carissa carandas"* a variety of karonda fruit. A statistically significant increase ($p<0.05$) in alkaloid content was observed in fresh karonda samples, the increasing order being FRS<SD<MDS<FS. The alkaloid content of sun dried karonda was found to be 1.92 gm /100gm. Alkaloid content decreased by 1.03 % in sun dried karonda as compared to fresh ones. Alkaloid content of microwave dried karonda was found to be 1.92 gm /100gm. Alkaloid content decreased by 1.03 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Chinyere and Obasi (2013) in leafy vegetable they found 22.83 % decrease in alkaloid content during heat treatment and Yusuf and Obiegbuna (2011), wherein they reported decrease 68.12% alkaloid content in *Vernonia amygdalina* by thermal process. This decrease in alkaloid content by thermal process might be due to the breakdown of cell structure which results migration of components that leads to loss by various chemical reactions i.e. involving enzymes, light and heat (Atlabachew *et al*. 2013). Alkaloid content of frozen karonda was found to be 1.90 gm /100gm. Alkaloid content decreased by 2.06 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Atlabachew *et al*. (2007), where they reported 56 % decrease in alkaloid content (cathinone) in frozen (*Catha Edulis* Forsk) leaves.

The anthocyanin content of karonda fruit is depicted in Table 5.9. Total anthocyanin content of fresh karonda was found to be 54.03 mg cyanidin-3-glucoside equivalents/100gm. Similar results, i.e. 54 mg/100gm was reported by Pewlong *et al*. (2014) in "*Carissa carandas"* a variety of karonda fruit.

Anthocyanin content increased non significantly ($p>0.05$) in frozen karonda samples, the increasing order being MDS<SD<FS<FRS. The anthocyanin content of sun dried karonda was found to be 53.43 mg /100gm. Anthocyanin content decreased by 1.11 % in sun dried karonda as compared to fresh ones. Anthocyanin content of microwave dried karonda was found to be 53.39 mg /100gm. Anthocyanin content decreased by 1.18 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Wojdylo *et al.* (2009) in strawberry where they found 12.9 % decrease in anthocyanin content in microwave dried fruit. Similar decrease in anthocyanin content (35.69 %) has been reported by Wojdylo *et al*. (2014) in microwave dried sour cherries. This decrease in anthocyanin content by thermal process (Juan *et al*.2013) might be due to different factors i.e. heat, oxygen, metal ion, co-pigmentation and pH (Mishra and Yang, 2008), polyphenol oxidase enzymes activity (Kwok *et al*.2004) and browning reaction (Wrolstad *et al.* 2004).

Anthocyanin content of frozen karonda was found to be 55.20 mg /100gm. Anthocyanin content increased by 2.16 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Scibisz and Mitek (2007), where they reported 1.30 % increase in anthocyanin content in frozen blueberries. Similar increase in anthocyanin content (2.16%) has been reported by Mullen *et al.* (2002) in frozen red raspberries. This increase in anthocyanin content might be due to ice crystal formation that favours to reallocation of water molecules in cell structure, that leads to enhance the release of membrane bound anthocyanin (Szczesniak, 1998; Leong and Oey, 2012) and also due to the cellular disruption in fruits (Skrede, 1996) which contributes to increase the cyanidin -3-galactoside content in fruits (Scibisz and Mitek, 2007).

5.2 (i) Mineral composition of karonda

The mineral composition of karonda fruit is depicted in Table 5.10. Calcium content of fresh karonda was found to be 29.00 mg /100gm. Similar results, i.e. 28.89 mg/100gm was reported

by Ara *et al*. (2014) in "*Carissa carandas"* a variety of karonda fruit. Calcium content increased significantly ($p<0.05$) in microwave dried karonda sample, the increasing order being FRS<FS<SD<MDS.

Table 5.10 Effect of processing methods on mineral composition of karonda

Drying methods	FS	SD	FRS	MDS
Calcium- (mg/100g)	29.00 ± 0.57^{a}	275.67 ± 0.00^{b}	28.9 ± 0.05^{c}	286.35 ± 0.00^{cd}
Iron- (mg/100g)	3.45 ± 0.00^{a}	12.43 ± 0.00^{b}	3.40 ± 0.05^{c}	12.82 ± 0.00^{cd}
Phosphorus- (mg/100g)	32.10 ± 0.05^{a}	106.20 ± 0.00^{b}	31.90 ± 0.05^{c}	$108.50\pm .00^{cd}$

Mineral composition might be increased or decreased by different processing methods (Rickman *et al.* 2007). The calcium content of sun dried karonda was found to be 275.67 mg /100gm. Calcium content increased by 850.6 % in sun dried karonda as compared to fresh ones. Calcium content of microwave dried karonda was found to be 286.35 mg /100gm. Calcium content increased by 887.44 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015), where they found 1028.09 % increase calcium content in microwave dried okra and Incedayi *et al.* (2016), wherein they reported 70.93 % increase in calcium content in microwave dried apricot fruit. This increase in calcium content by thermal process might be due to increasing of dry matter content. Ozcan *et al.* (2004) also reported that changes in the concentration of minerals are also depending on the method and the drying temperature used (Ozcan *et al.* 2004).

Calcium content of frozen karonda was found to be 28.9 mg /100gm. Calcium content decreased by 0.34 % in frozen storage karonda as compared to fresh ones. Similar results were reported by Zolfaghari *et al*. (2010), where they reported 1.53 % decrease in calcium content

in frozen kiwi fruit of "Monty" cultivar. Similar decrease in calcium content (5.23%) has been reported by Bouzari *et al*.(2014) in frozen strawberries.

Iron content of fresh karonda was found to be 3.45 mg /100gm. Similar results, i.e. 6.24 mg/100gm was reported by Dalal *et al*. (2010) in fresh "*Carissa carandas"* a variety of karonda fruit. Iron content increased significantly ($p<0.05$) in microwave dried karonda sample, the increasing order being FRS<FS<SD<MDS. The iron content of sun dried karonda was found to be 12.43 mg /100gm. Iron content increased by 260.28 % in sun dried karonda as compared to fresh ones. Iron content of microwave dried karonda was found to be 12.82 mg /100gm. Iron content increased by 271.59 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015) in okra where they found 963.75 % increase in iron content during thermal process. Similar increase in iron content (395.06%) has been reported by Jung *et al*. (2005) in microwave dried persimmon fruit. Iron content of frozen karonda was found to be 3.40 mg /100gm. Iron content decreased by 1.44 % in frozen storage karonda as compared to fresh ones. Similar results have been reported by Musa (2013) in *Amaranthus cruentus* leaf where they found 33.19 % decrease in iron content in frozen storage.

Phosphorus content of fresh karonda was found to be 32.10 mg /100gm. Similar results, i.e. 38 mg/100gm was reported by "CSIR NEW DELHI" (1950) in "*Carissa carandas"* a variety of karonda fruit. Phosphorus content increased significantly ($p<0.05$) in microwave dried karonda sample, the increasing order being FRS<FS<MDS<SD. The phosphorus content of sun dried karonda was found to be 106.20 mg /100gm. Phosphorus content increased by 230.85 % in sun dried karonda as compared to fresh ones. Phosphorus content of microwave dried karonda was found to be 108.50 mg/100gm. Phosphorus content increased by 238.01 % in microwave dried karonda as compared to fresh ones. Similar results have been reported by Famurewa and Olumofin, (2015) in okra where they found 811.45 % increase in phosphorus content during microwave heat treatment. Phosphorus content of frozen karonda was found to be 31.90 mg /100gm. Phosphorus content decreased by 1.42 % in frozen storage karonda as compared to fresh ones. Similar decrease in phosphorus content (0.62 %) has been reported by Zolfaghari *et al*.(2010) in frozen kiwi fruit and Ogbadoyi and Musa (2013), wherein they reported reduction in mineral content in frozen storage "*Amaranthus cruentus".* This may be attributed to the fact

that frozen storage leads to decrease in iron content of fruits as high moisture content that leads to form ice crystals and causes leakage from the cell membranes (Baker and Gawish, 1997) that leads reduction in mineral elements (Hui *et al*. 2004; McDonald *et al.* 2006).

5.3 Experimental Design

5.3 (a) Effect of fig (*Ficus carica)* methanolic extract on fasting blood glucose (FBG) level on diabetic and normoglycemic rats

The aim of the present study is to explored the scientific basis of the utility of fig (*Ficus carica*) fruit methanolic extract to improve FBG level in selected group of rats. The calculated percentage yield of methanolic extract of fig fruit was 31.6 per cent. Acute toxicity test revealed non toxic nature of fig fruit methanolic extract on rats. There was no lethality and toxic reactions at any dose.

The effect of fig methanolic fruit extract on fasting blood glucose level in rats is depicted in **Table 5.11**. FBG level was found highest on 21th day (277.45 mg/dl) and lowest on 0 day (259.35 mg/dl). FBG level in normal control group ranged from 95.61 to 97.27 mg/dl. The FBG level were increased in diabetic rats whose having streptozotocin intraperitoneal injection, ranged from 259.35 to 277.45 mg/dl. FBG level significantly ($p<0.05$) increased (171.25%) on starting 0 day in diabetic control group as compared to normal group. And, on 7th day (1.98 %), 14th day (5.20 %) and 21th day (6.97%), FBG level increased after 3 days of streptozotocin intraperitoneal injection to rats as compared to 0 day. FBG level was highest on 21 th day (277.45 mg/dl) and lowest on 0 day before the start of treatment (259.35 mg/dl). The increase in fasting blood glucose level might be due to streptozotocin injection which causes death of β-cells that leads insufficient production of insulin and elevates blood glucose level (Shen *et al.* 2010).

Metformin treated diabetic rats fasting glucose level ranged from 266.27 to 90.34 mg/dl. FBG level significantly ($p<0.05$) reduced on 7 th day (59.06 %), 14th day (63.62 %) and 21th day (66.07 %) with repeated oral dose administration of metformin (50 mg/kg b.wt.) as compared to 0 day. This decrease in fasting blood glucose level might be due to metformin suppress hepatic glucose production (Stumvoll *et al.*1995) and improved the insulin sensitivity that leads enhancement in binding of insulin to its receptors in several cell (Yanardag *et al.* 2005).

Table 5.11 : Effect of fig (*Ficus carica)* methanolic extract on FBG level in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14Day	21 Day
	Diabetic					
I	Control	35mg/kg	259.35±6.11^{a} (↑171.25%)*	264.50±5.08^{b} (↑ 173.10%)*	272.86±3.79^{bc} (↑181.79%)*	277.45±4.05^{bc} (↑ 185.23%)*
II	Metformin	50 mg/kg	266.27±6.61^{a}	109.0± 5.81^{b} (↓58.79 %)$^{\#}$	96.85±1.61^{bc} (↓64.50 %)$^{\#}$	90.34±3.36^{bc} (↓ 67.43 %)$^{\#}$
III	Fig extract	500 mg/kg	255.33± 1.90^{a}	197.0± 2.25^{b} (↓ 25.51%)$^{\#}$	187.13±2.38^{bc} (↓31.41 %)$^{\#}$	169.64±4.56^{bc} (↓38.85%)$^{\#}$
	Normoglycemic					
IV	Control group	_	95.61±1.78^{a}	96.85±1.61^{a}	96.83±1.84^{a}	97.27±1.59^{b}
V	Fig extract	500 mg/kg	96.87± 1.34^{a}	96.86±1.43^{a} (↓ 0.01%)*	94.42±4.45^{a} (↓2.48%)*	91.30±5.23^{ab} (↓ 6.13%)*

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

Administration of repeated dose of fig methanolic extract (500 mg/kg) body weight of rats had significantly ($p<0.05$) reduced the FBG level in diabetic rats after seven days. The FBG level significantly ($p<0.05$) reduced on7th day (22.84 %), 14 th day (26.71%) and 21 th day (33.56%) as compared to 0 day. This reduction in FBG level might be due to methanolic fruit extract creates anti- hyperglycemic effect by increasing pancreatic secreation of insulin from β cells (Stanley *et al.* 2004).

Administration of repeated oral dose of fig methanolic extract significantly ($p<0.05$) proved effective for the reduction of FBG level in normal group of rats after seven days. The FBG level reduced on 7 th day (0.01 %), 14th day (2.52 %) and 21th day (5.74 %) as compared to 0 day. As per standard protocol, we used to perform activity for 21 days (Girija *et al*. 2011; Kumar *et al*.2012). Drug treatment for diabetes, if normalizes the effect within 21 days only and significant improvement in all parameters of diabetes were improving so that study was conducted these many days only.

5.3 (b) Effect of fig (*Ficus carica)* methanolic extract on body weight in diabetic and normoglycemic rats

The effect of selected fruit methanolic extract on the body weight in diabetic and normoglycemic rats are depicted in **Table 5.12.** Normal group of rats body weight was significantly ($p<0.05$) increased on 7th day (1.37 %), 14 th day (2.32 %) and 21th day (3.02 %) as compared to 0 day.

The body weight was significantly ($p<0.05$) reduced (4.13 %) on starting 0 day in diabetic control group as compared to normal control group and on 7th day (1.59 %), 14 th day (2.23 %) and 21 thday (3.85 %) as compared to 0 day. The reduction in body weight might be due to muscle wasting (Islam, 2011). Repeated administration of metformin dose was significantly reduced the body weight in diabetic rats on 7th day (0.58 %), 14 th day (1.04 %) but showed improvement on 21 th day (1.24 %) as compared to 0 day. The reduction in body weight in diabetic rats might be due to breakdown of tissue protein (Andulla and Varadacharyulu, 2003).

Table 5.12 : Effect of fig (*Ficus carica)* methanolic extract on body weight in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14 Day	21 Day
	Diabetic					
I	Control	35mg/kg	241.0±4.08[a] (↓4.13 %)[*]	238.40±3.41[a] (↓ 6.37 %)[*]	235.61±4.31[ab] (↓ 8.40 %)[*]	231.72±4.10[b] (↓ 10.53%)[*]
II	Metformin	50 mg/kg	240.10±1.07[a]	238.70±1.78[a] (↑ 0.64 %)	237.60± 2.31[ab] (↑0.84 %)	237.11±3.36[ab] (↑ 2.32 %)[#]
III	Fig extract	500 mg/kg	244.76±1.87[a]	246.13±2.20[a] (↑ 3.24 %)[#]	249.43±2.60[b] (↑ 5.86 %) [#]	252.44±2.09[bc] (↑ 8.94%)[#]
	Normoglycemic					
IV	Control group	-	251.40±1.35[a]	254.85±2.17[b]	257.24 ±1.89[bc]	259.0±1.69[bc]
V	Fig extract	500 mg/kg	252.56±1.35[a]	256.46±1.95[b] (↑ 0.63 %)	258.23±1.43[bc] (↑ 0.38 %)	260.17± 1.01[bc] (↑ 0.45 %)

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

The effect of repeated fig methanolic extract (500 mg/kg b.wt) had significantly ($p<0.05$) improved diabetic rats body weight on 7th day (0.56 %), 14 th day (1.90 %) and 21 th day (3.13 %) as compared to 0 day. This increase in body weight might be due to improved metabolic disturbance by given fruit extract that leads reduction in polyphagia, polyuria and polydipsia. It also helps to control muscle wasting (Whitton and Hems, 1975). Repeated oral dose of fig methanolic extract (500 mg/kg) according to body weight of rats proved very effective to increase the body weight in normal rats on7th day (1.54 %), 14 th day (2.24 %) and 21 th day (3.01%) as compared to 0 day.

5.4 Experimental Design

5.4 (a) Effect of karonda (*Carissa spinarum)* methanolic extract on fasting blood glucose level in diabetic and normoglycemic rats

The aim of the present study is to explored the scientific basis of the utility of karonda (*Carissa spinarum*), fruit methanolic extract to improve FBG level in selected group of rats. The calculated percentage yield of methanolic extract of karonda fruit was 29 per cent. Acute toxicity test revealed non toxic nature of karonda fruit methanolic extract on rats. There was no lethality and toxic reactions at any dose.

The effect of karonda methanolic fruit extract on fasting blood glucose level in rats is depicted in **Table 5. 13**. FBG level was found highest on 21th day (277.45 mg/dl) and lowest on 0 day (259.35 mg/dl). FBG level in normal control group ranged from 95.61 to 97.27 mg/dl. The FBG level were increased in diabetic rats whose having streptozotocin intraperitoneal injection, ranged from 259.35 to 277.45 mg/dl. FBG level significantly ($p<0.05$) increased (171.25%) on starting 0 day in diabetic control group as compared to normal group. And, on 7th day (1.98 %), 14th day (5.20 %) and 21th day (6.97%), FBG level increased after 3 days of streptozotocin intraperitoneal injection to rats as compared to 0 day. The increase in fasting blood glucose level might be due to streptozotocin injection which causes death of β-cells that leads insufficient production of insulin and elevated blood glucose level (Rossetti *et al.* 1990).

Metformin treated diabetic rats fasting blood glucose level ranged from 266.27 to 90.34 mg/dl. FBG level significantly ($p<0.05$) reduced on 7 th day (59.06 %), 14th day (63.62 %) and 21th day (66.07 %) with repeated oral dose administration of metformin (50 mg/kg b.wt.) as compared to 0 day. This decrease in fasting blood glucose level might be due to metformin suppress hepatic glucose production (Stumvoll *et al*.1995) and improved the insulin sensitivity that leads enhancement in binding of insulin to its receptors in several cell (Yanardag *et al.* 2005).

Table 5.13 : Effect of karonda (*Carissa spinarum)* methanolic extract on fasting blood glucose level in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14Day	21 Day
	Diabetic					
I	Control	35mg/kg	259.35±6.11[a] (↑171.25%)[*]	264.50±5.08[b] (↑ 173.10%)[*]	272.86±3.79[bc] (↑181.79%)[*]	277.45±4.05[bc] (↑ 185.23%)[*]
II	Metformin	50 mg/kg	266.27±6.61[a]	109.0± 5.81[b] (↓58.79 %)[#]	96.85±1.61[bc] (↓64.50 %)[#]	90.34±3.36[bc] (↓ 67.43 %)[#]
III	karonda extract	500 mg/kg	264.90±5.50[a]	192.73±6.12[b] (↓ 27.10 %)[#]	178.88±5.39[bc] (↓ 34.44%)[#]	168.22±5.23[bc] (↓39.36%)[#]
	Normoglycemic					
IV	Control group	_	95.61±1.78[a]	96.85±1.61[a]	96.83±1.84[a]	97.27±1.59[b]
V	Karonda extract	500 mg/kg	95.70±1.63[a]	90.10±5.38[b] (↓ 6.96 %)	85.63±2.39[bc] (↓11.56%)	81.72±3.52[bc] (↓ 15.98%)[*]

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

Administration of repeated dose of karonda methanolic extract (500 mg/kg) body weight of rats had significantly ($p< 0.05$) reduced the FBG level in diabetic rats after seven days. The FBG level significantly ($p< 0.05$) reduced on 7 th day (27.24 %), 14th day (32.47 %) and 21th day (36.49%) as compared to 0 day. Administration of repeated oral dose of karonda methanolic extract significantly ($p<0.05$) proved effective for the reduction of FBG level in normal group of rats after seven days. The FBG level reduced on 7 th day (5.85 %), 14th day (10.52%) and 21th day (14.60%) as compared to 0 day. This reduction in FBG level might be due to methanolic fruit extract creates anti- hyperglycemic effect by increasing pancreatic secreation of insulin from β cells (Stanley *et al.* 2004) and due to the presence of flavonoid content and tannin content in methanolic extract of selected fruits (Sanwal and Chaudhory, 2011).

5.4 (b) Effect of karonda (*Carissa spinarum)* methanolic extract on body weight in diabetic and normoglycemic rats

The effect of selected fruit methanolic extract on the body weight in diabetic and normoglycemic rats are depicted in **Table 5.14.**

Table 5.14 : Effect of karonda (*Carissa spinarum)* methanolic extract on body weight in diabetic and normoglycemic rats

Groups	Treatment	Dose	0 Day	7 Day	14Day	21 Day
	Diabetic					
I	Control	35mg/kg	241.0±4.08^{a} (↓4.13 %)*	238.40±3.41^{a} (↓ 6.37 %)*	235.61±4.31^{ab} (↓ 8.40 %)*	231.72±4.10^{b} (↓ 10.53%)*
II	Metformin	50 mg/kg	240.10±1.07^{a}	238.70±1.78^{a} (↑ 0.64 %)	237.60± 0.31^{ab} (↑0.84 %)	237.11±3.36^{ab} (↑ 2.32 %)$^{\#}$
III	karonda extract	500 mg/kg	240.22±7.62^{a}	246.27±2.21^{ab} (↑ 3.30 %) $^{\#}$	248.67±2.71^{bc} (↑ 5.54 %) $^{\#}$	252.27±2.68^{b} (↑ 8.86 %)$^{\#}$
	Normoglycemic					
IV	Control group	-	251.40±1.35^{a}	254.85±2.17^{b}	257.24 ±1.89^{bc}	259.0±1.69^{bc}
V	Karonda extract	500 mg/kg	252.35±1.50^{a}	256.13±2.29^{ab} (↑0.50 %)	257.58±2.30^{b} (↑ 0.13 %)	259.53±1.59^{bc} (↑ 0.20 %)

All value are represented as Mean ± SEM, (n=6) significantly different($p<0.05$) compared with respect to 0 day. *Group I, V compared with group IV, # group II, III compared with group I

Normal group of rats body weight was significantly ($p<0.05$) increased on 7th day (1.37 %), 14 th day (2.32 %) and 21th day (3.02 %) as compared to 0 day. The body weight was significantly ($p <0.05$) reduced (4.13 %) on starting 0 day in diabetic control group as compared to normal control group and on 7th day (1.59 %), 14 th day (2.23 %) and 21 th day (3.85 %) as compared to 0 day. The reduction in body weight might be due to muscle wasting (Swanston *et al*.1990). Repeated administration of metformin dose was significantly reduced the body weight in diabetic rats on 7th day (0.58 %), 14 th day (1.04 %) but showed improvement on 21 th day (1.24 %) as compared to 0 day. The reduction in the body weight due to breakdown of protein in diabetic rats (Andulla and Varadacharyulu, 2003).

The effect of repeated karonda methanolic extract (500 mg/kg b.wt) had significantly ($p<0.05$) improved diabetic rats body weight on 7th day (2.51 %), 14 th day (3.39 %) and 21 th day (4.77 %) as compared to 0 day. Repeated oral dose of karonda methanolic extract (500 mg/kg) according to body weight of rats proved very effective to increase the body weight in normal rats on7th day (1.49 %), 14 th day (2.07 %) and 21 th day (2.84 %) as compared to 0 day. This increase in body weight might be due to improved metabolic disturbance by given fruit extract that leads reduction in polyphagia, polyuria and polydipsia. It also helps to control muscle wasting (Whitton and Hems, 1975).

5.5 Formulation of value added products with the substitution of fig

5.5 (a) Bun

5.5 (b) Nutritional composition

The moisture content (**Table 5.15**) of wheat flour bun substituted with fresh fig ranged from 6.47 per cent to 8.41 per cent. In control it was only 6.47 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of moisture content i.e. 8.41 per cent was noted in T4. Similar increase in moisture content i.e. 5.96 per cent was reported in bread substituted with bread fruit flour (Malomo *et al*. 2015). This increase in moisture content might be due to high moisture content in fresh fruit (Raj and Masih, 2014).

The ash content of wheat flour bun substituted with fresh fig ranged from 1.10 per cent to 1.19 per cent. The result of ash content increased non significantly ($p<0.05$) in bun samples substituted with fresh fig. Similar increase in ash content i.e. 1.02 to 1.04 per cent was reported in bread substituted with bread fruit flour (Alice *et al*. 2012). Romjaun and Prakash (2015) also reported similar increase in ash content i.e. 0.82 to 1.31 per cent in bread substituted with carrot powder. This increase in ash content might be due to the high mineral content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.15**) of wheat flour bun substituted with fresh fig ranged from 75.52 per cent to 104.58 per cent. In control it was only 75.52 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of carbohydrate content i.e. 104.58 per cent was noted in T4. Similar increase in carbohydrate content i.e.78.69 per cent was reported in cookies substituted with unripe plantain flour(Chinma*etal*.2012). This increase in carbohydrate content might be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour bun substituted with fresh fig ranged from 6.64 per cent to 7.84 per cent. The result of protein content increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. Similar increase in protein content i.e. 4.39 to 7.25 per cent

was reported in bread substituted with soursop fruit flour (Zabidi *et al*. 2014). This increase in protein content might be due to higher addition of fruits at the time of bun development that leads to increase in protein content (Thorvaldsson and Skjoldebrand, 1998).

Table 5.15 Nutritional composition of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
Moisture (%)	6.47± 0.02[a]	6.84±0.01[c] (5.71%)↑	8.26±0.00[b] (27.66%)↑	8.41±0.01[cd] (29.98%)↑
Ash (%)	1.10±0.05[a]	1.13±0.10[a] (2.27 %)↑	1.16±0.05[a] (5.45%)↑	1.19±0.05[a] (8.18 %)↑
Carbohydrate (%)	75.52±0.01[a]	85.85±0.30[b] (13.67 %)↑	95.6±0.1[c] (26.58%)↑	104.58±0.07[cd] (38.47%)↑
Protein (%)	6.64±0.14[a]	7.44±0.08[a] (12.04 %)↑	7.69±0.95[a] (15.81%)↑	7.84±0.08[a] (18.07%)↑
Fat (%)	1.62±0.07[a]	1.73±0.04[a] (6.79 %)↑	1.80±0.38[a] (11.11%)↑	1.92±0.28[a] (18.51%)↑

Where, T1 (control sample) = 100% wheat flour bun, T2=15 % fig, T3=30% fig, T4 =45 % fig)

The fat content (**Table 5.15**) of wheat flour bun substituted with fresh fig ranged from 1.62 per cent to 1.92 per cent. Similar results, i.e. 1.57 per cent was reported by Michael *et al*. (2013) in wheat flour bread. The result of fat content increased non significantly ($p>0.05$) in bun sample substituted with fresh fig. The fat content was highest in T4 (1.92 %) and lowest in T1(1.62%). Similar increase in fat content i.e. 2.55 per cent was reported in bread substituted with pumpkin flour (See *et al.* 2007). This increase in fat content may be due to relative increase of fat content in fruits (Asp and Bjorck, 1992).

5.5 (c) Dietary fiber

The neutral detergent fiber (**Table 5.16**) of wheat flour bun substituted with fresh fig ranged from 23.73 per cent to 24.83 per cent. Similar results, i.e. 23.16 per cent was reported by Krishan *et al*. (1987) in wheat flour bread. NDF increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. The NDF was highest in T4 (24.83 %) and lowest in T1(23.73 %). Similar increase in dietary fiber i.e. 24.20 per cent was reported in bread substituted with watermelon rind (Ho and Dahri, 2016). Lopez *et al.* (2011) also reported similar increase i.e. 25.2 per cent was reported in bread substituted with orange powder. This increase in dietary fiber might be due to high dietary fiber in fruits (Sudha *et al.*2007).

The acid detergent fiber (ADF) of wheat flour bun substituted with fresh fig ranged from 1.30 per cent to 1.60 per cent. The results of ADF increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. ADF increased with increase in fresh fig fruit substitution. Similar increase in dietary fiber i.e. 0.75 to 1.13 per cent was reported in wheat flour cookie substituted with mango seed kernel (Legesse and Emire, 2012).

Hemicellulose content (**Table 5.16**) of wheat flour bun substituted with fresh fig ranged from 23.39 per cent to 23.22 per cent. Hemicellulose content increased significantly ($p<0.05$) in bun samples substituted with fresh fig. The hemicellulose content was highest in T4 (23.22 %) and lowest in T1(22.39 %).

The cellulose content of wheat flour bun substituted with fresh fig ranged from 2.48 per cent to 2.62 per cent. The result of cellulose increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. The cellulose content increased with increase in fresh fig fruit

substitution. Similar increase in cellulose content i.e. 0.02 to 4.40 per cent was reported in cookies substituted with raspberry pomace fruit (Gorecka *et al.* 2010). This increase in dietary fiber might be due to addition of dietary fiber rich fruits in bun, especially cellulose content (Thorvaldsen and Skjoldebrand, 1998).

Table 5.16 Dietary fiber of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
NDF (%)	23.73±0.05[a]	23.80±0.10[a] (0.29%)↑	24.23±0.05[a] (2.10%)↑	24.83±0.98[a] (4.63%)↑
ADF (%)	1.30±0.34[a]	1.40±0.45[a] (7.69%)↑	1.53±0.23[a] (17.69%)↑	1.60±0.17[a] (23.07%)↑
Hemicellulose (%)	22.39±0.00[a]	22.42±0.00[b] (0.13%)↑	22.56±0.00[c] (0.75%)↑	23.22±0.00[cd] (3.70%)↑
Cellulose(%)	2.48±0.10[a]	2.51±0.07[a] (1.20%)↑	2.56±0.03[a] (3.22%)↑	2.62±0.01[a] (5.64%)↑
Lignin (%)	1.23±0.63[a]	1.60±0.10[a] (30.08%)↑	1.73±0.05[a] (40.65%)↑	1.76±0.05[a] (43.08%)↑

The lignin content (**Table 5.16**) of wheat flour bun substituted with fresh fig ranged from 1.23 per cent to 1.76 per cent. The results of lignin content increased non significantly ($p>0.05$) in bun samples substituted with fresh fig. The lignin content was highest in T4 (1.70 %) and lowest in T1(1.56 %). Similar increase in lignin content i.e. 3.98 per cent was reported in cookies substituted with raspberry pomace fruit (Gorecka *et al.* (2010).

5.5 (d) Mineral composition

The calcium content (**Table 5.17**) of wheat flour bun substituted with fresh fig ranged from 10.80 mg/100gm to 73.61 mg/100gm. Similar results, i.e. 10.70 mg/100gm was reported by Surekha *et al*. (2013) in wheat flour cookies. In control it was only 10.80 mg/100gm and increased significantly with more replacement of fresh fig fruit. Maximum value of calcium content i.e. 73.61 mg/100gm was noted in T4. Similar increase in calcium content i.e. 14.0 per cent was reported in wheat flour muffin substituted with pumpkin (Krishanaprabha and Kiruthiga, 2015). Waghray *et al.* (2011) also reported similar increase i.e. 70.80 per cent in wheat flour chapatti substituted with date pulp. This increase in calcium content might be due to high mineral content in fruits i.e. iron, phosphorus and calcium (Armeu *et al.* 2006; Niemen *et al*. 1992). Zabidi and Yunus (2014) also reported increase in mineral content in bun substituted with fruits.

Table 5.17 Mineral composition of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	10.80 ± 0.00^{a}	14.96 ± 0.00^{b} (38.51%)↑	70.14 ± 0.00^{c} (549.44%)↑	73.61 ± 0.00^{cd} (581.57%)↑
Iron (mg/100gm)	25.83 ± 0.00^{a}	284.91 ± 0.00^{b} (1003.01%)↑	310.75 ± 0.00^{c} (1103.05) ↑	344.83 ± 0.00^{cd} (1234.99%)↑
Phosphorus (mg/100gm)	333.39 ± 0.00^{a}	371.70 ± 0.00^{b} (11.49%)↑	423.54 ± 0.00^{c} (27.04%)↑	444.00 ± 0.00^{cd} (33.18%)↑

The iron content of wheat flour bun substituted with fresh fig ranged from 25.83 mg/100gm to 344.83 mg/100gm. The result of iron content increased significantly ($p<0.05$) in bun samples substituted with fresh fig. The iron content increased with increase in fresh fig fruit substitution. Similar increase in iron content i.e. 21 to 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

The phosphorus content (**Table 5.17**) of wheat flour bun substituted with fresh fig ranged from 333.39 mg/100gm to 444.00 mg/100gm.The results of the phosphorus content increased significantly ($p<0.05$) in bun samples substituted with fresh fig. The phosphorus content was highest in T4 (444.00 mg/100gm) and lowest in T1(333.39 mg/100gm). Similar increase in phosphorus content i.e. 377.15 per cent was reported in wheat flour chapatti substituted with date pulp (Waghray *et al.* 2011).

5.5 (e) Organoleptic analysis of bun

Table 5.18 Organoleptic analysis of bun substituted with fresh fig

Parameters	T1	T2	T3	T4
Appearance	7.4±0.69[a]	7.2±0.63 [a]	7.4±0.69 [a]	7.2 ±0.63 [a]
Colour	7.2±0.42 [a]	7.0±0.47 [a]	7.1±0.31 [a]	7.0 ±0.66 [a]
Texture	7.2±0.63 [a]	7.2±0.63 [a]	7.3±0.48 [a]	7.1 ±0.31[a]
Flavour	7.5±0.52 [a]	7.2±0.42 [a]	7.3±0.67 [a]	7.1 ±0.31 [a]
Overall Acceptability	7.3±0.48 [a]	7.2±0.42 [a]	7.3±0.48 [a]	7.0 ±0.66 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant($p<0.05$)

Where, T1 (control sample) = 100% wheat flour bun, T2=15 % fig, T3=30% fig, T4 =45 % fig)

As shown in Table 5.18, sensory characteristics of wheat flour bun substituted with fresh fig T2, T3 and T4 were non significantly ($p>0.05$) different from wheat flour bun T1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour bun substituted

with fresh fig were not affected by increased concentration of fresh fig. . However, all samples were found to be acceptable.

Fig. 5.9 T1 (control sample) = 100% wheat flour bun,

T2=15 % fig,T3=30% fig, T4 =45 % fig)

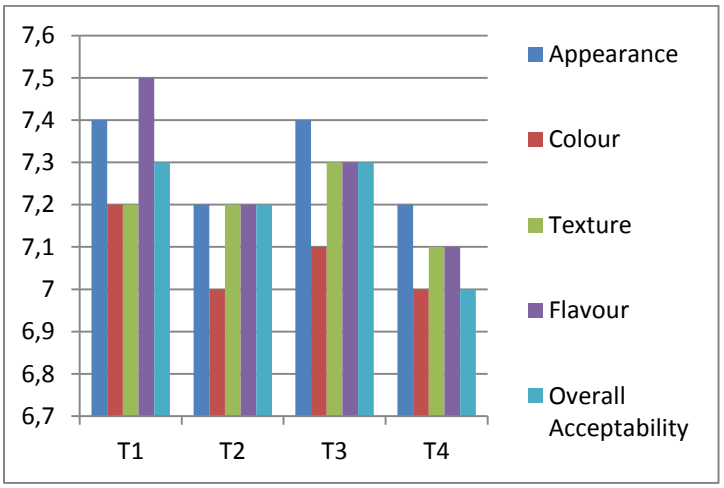

Fig. 5.10 Sensory scores of bun samples

5.6 Muffin

5.6 (a) Nutritional composition

The moisture content (**Table 5.19**) of wheat flour muffin substituted with fresh fig ranged from 10.80 per cent to 20.80 per cent. Similar results, i.e. 10.96 per cent was reported by Uchenna *et al*. (2013) in wheat flour muffin. In control it was only 10.80 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of moisture content i.e. 20.80 per cent was noted in T4. Similar increase in moisture content i.e.20.65 per cent was reported in muffin substituted with young corn powder (Jauharah *et al*. 2014). This increase in moisture content might be due to the presence of fiber content in fruits that leads to enhance the water absorption capacity by hydroxyl group (Rosell *et al.* 2011).

Table 5.19 Nutritional composition of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
Moisture (%)	10.80 ± 0.1^{a}	19.85 ± 0.09^{b} (83.79%)↑	20.15 ± 0.09^{ac} (86.57%)↑	20.80 ± 0.00^{cd} (92.59%)↑
Ash (%)	1.12 ± 0.11^{a}	1.16 ± 0.05^{a} (3.57 %)↑	1.19 ± 0.05^{a} (6.25 %)↑	1.29 ± 0.05^{a} (15.17 %)↑
Carbohydrate (%)	45.45 ± 0.48^{a}	52.48 ± 2.11^{b} (15.46%)↑	62.50 ± 2.54^{c} (37.51%)↑	71.95 ± 2.58^{cd} (58.30%)↑
Protein (%)	6.42 ± 0.12^{a}	6.92 ± 0.11^{a} (7.78%)↑	7.17 ± 0.05^{a} (11.68%)↑	7.38 ± 0.16^{a} (14.95%)↑
Fat (%)	10.33 ± 0.11^{a}	10.73 ± 0.11^{b} (3.87%)↑	11.13 ± 0.11^{c} (7.74%)↑	11.33 ± 0.11^{cd} (9.68%)↑

The ash content of wheat flour muffin substituted with fresh fig ranged from 1.12 per cent to 1.29 per cent. The ash content increased non significantly ($p>0.05$) in muffin samples substituted with fresh fig. Similar increase in ash content i.e. 0.82 to 1.31 per cent was reported in muffin substituted with carrot powder (Romjaun and Prakash, 2014). Mc Clements (2003)

also reported similar increase in ash content in muffin substituted with corn powder. This increase in ash content might be due to high ash content in fruit (Seleem, 2015).

The carbohydrate content (**Table 5.19**) of wheat flour muffin substituted with fresh fig ranged from 45.45 per cent to 71.95 per cent. Similar results, i.e. 45.08 per cent was reported by Krishanaprabha and Kiruthiga (2015) in wheat flour muffin. In control it was only 45.45 per cent increased significantly with more replacement of fresh fig fruit. Maximum value of carbohydrate content i.e. 71.95 per cent was noted in T4. Similar increase in carbohydrate content i.e. 64.81 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).Legesse and Emire (2012) also reported similar increase i.e. 72.12 per cent in wheat flour biscuit substituted with breadfruit flour. Adubofuor and Mensah (2012) also reported increase in carbohydrate content i.e. 51.86 per cent in wheat flour cake substituted with ripe pawpaw pulp. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour muffin substituted with fresh fig ranged from 6.42 per cent to 7.38 per cent. Similar results, i.e. 6.73 per cent was reported by Jauharah *et al.* (2014) in wheat flour muffin. The protein content increased non significantly ($p>0.05$) in protein content was observed in muffin samples substituted with fresh fig. Similar increase in protein content i.e. 6.6 to 7.4 per cent was reported in wheat flour panjiri substituted with potato flour (Kaur and Kochhar, 2014). Jauharah *et al.* (2014) also reported similar increase in protein content in muffin substituted with corn powder. This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.19**) of wheat flour muffin substituted with fresh fig ranged from 10.33 per cent to 11.33 per cent. The fat content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The fat content was highest in T4(11.33 %) and lowest in T1(10.33 %). Similar increase in fat content i.e. 12.50 per cent was reported in muffin substituted with pumpkin powder (Krishanaprabha and Kiruthiga, 2015). Chuen and Aziz (2009) also reported similar increase i.e. 9.23 per cent in muffin substituted with mango pulp flour. This increase in fat content may be due to high fat content in fruits (Seleem, 2015).

5.6 (b) Dietary fiber

The neutral detergent fiber (**Table 5.20**) of wheat flour muffin substituted with fresh fig ranged from 23.66 per cent to 24.46 per cent. NDF increased non significantly ($p>0.05$) in muffin substituted with fresh fig. The NDF was highest in T4 (24.46 %) and lowest in T1(23.66 %). Similar increase in NDF i.e. 24.68 per cent was reported in wheat flour cookie substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to proportionally increase in dietary fiber in fruit mixture (Seleem, 2015).

Table 5.20 Dietary fiber of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
NDF(%)	23.66 ± 0.15^{a}	23.76 ± 0.11^{a} (0.42%)↑	24.06 ± 0.32^{a} (1.69%)↑	24.46 ± 0.86^{a} (3.38%)↑
ADF(%)	5.46 ± 0.63^{a}	5.73 ± 0.56^{a} (4.94%)↑	5.83 ± 0.63^{a} (6.77%)↑	6.03 ± 0.86^{a} (10.43%)↑
Hemicellulose (%)	17.86 ± 0.00^{a}	18.19 ± 0.00^{b} (1.84%)↑	18.32 ± 0.00^{c} (2.57%)↑	18.42 ± 0.00^{cd} (3.13%)↑
Cellulose(%)	4.18 ± 0.19^{a}	4.19 ± 0.19^{a} (0.23%)↑	4.20 ± 0.19^{a} (0.47%)↑	4.24 ± 0.19^{a} (1.43%)↑
Lignin (%)	1.60 ± 0.01^{b}	1.70 ± 0.00^{ab} (6.25%)↑	1.71 ± 0.02^{ac} (6.8%)↑	1.72 ± 0.02^{cd} (7.5%)↑

The acid detergent fiber (ADF) of wheat flour muffin substituted with fresh fig ranged from 5.46 per cent to 6.03 per cent. The ADF increased non significantly ($p>0.05$) in muffin samples substituted with fresh fig. ADF increased with increase in fresh fig fruit substitution. Similar increase in ADF i.e. 1.11 to 8.05 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010).

Hemicellulose content (**Table 5.20**) of wheat flour muffin substituted with fresh fig ranged from 17.86 per cent to 18.42 per cent. Hemicellulose content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The hemicellulose content was highest in T4 (18.42 %) and lowest in T1(17.86 %). Similar increase in dietary fiber i.e.19.00 per cent was reported in wheat flour biscuit substituted with grape pomace (Szkudlarz *et al.* 2013).

The cellulose content of wheat flour muffin substituted with fresh fig ranged from 4.18 per cent to 4.24 per cent. Similar results, i.e. 4.50 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. The cellulose content increased non significantly ($p>0.05$) in muffin samples substituted with fresh fig. The cellulose content increased with increase in fresh fig fruit substitution. Similar increase in dietary fiber i.e. 1.44 to 4.24 per cent was observed in wheat flour cookie substituted with unripe plantain flour (Chinma *et al.* 2012).Similar increase i.e. 0.02 to 4.07 per cent was reported in wheat flour cookie substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to high dietary fiber in fruits(Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.20**) of wheat flour muffin substituted with fresh fig ranged from 1.60 per cent to 1.72 per cent. Similar results, i.e. 1.80 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. Lignin content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The lignin content was highest in T4 (1.72 %) and lowest in T1(1.60 %). Similar increase in dietary fiber i.e. 1.28 per cent was reported in wheat flour mathri substituted with potato flour (Kaur and Kochhar,2014). Gorecka *et al.* (2010) also reported similar increase i.e. 3.98 per cent in wheat flour cookies substituted with raspberry pomace.

5.6 (c) Mineral composition

The calcium content (**Table 5.21**) of wheat flour muffin substituted with fresh fig ranged from 146.79 mg/100gm to 339.29 mg/100gm. In control it was only 146.79 mg/100gm increased significantly with more replacement of fresh fig fruit. Maximum value of calcium content i.e. 339. 29 mg/100gm was noted in T4. Similar increase in calcium content i.e. 148.33 per cent was reported in muffin substituted with carrot powder (Romjaun and Prakash, 2013). This increase in calcium content might be due to high mineral content in fruits (Saunders, 1990).

Table 5.21Mineral composition of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	146.79±0.00^{a}	241.01±0.00^{b} (64.18%)↑	307.95±0.00^{c} (109.78%)↑	339.29±0.00^{cd} (131.13%)↑
Iron (mg/100gm)	10.92±0.00^{a}	16.04±0.00^{b} (46.88%)↑	18.14±0.00^{c} (66.11%)↑	19.88±0.00^{cd} (82.05%)↑
Phosphorus (mg/100gm)	62.40±0.00^{a}	86.65±0.00^{b} (38.86%)↑	120.42±0.00^{c} (92.98%)↑	175.43±0.00^{cd} (181.13%)↑

The iron content of wheat flour muffin substituted with fresh fig ranged from 10.92 mg/100gm to 19.88 mg/100gm. The iron content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The iron content increased with increase in fresh fig fruit substitution. Similar increase in iron content i.e. 21 to 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

The phosphorus content (**Table 5.21**) of wheat flour muffin substituted with fresh fig ranged from 62.40 mg/100gm to 175.43 mg/100gm.The results of the phosphorus content increased significantly ($p<0.05$) in muffin samples substituted with fresh fig. The phosphorus content was highest in T4 (175.43 mg/100gm) and lowest in T1(62.40 mg/100gm). Similar increase in phosphorus content i.e. 170.22per cent was reported in wheat flour biscuit substituted with date palm fruit (Sharnouby *et al.* 2012). Romjaun and Prakash (2013) also reported similar increase i.e. 119 per cent in wheat flour muffin substituted with carrot powder.

5.6 (d) Organoleptic analysis of muffin

Table 5.22 Organoleptic analysis of muffin substituted with fresh fig

Parameters	T1	T2	T3	T4
Appearance	7.9±0.31 [a]	7.4±0.51 [a]	7.7±0.48 [a]	7.4±0.51 [a]
Colour	7.2±0.42 [a]	7.6±0.51 [a]	7.4±0.51 [a]	7.2±0.42 [a]
Texture	7.3±0.48 [a]	7.4±0.51 [a]	7.4±0.51 [a]	7.3±0.48 [a]
Flavour	7.8±0.42 [a]	7.3±0.48 [a]	7.6±0.51 [a]	7.4±0.51 [a]
Overall Acceptability	7.6±0.48 [a]	7.4±0.52 [a]	7.5±0.48 [a]	7.3±0.48 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant($p<0.05$)

Where, T1 (control sample) = 100% wheat flour muffin, T2=15 % fig, T3=30% fig, T4 =45 % fig)

As shown in Table 5.22, sensory characteristics of wheat flour muffin substituted with fresh fig T2, T3 and T4 were non significantly ($p>0.05$) different from wheat flour muffin T1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour muffin substituted with fresh fig were not affected by increased concentration of fresh fig. In conclusion, T2 and T3 was found to be most acceptable as compared to T4, so wheat flour muffin sample was only substituted till 45 per cent.

Fig. 5.11 T1 (control sample) = 100% wheat flour muffin,

T2=15 % fig, T3=30% fig, T4 =45 % fig)

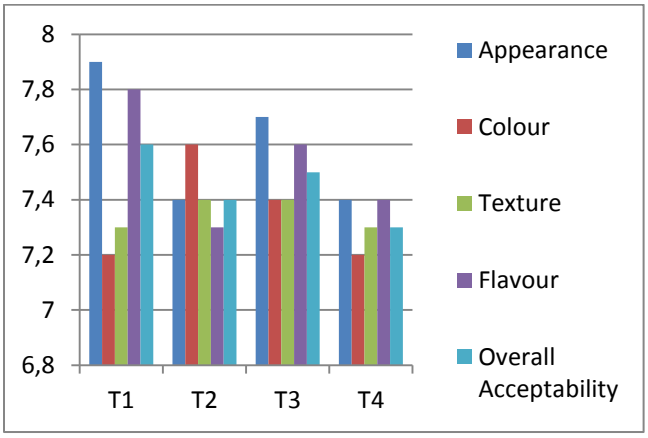

Fig. 5.12 Sensory scores of muffin samples

5.7 Noodles

5.7 (a) Nutritional composition

The moisture content (**Table 5.23**) of wheat flour noodles substituted with dried fig ranged from 6.61 per cent to 8.75 per cent. In control it was only 6.61 per cent increased non significantly with more replacement of dried fig fruit. Maximum value of moisture content i.e. 8.75 per cent was noted in T4. Similar increase in moisture content i.e. 11.35 per cent was reported in noodles substituted with sweet potato powder (Ibitoye *et al*. 2013). Taneya *et al.* (2014) also reported similar increase i.e. 6.27 per cent in wheat flour noodles substituted with potato flour. Similar increase i.e.8.67 per cent was reported in wheat flour noodles substituted with unripe banana flour (Ritthiruangdej *et al*. 2011).This increase in moisture content might be due to high moisture content in fruits (Mansour *et al*. 1999).

Table 5.23 Nutritional composition of noodles substituted with dried fig

Parameters	T1	T2	T3	T4
Moisture (%)	6.61 ± 0.16 [a]	8.26± 0.13 [a] (24.96%)↑	8.45± 0.12 [a] (27.83%)↑	8.75±3.24 [a] (32.37%)↑
Ash(%)	2.13 ± 0.00[a]	2.51± 0.10 [a] (17.84%)↑	2.84 ±0.09 [a] (33.33%)↑	3.67± 1.33 [a] (72.30%)↑
Carbohydrate (%)	85.53±0.01 [a]	95.85±0.30 [b] (12.06%)↑	105.60±0.1 [c] (23.46%)↑	114.58±0.07 [cd] (33.96%)↑
Protein (%)	6.51±0.11 [a]	7.44±0.08 [b] (14.28%)↑	7.48±1.05[bc] (14.90%)↑	7.84±0.08 [cd] (20.43%)↑
Fat (%)	1.56±0.02 [a]	1.62±0.07 [a] (3.84%)↑	1.73±0.04 [ab] (10.89%)↑	1.82±0.05 [bc] (16.66%)↑

The ash content of wheat flour noodles substituted with dried fig ranged from 2.13 per cent to 3.61 per cent. Similar results, i.e. 2.21 per cent was reported by Taneya *et al*. (2014) in wheat flour noodles. The ash content increased non significantly ($p>0.05$)in noodles samples. The ash content increased with increase in dried fig fruit substitution. Similar increase in ash content i.e. 2.21 to 2.44 per cent was reported in wheat flour noodles substituted with potato flour(Taneya *et al*.2014).Similar increase i.e. 0.93 to 1.04 per cent was reported in wheat flour bread substituted with bread fruit flour (Alice *et al.* 2012). Similar increase in ash content i.e. 2.17 to 2.39 per cent was reported in wheat flour cookies substituted with pitaya peel flour (Ho and Latif,2016). This increase in ash content might be due to high ash content in fruit (Brito *et al*.2006).

The carbohydrate content (**Table 5.23**) of wheat flour noodles substituted with dried fig ranged from 85.53 per cent to 114.58 per cent. In control it was only 85.53 per cent increased significantly with more replacement of dried fig fruit. Maximum value of carbohydrate content i.e. 114.58 per cent was noted in T4. Similar increase in carbohydrate content i.e. 97.57 per cent was reported in wheat flour bread substituted with breadfruit flour (Alice *et al.*2012).Ariffin *et al.* (2015) also reported similar increase in carbohydrate content i.e. 86.75 per cent in wheat flour bread substituted with durian flour. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour noodles substituted with dried fig ranged from 6.51 per cent to 7.84 per cent. Similar results, i.e. 6.73 per cent was reported by Ho and Latif (2016) in wheat flour cookies. The protein content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The protein content increased with increase in dried fig fruit substitution. Similar increase in protein content i.e.7.59 to 7.82 per cent was reported in wheat flour cookies substituted with breadfruit flour (Ojinnaka *et al.*2013).Similar increase in protein content i.e. 6.73 to 7.04 per cent was reported in wheat flour cookies substituted with pitaya peel flour (Ho and Latif,2016). This increase in protein content might be due to high protein content in fruits (Brito *et al*.2006).

The fat content (**Table 5.23**) of wheat flour noodles substituted with dried fig ranged from 1.56 per cent to 1.82 per cent. Similar results, i.e. 1.56 per cent was reported by Hardi *et al*. (2007) in wheat flour noodles. The fat content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The fat content was highest in T4 (1.82 %) and lowest in T1(1.56 %). Similar increase in fat content i.e. 1.3 to 3.9 per cent was reported in wheat flour noodles substituted with banana peel (Singh *et al*. 2015). This increase in fat content may be due to high fat content in fruits (Vinod *et al*. 2015).

5.7 (b) Dietary fiber

The neutral detergent fiber (**Table 5.24**) of wheat flour noodles substituted with dried fig ranged from 21.93 per cent to 23.90 per cent. NDF increased non significantly ($p>0.05$) in noodles substituted with dried fig. The NDF was highest in T4 (23.90 %) and lowest in T1(21.93 %). Similar increase in dietary fiber i.e. 24.20 per cent was reported in wheat flour noodles substituted with watermelon rind powder (Ho and Dahri, 2016). This increase in dietary fiber might be due to high dietary fiber in fruit mixture (Nwanekezi *et al.* 2015).

Table 5.24 Dietary fiber of noodles substituted with dried fig

Parameters	T1	T2	T3	T4
NDF (%)	21.93±1.90 [a]	22.50±2.16 [a] (2.59%)↑	23.70±1.70 [a] (8.07%)↑	23.90±0.26 [a] (8.98%)↑
ADF (%)	1.53±0.05 [a]	1.60±0.10 [a] (4.57 %)↑	1.76±0.11 [a] (15.03 %)↑	1.83±0.11 [ab] (19.60%)↑
Hemicellulose (%)	21.4±4.35 [a]	21.90±4.35 [b] (2.33%)↑	22.94±0.00 [c] (7.19%)↑	23.07±4.35 [cd] (7.80%)↑
Cellulose (%)	3.14±0.18 [a]	3.17±0.03 [b] (0.95%)↑	3.21±0.01 [a] (2.22%)↑	3.33±0.10 [a] (6.05%)↑
Lignin (%)	1.46±0.05 [a]	1.50±0.10 [a] (2.73 %)↑	1.53±0.05 [a] (4.79 %)↑	1.63±0.05 [a] (11.64 %)↑

The acid detergent fiber (ADF) of wheat flour noodles substituted with dried fig ranged from 1.53 per cent to 1.83 per cent. The ADF increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The ADF increased with increase in dried fig fruit substitution.

Hemicellulose content (**Table 5.24**) of wheat flour noodles substituted with dried fig ranged from 21.40 per cent to 23.07 per cent. Hemicellulose content increased significantly ($p<0.05$) in muffin samples substituted with dried fig. The hemicellulose content was highest in T4 (23.07%) and lowest in T1(21.40 %).

The cellulose content of wheat flour noodles substituted with dried fig ranged from 3.14 per cent to 3.33 per cent. The cellulose content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The cellulose content increased with increase in dried fig fruit substitution. This increase in dietary fiber might be due to the addition of dietary fiber rich fruits in noodles (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.24**) of wheat flour noodles substituted with dried fig ranged from 1.46 per cent to 1.63 per cent. Similar results, i.e. 1.08 per cent was reported by Gorecka *et al.* (2010) in wheat flour cookies. The results of the lignin content increased non significantly ($p>0.05$) in noodles samples substituted with dried fig. The lignin content was highest in T4 (0.63 %) and lowest in T1(0.46 %). Similar increase in dietary fiber i.e. 3.34 per cent was reported in wheat flour cookies substituted with potato flour (Pratyush *et al*. 2015). Similar increase in dietary fiber i.e. 0.75 per cent was reported in wheat flour biscuits substituted with jackfruit powder (Butool and Butool,2013).

5.7 (c) Mineral composition

The calcium content (**Table 5.25**) of wheat flour noodles substituted with dried fig ranged from 18.96 mg/100gm to 33.91 mg/100gm. In control it was only 18.96 mg/100gm increased significantly with more replacement of dried fig fruit. Maximum value of calcium content i.e. 33.91 mg/100gm was noted in T4. Similar increase in calcium content i.e. 32 per cent was reported in wheat flour cake substituted with beetroot powder (Pinki and Awasthi, 2014).Seleem (2015) also reported increase in calcium content i.e. 20.40 per cent in wheat flour cake

substituted with doum fruit powder. This increase in calcium content might be due to high mineral content in fruits (Seleem, 2015).

Table 5.25 Mineral composition of noodles substituted with dried fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	18.96±0.00 [a]	23.80±0.00 [b] (25.52%)↑	27.89±0.00 [c] (47.09%)↑	33.91±0.00 [cd] (78.85%)↑
Iron (mg/100gm)	10.92± 0.00[a]	14.96 ±0.00 [b] (36.99%)↑	18.14 ±0.00 [c] (66.11%)↑	70.14 ±0.00 [c] (542.30 %)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	333.39±0.00 [b] (2.86 %)↑	444.00±0.00 [c] (36.99%)↑	666.54±0.00 [cd] (105.65%)↑

The iron content of wheat flour noodles substituted with dried fig ranged from 10.92 mg/100gm to 70.14 mg/100gm. The iron content increased significantly ($p<0.05$) in all noodles samples substituted with dried fig. The iron content increased with increase in dried fig fruit substitution. Similar increase in iron content i.e. 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

The phosphorus content (**Table 5.25**) of wheat flour noodles substituted with dried fig ranged from 324.1 mg/100gm to 666.54 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in noodles samples substituted with dried fig. The phosphorus content was highest in T4 (0.16 mg/100gm) and lowest in T1(0.11 mg/100gm).Similar increase in phosphorus content i.e. 467 per cent was reported in wheat flour cakes substituted with beetroot powder (Pinki and Awasthi, 2014).

Fig. 5.13 T1 (control sample = 100% wheat flour noodles,

T2=15 % fig, T3=30% fig, T4 =45 % fig)

5.8 Nugget

5.8 (a) Nutritional composition

The moisture content (**Table 5.26**) of green gram nugget substituted with dried fig ranged from 19.80 per cent to 20.80 per cent. In control it was only 19.80 per cent increased significantly with more replacement of dried fig fruit. Maximum value of moisture content i.e. 20.80 per cent was noted in T4. Similar increase in moisture content i.e.22.98 per cent was reported in composite pulse flour chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in moisture content might be due to high moisture content in fruits (Nwanekezi *et al.* 2015).

Table 5.26 Nutritional composition of nugget substituted with dried fig

Parameters	T1	T2	T3	T4
Moisture (%)	19.80±0.1 [a]	19.85±0.09 [a] (0.25%)↑	20.15±0.09 [b] (1.76%)↑	20.80±0.00 [b c] (5.05%)↑
Ash (%)	1.10±0.05 [a]	1.16±0.05 [a] (5.45%)↑	1.19±0.05 [a] (8.18 %)↑	1.29±0.20 [a] (17.27%)↑
Carbohydrate (%)	65.64±0.22 [a]	72.48±2.11 [b] (10.42%)↑	82.50±1.09 [c] (25.68%)↑	93.78±0.63 [cd] (42.87%)↑
Protein (%)	13.34±0.08 [a]	13.59±0.08 [b] (1.87%)↑	14.39±0.08 [c] (7.87%)↑	14.72±0.08 [cd] (10.34%)↑
Fat (%)	1.85±2.71 [a]	2.20±0.05 [b] (18.91%)↑	2.27±0.02 [bc] (22.70%)↑	2.33± 0.07 [bd] (25.94%)↑

The ash content of green gram nugget substituted with dried fig ranged from 1.37 per cent to 1.77 per cent. The ash content increased non significantly ($p>0.05$) in nugget samples substituted with dried fig. The ash content increased with increase in dried fig fruit substitution. Similar increase in ash content i.e. 1.20 to 1.72 per cent was reported in gram composite flour

chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in ash content might be due to high ash content in fruit(Nwanekezi *et al.* 2015).

The carbohydrate content (**Table 5.26**) of green gram nugget substituted with dried fig ranged from 65.64 per cent to 93.78 per cent. Similar results, i.e. 65.50 per cent was reported by Aziz *et al*. (2012) in nugget. In control it was only 65.64 per cent increased significantly with more replacement of fresh dried fruit. Maximum value of carbohydrate content i.e. 93.78 per cent was noted in T4. Similar increase in carbohydrate content i.e. 65.78 per cent was reported in pulse based weaning food substituted with banana fruit (Mishra *et al.* 2014). Singh *et al.*(2014) also reported similar increase in carbohydrate content i.e. 70.72 per cent in bengal gram dal substituted with kondhara leaves. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of green gram nugget substituted with dried fig ranged from 13.34 per cent to 14.72 per cent. The protein content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The protein content increased with increase in dried fig fruit substitution. Similar increase in protein content i.e. 11.48 to 30.44 per cent protein content was reported in bengal gram dal substituted with kondhara leaves (Sultana *et al.* 2014). Similar increase in protein content i.e. 14.26 to 14.80 per cent was reported in legume composite flour thalipeeth (pan cake like product) substituted with green leafy vegetables (Gupta and Prakash,2011). This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.26**) of green gram nugget substituted with dried fig ranged from 1.85 per cent to 2.33 per cent. Similar results, i.e. 1.30 per cent was reported by Pardeshi *et al*. (2013) in nugget. The fat content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The fat content was highest in T4 (2.33 %) and lowest in T1(1.85 %). Similar increase in fat content i.e. 1.28 per cent was reported in composite gram flour based chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in fat content may be due to high fat content in fruits (Nwanekezi *et al.* 2015).

5.8 (b) Dietary fiber

The neutral detergent fiber (**Table 5.27**) of green gram nugget substituted with dried fig ranged from 23.56 per cent to 24.20 per cent. NDF increased non significantly ($p>0.05$) in nugget samples substituted with dried fig. The NDF was highest in T4 (24.20 %) and lowest in T1 (23.56 %). Similar increase in dietary fiber i.e. 18.15 per cent was reported in composite gram flour chakli (Rosy *et al.* 2015). This increase in dietary fiber might be due to proportionally increase in dietary fiber in fruits (Rupasinghe *et al.* 2008).

Table 5.27 Dietary fiber of nugget substituted with dried fig

Parameters	T1	T2	T3	T4
NDF (%)	23.56±0.11 [a]	23.63±0.11 [a] (3.94%)↑	24.06±0.32 [a] (2.12%)↑	24.20±1.04 [a] (2.71%)↑
ADF (%)	21.06±0.92 [a]	21.33±1.15 [a] (1.28%)↑	21.73±0.23 [a] (3.18%)↑	21.76±1.85 [a] (3.32%)↑
Hemicellulose (%)	1.97±0.00 [a]	2.36±0.00 [b] (19.79%)↑	2.47±0.00 [c] (25.38%)↑	2.50±0.00 [cd] (26.90%)↑
Cellulose (%)	11.88±0.65 [a]	11.51±0.65 [a] (3.11%)↑	11.89±0.61 [a] (0.08%)↑	12.54±0.66 [a] (5.55%)↑
Lignin (%)	1.68±0.00 [b]	1.70±0.00 [a] (1.19%)↑	1.71±0.00 [ac] (1.78%)↑	1.73±0.01 [a] (2.97%)↑

The acid detergent fiber (ADF) of nugget substituted with dried fig ranged from 21.06 per cent to 21.76 per cent. The ADF content increased non significantly ($p>0.05$) in nugget samples substituted with dried fig. The ADF increased with increase in dried fig fruit substitution.

Hemicellulose content (**Table 5.27**) of nugget substituted with dried fig ranged from 1.97 per cent to 2.50 per cent. Hemicellulose content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The hemicellulose content was highest in T4 (2.50 %) and lowest in T1(1.97 %).Similar increase in hemicellulose content i.e.0.38 to 0.51 per cent was reported in gram dal substituted with bathua leaves (Singh *et al.* 2007). Singh *et al.*(2014) also reported similar increase i.e. 0.25 to 5.75 per cent dietary fiber in bengal gram dal substituted with kondhara leaves.

The cellulose content of nugget substituted with dried fig ranged from 11.88 per cent to 12.54 per cent. The cellulose content increased non significantly ($p<0.05$) in cellulose content was observed in all nugget samples substituted with dried fig. The cellulose content increased with increase in dried fig fruit substitution. This increase in cellulose content might be due to addition of dietary fiber rich fruits in nugget (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.27**) of nugget substituted with dried fig ranged from 1.68 per cent to 1.73 per cent. The results of the lignin content increased significantly ($p<0.05$) in nugget samples substituted with dried fig. The lignin content was highest in T4 (1.73 %) and lowest inT1(1.68 %). Similar increase in dietary fiber i.e. 1.82 per cent was reported in gram composite flour khakara substituted with carrot powder (Surekha and Naik, 2014).Verma and Singh (2014) also reported similar increase in lignin content i.e. 1.28 per cent in besan laddu substituted with mushroom powder.

5.8 (c) Mineral composition

The calcium content (**Table 5.28**) of nugget substituted with dried fig ranged from 146.79 mg/100gm to 333.29 mg/100gm.In control it was only 146.79 mg/100gm increased significantly with more replacement of dried fig fruit. Maximum value of calcium content i.e. 333.29 mg/100gm was noted in T4. Similar increase in calcium content i.e. 335.0 per cent was

reported in bengal gram dal substituted with kondhara leaves (Singh *et al.*2014).This increase in calcium content might be due to high mineral content in fruits (Armeu *et al.* 2006).

Table 5.28 Mineral composition of nugget substituted with dried fig

Parameters	T1	T2	T3	T4
Calcium (mg/100gm)	146.79± 0.00 [a]	241.01±0.00 [b] (64.18%)↑	307.95±0.00 [c] (109.78%)↑	339.29±0.00 [cd] (131.13%)↑
Iron (mg/100gm)	10.92±0.00 [a]	16.04±0.00 [b] (46.61%)↑	18.14±0.00 [c] (66.11%)↑	19.88±0.00 [cd] (82.05%)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	666.54±0.00 [b] (105.65%)↑	704.27±0.00 [c] (117.30%)↑	754.35±0.00 [cd] (132.75%)↑

The iron content of nugget substituted with dried fig ranged from 10.92 mg/100gm to 19.88 mg/100gm. The iron content significantly increase ($p<0.05$) in nugget samples substituted with dried fig. The iron content increased with increase in dried fig fruit substitution. Similar increase in iron content i.e. 3.90 to 8.99 per cent was reported in legume composite flour thalipeeth (pan cake like product) substituted with green leafy vegetables (Gupta and Prakash, 2011). Singh *et al.*(2014) also reported similar increase in iron content i.e. 7.25 to 28.77 per cent in bengal gram dal substituted with kondhara leaves. Similar increase in iron content i.e. 6.10 to 6.34 per cent was reported in gram composite flour khakara substituted with carrot powder (Surekha and Naik, 2014).

The phosphorus content (**Table 5.28**) of nugget substituted with dried fig ranged from 324.1 mg/100gm to 754.35 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$)in nugget samples substituted with dried fig. The phosphorus content increased with increase in dried fig fruit substitution. The phosphorus content was highest in T3 (754.35 mg/100gm) and lowest in T1(324.1 mg/100gm). Similar increase in phosphorus content i.e. 320 to 378 per cent was reported in gram composite flour roti substituted with methi powder (Kadam *et al*.2012).

Fig. 5.14 T1 (control sample = 100% green gram nugget,

T2=15 % fig, T3=30% fig, T4 =45 % fig)

5.9 Formulation of value added products with the substitution of karonda

5.9 (a) Bun

5.9 (b) Nutritional composition

The moisture content (**Table 5.29**) of wheat flour bun substituted with fresh karonda fruit ranged from 6.47 per cent to 9.87 per cent. In control it was only 6.47 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of moisture content i.e. 9.87 per cent was noted in B4. Similar increase in moisture content i.e. 9.50 per cent was reported in biscuit substituted with date palm fruit (Sharnouby *et al.* 2012). This increase in moisture content might be due to high moisture content in fresh fruit (Rosell *et al.* 2011).

The ash content of wheat flour bun substituted with fresh karonda ranged from 1.10 per cent to 1.29 per cent. The ash content increased non significantly ($p>0.05$) in bun samples substituted with fresh karonda. The ash content increased with increase in fresh karonda fruit substitution. Similar increase in ash content i.e. 1.30 to 1.60 per cent was reported in wheat flour bun substituted with ripe pawpaw pulp (Adubofuor and Mensah, 2012). See *et al.* (2007) also reported similar increase in ash content i.e.1.83 to 2.43 per cent in bread substituted with pumpkin flour. This increase in ash content might be due to the high ash content in fruit (El-Sharnouby *et al.* 2012).

The carbohydrate content (**Table 5.29**) of wheat flour bun substituted with fresh karonda ranged from 75.52 per cent to 107.56 per cent. In control it was only 75.52 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of carbohydrate content i.e. 107.56 per cent was noted in B4. Similar increase in carbohydrate content i.e. 78.69 per cent was reported in cookies substituted with unripe plantain flour (Chinma *et al*. 2012). This increase in carbohydrate content may be due to high carbohydrate content in fruits (Kulkarni and Joshi, 2014).

Table 5.29 Nutritional composition of bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
Moisture (%)	6.47± 0.02[a]	7.45±0.01[b] (15.14%) ↑	8.24±0.66[cd] (52.55%)↑	9.87±0.02[c] (27.35%)↑
Ash (%)	1.10±0.05[a]	1.16±0.05[a] (3.59 %)↑	1.19±0.05[a] (7.91 %)↑	1.29±0.20[a] (23.74 %)↑
Carbohydrate (%)	75.52±0.01[a]	89.58±0.07[b] (18.61%)↑	98.05±0.05[c] (29.83%)↑	107.56±0.05[cd] (42.42%)↑
Protein (%)	6.64±0.14[a]	6.79±0.08[a] (2.25%)↑	7.10±0.1[b] (6.92%)↑	7.52±0.08[bc] (13.25%)↑
Fat (%)	1.62±0.07[a]	1.73±0.04[a] (6.79%)↑	1.82±0.05[a] (12.34%)↑	1.92±0.28[a] (18.52%)↑

Where, B1 (control sample) = 100% wheat flour bun, B2= 15% karonda, B3=30% karonda, B4= 45% karonda)

The protein content of wheat flour bun substituted with fresh karonda ranged from 6.64 per cent to 7.52 per cent. The protein content significantly increase ($p<0.05$) in all bun samples substituted with fresh karonda. The protein content increased with increase in fresh karonda fruit substitution. Similar increase in protein content i.e. 7.01 to 7.69 per cent was reported in bread substituted with bread fruit flour (Alice *et al*. 2012). Youssef *et al.* (2012) also reported similar increase in protein content i.e. 7.01 to 7.69 per cent in wheat flour biscuit substituted with citrus peels powder. This increase in protein content might be due to high protein content in fruits (Thorvaldsson and Skjoldebrand, 1998).

The fat content (**Table 5.29**) of wheat flour bun substituted with fresh karonda ranged from 1.62 per cent to 1.92 per cent. Similar results, i.e. 1.57 per cent was reported by Michael *et al*. (2013) in wheat flour bread. The fat content non significantly increase ($p>0.05$) in bun samples substituted with fresh karonda. The fat content was highest in B4 (1.92 %) and lowest in B1(1.62 %). Similar increase in fat content i.e. 1.41 per cent was reported in wheat flour cookie substituted with unripe plantain flour (Chinma *et al*. 2012). This increase in fat content may be due to relative increase in fat content in fruits (Kulkarni and Joshi, 2014).

5.9 (c) Dietary fiber

The neutral detergent fiber (**Table 5.30**) of wheat flour bun substituted with fresh karonda ranged from 23.73 per cent to 25.66 per cent. Similar results, i.e. 23.16 per cent was reported by Krishan *et al.* (1987) in wheat flour bread. NDF increased significantly ($p<0.05$)in bun samples substituted with fresh karonda. The NDF was highest in B4 (25.66 %) and lowest in B1(23.73 %). Similar increase in dietary fiber i.e. 24.20 per cent was reported in bread substituted with watermelon rind (Ho and Dahri, 2016). Lopez *et al.* (2011) also reported similar increase i.e. 25.20 per cent in bread substituted with orange powder (Lopez *et al.* 2011). This increase in dietary fiber might be due to high dietary fiber in fruits (El- Sharnouby *et al.* 2012).

The acid detergent fiber (ADF) of wheat flour bun substituted with fresh karonda ranged from 1.30 per cent to 1.66 per cent. The ADF content increased non significantly ($p>0.05$)in bun samples substituted with fresh karonda. ADF increased with increase in fresh karonda fruit substitution. Similar increase in dietary fiber i.e. 0.75 to 1.13 per cent was reported in wheat flour cookie substituted with mango seed kernel (Legesse and Emire, 2012).

Table 5.30 Dietary fiber of bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
NDF (%)	23.73±0.10[a]	24.23±0.05[a] (2.10%)↑	24.83±0.98[a] (4.63%)↑	25.66±0.23[ab] (8.13%)↑
ADF (%)	1.30±0.45[a]	1.56±0.20[a] (20.0%)↑	1.60±0.17[a] (23.07%)↑	1.66±0.11[a] (27.69%)↑
Hemicellulose (%)	22.39±0.00[a]	22.69±0.00[a] (1.33%)↑	23.22±0.00[a] (3.70%)↑	23.99±0.00[a] (7.14%)↑
Cellulose (%)	2.48±0.10[a]	2.59±0.04[a] (4.43%)↑	2.64±0.05[a] (6.45%)↑	2.83±0.10[b] (14.11%)↑
Lignin (%)	1.23±0.63[a]	1.63±0.05[a] (32.52%)↑	1.66 ±0.05[a] (34.95 %)↑	1.73±0.05[a] (40.65 %)↑

Hemicellulose content (**Table 5.30**) of wheat flour bun substituted with fresh karonda ranged from 23.39 per cent to 23.99 per cent. Hemicellulose content increased non significantly ($p>0.05$) in bun samples substituted with fresh karonda. The hemicellulose content was highest in B4 (23.99 %) and lowest in B1(22.39 %).

The cellulose content of wheat flour bun substituted with fresh karonda ranged from 2.48 per cent to 2.83 per cent. The cellulose content significantly increased ($p<0.05$) in bun samples substituted with fresh karonda. The cellulose content increased with increase in fresh karonda fruit substitution. Similar increase in cellulose content i.e. 0.02 to 7.66 per cent was reported in

cookies substituted with raspberry pomace fruit (Gorecka *et al.* 2010). This increase in dietary fiber might be due to addition of cellulose rich fruits (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.30**) of wheat flour bun substituted with fresh karonda ranged from 1.23 per cent to 1.73 per cent. The results of the lignin content increased non significantly ($p>0.05$)in bun samples substituted with fresh karonda. The lignin content was highest in B4 (0.75 %) and lowest in B1(0.56 %). Similar increase in lignin content i.e.3.98 per cent was reported in wheat flour biscuits substituted with raspberry pomace fruit (Gorecka *et al.* (2010).

5.9 (d) Mineral composition

The calcium content (**Table 5.31**) of wheat flour bun substituted with fresh karonda ranged from 10.80 mg/100gm to 94.05 mg/100gm. Similar results, i.e. 10.70 mg/100gm was reported by Surekha *et al*. (2013) in wheat flour cookie. In control it was only 10.80 mg/100gm increased significantly with more replacement of fresh karonda fruit. Maximum value of calcium content i.e. 94.05 mg/100gm was noted in B4. Similar increase in calcium content i.e. 32 per cent was reported in wheat flour cake substituted with beetroot powder (Pinki and Awasthi, 2014). Seleem (2015) also reported similar increase in calcium content i.e. 20.40 per cent in wheat flour cake substituted with doum fruit powder. This increase in calcium content might be due to high mineral content in fruits (Kulkarni and Joshi, 2013).

The iron content of wheat flour bun substituted with fresh karonda ranged from 25.83 mg/100gm to 369.12 mg/100gm. The iron content significantly increase ($p<0.05$) in bun samples substituted with fresh karonda. The iron content increased with increase in fresh karonda fruit substitution. Similar increase in iron content i.e. 21 to 32 per cent was reported in wheat flour biscuit substituted with pumpkin flour (Kulkarni and Joshi, 2013).

Table 5.31 Mineral composition of bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
Calcium (mg/100gm)	10.80 ± 0.00^{a}	49.57 ± 0.00^{b} (358.98%)↑	57.40 ± 0.00^{c} (431.48%)↑	94.05 ± 0.00^{cd} (770.83%)↑
Iron (mg/100gm)	25.83 ± 0.00^{a}	307.61 ± 0.00^{b} (1090.90%)↑	355.43 ± 0.00^{c} (1276.03%)↑	369.12 ± 0.00^{cd} (1329.0%)↑
Phosphorus (mg/100gm)	333.39 ± 0.00^{a}	416.77 ± 0.00^{b} (25.0%)↑	443.73 ± 0.00^{c} (33.09%)↑	501.13 ± 5.77^{cd} (50.31%)↑

The phosphorus content (**Table 5.31**) of wheat flour bun substituted with fresh karonda ranged from 333.39 mg/100gm to 501.13 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in bun samples substituted with fresh karonda. The phosphorus content was highest in B4 (501.13 mg/100gm) and lowest in B1(333.39 mg/100gm). Similar increase in phosphorus content i.e.377.15 per cent was reported in wheat flour chapatti substituted with date pulp (Waghray *et al.*2011). Similar increase in phosphorus content i.e. 540 per cent was reported in wheat bran biscuit substituted with palm fruit (El- Sharnouby *et al*. 2012).

5.9 (e) Organoleptic Analysis

Table 5.32 Bun substituted with fresh karonda

Parameters	B1	B2	B3	B4
Appearance	7.4±0.69[a]	7.5±0.52 [a]	7.4±0.51 [a]	7.2±0.42 [a]
Colour	7.2±0.42 [a]	7.4±0.51 [a]	7.6±0.52 [a]	7.2±0.42 [a]
Texture	7.2±0.63 [a]	7.5±0.52 [a]	7.5±0.52 [a]	7.2±0.42 [a]
Flavour	7.5±0.52 [a]	7.4±0.51 [a]	7.6±0.51 [a]	7.3±0.48 [a]
Overall Acceptability	7.3±0.48 [a]	7.5±0.52 [a]	7.5±0.52 [a]	7.2±0.63 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant($p<0.05$)

Where, B1 (control sample) = 100% wheat flour bun, B2=15 % karonda, B3=30% karonda, B4 =45 %karonda)

As shown in Table 5.32, sensory characteristics of wheat flour bun substituted with fresh karonda B2, B3 and B4 were non significantly ($p>0.05$) different from wheat flour bun B1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour bun substituted with fresh karonda were not affected by increased concentration of fresh karonda. However, all samples were found to be acceptable.

Fig. 5.15 B1(control sample) = 100% wheat flour bun,

B2=15 % karonda,B3=30% karonda, B4 =45 % karonda)

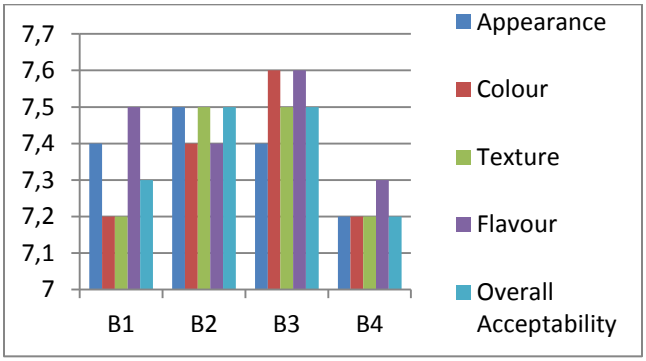

Fig. 5.16 Sensory scores of bun samples

5. 10 Muffin

5.10 (a) Nutritional composition

The moisture content (**Table 5.33**) of wheat flour muffin substituted with fresh karonda ranged from 10.80 per cent to 20.80 per cent. Similar results, i.e. 10.96 per cent was reported by Uchenna *et al*. (2013) in wheat flour muffin. In control it was only 10.80 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of moisture content i.e. 20.80 per cent was noted in B4.Similarincrease in moisture content i.e. 9.50 per cent was reported in wheat bran biscuits substituted with date palm powder (El- Sharnouby *et al.* 2012). Mansour *et al.* (1999) also reported similar increase in moisture content in wheat flour muffin substituted with pumpkin powder. This increase in moisture content might be due to high moisture content in fruits (Rosell *et al.* 2011).

Table 5.33 Nutritional composition of muffin substituted with fresh karonda

Parameters	B1	B2	B3	B4
Moisture (%)	10.80 ± 0.1^{a}	20.66 ± 0.05^{b} (91.29%)↑	19.68 ± 0.09^{c} (102.12%)↑	21.83 ± 0.00^{ad} (82.22%)↑
Ash(%)	1.12 ± 0.11^{a}	1.13 ± 0.10^{a} (0.89 %)↑	1.19 ± 0.05^{a} (6.25 %)↑	1.28 ± 0.19^{a} (14.28 %)↑
Carbohydrate (%)	45.45 ± 0.48^{a}	52.29 ± 2.22^{b} (15.04%)↑	61.16 ± 3.20^{c} (34.56%)↑	70.07 ± 0.02^{cd} (54.16%)↑
Protein (%)	6.42 ± 0.12^{a}	7.16 ± 0.05^{a} (11.52%)↑	7.52 ± 0.08^{b} (17.13%)↑	7.76 ± 0.08^{bc} (20.87%)↑
Fat (%)	10.33 ± 0.11^{a}	11.53 ± 0.11^{b} (11.61%)↑	12.53 ± 0.11^{c} (21.29%)↑	12.73 ± 0.11^{cd} (23.23%)↑

The ash content of wheat flour muffin substituted with fresh karonda ranged from 1.12 per cent to 1.28 per cent. The ash content non significantly increase ($p>0.05$) in muffin samples substituted with fresh karonda. The ash content increased with increase in fresh karonda fruit

substitution. Similar increase in ash content i.e.1.42 to 1.52 per cent was reported in muffin substituted with apple skin powder (Rupasinghe *et al.* 2008). Lopez *et al.* (2011) also reported similar increase in ash content i.e. 2.20 to 3.70 per cent in muffin substituted with orange powder. This increase in ash content might be due to high ash content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.33**) of wheat flour muffin substituted with fresh karonda ranged from 45.45 per cent to 70.07 per cent. Similar results, i.e. 45.08 per cent was reported by Krishanaprabha and Kiruthiga (2015) in wheat flour muffin. In control it was only 45.45 per cent increased significantly with more replacement of fresh karonda fruit. Maximum value of carbohydrate content i.e. 70.07 per cent was noted in B4. Similar increase in carbohydrate content i.e. 64.81 per cent was reported in wheat flour biscuit substituted with pumpkin powder (Kulkarni and Joshi, 2013). This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of wheat flour muffin substituted with fresh karonda ranged from 6.42 per cent to 7.76 per cent. Similar results, i.e. 6.73 per cent was reported by Jauharah *et al.* (2014) in wheat flour muffin. The protein content significantly increase ($p<0.05$) in muffin samples substituted with fresh karonda. The protein content increased with increase in fresh karonda fruit substitution. Similar increase in protein content i.e.6.10 to 7.0 per cent was reported in wheat flour cake substituted with beetroot powder (Pinki and Awasthi, 2014). Jauharah *et al.* (2014) also reported similar increase in protein content in muffin substituted with corn powder. This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.33**) of wheat flour muffin substituted with fresh karonda ranged from 10.33 per cent to 12.73 per cent. The fat content significantly increase ($p<0.05$) in muffin samples substituted with fresh karonda. The fat content was highest in B4 (12.73 %) and lowest in B1(10.33 %). Similar increase in fat content i.e. 12.80 per cent was reported in wheat flour cookies substituted with mango kernel seed (Legesse and Emire,2012). Waghray *et al.* (2011) also reported similar increase in fat content i.e. 7.54 per cent in wheat flour chapatti substituted with dates. This increase in fat content may be due to high fat content in fruits (Asp and Bjorck, 1992).

5. 10 (b) Dietary fiber

The neutral detergent fiber (**Table 5.34**) of wheat flour muffin substituted with fresh karonda ranged from 23.66 per cent to 25.30 per cent. NDF increased non significantly ($p>0.05$) in muffin samples substituted with fresh karonda. The NDF was highest in B4 (25.30 %) and lowest in B1(23.66 %). Similar increase in NDF i.e. 24.68 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to relative increase of fiber content in fruits (Sadiq*et al.* 2003).

Table 5.34 Dietary fiber of muffin substituted with fresh karonda

Parameters	B1	B2	B3	B4
NDF(%)	23.66 ± 0.15^{a}	24.10 ± 0.34^{a} (1.85%)↑	24.46 ± 0.86^{a} (3.38%)↑	25.30 ± 0.86^{a} (6.93) ↑
ADF(%)	5.46 ± 0.63^{a}	6.06 ± 0.63^{a} (10.98%)↑	6.20 ± 1.10^{a} (13.55%)↑	6.56 ± 0.63^{a} (20.14%)↑
Hemicellulose (%)	17.86 ± 0.00^{a}	18.03 ± 0.00^{b} (0.95%)↑	18.25 ± 0.00^{c} (2.18%)↑	18.32 ± 0.00^{cd} (2.57%)↑
Cellulose(%)	4.18 ± 0.19^{a}	4.22 ± 0.19^{a} (0.95%)↑	4.26 ± 0.19^{a} (1.91%)↑	4.27 ± 0.19^{a} (2.15%)↑
Lignin (%)	1.60 ± 0.01^{b}	1.72 ± 0.02^{a} (7.50%)↑	1.73 ± 0.01^{a} (8.12%)↑	1.74 ± 0.01^{ab} (8.75%)↑

The acid detergent fiber (ADF) of wheat flour muffin substituted with fresh karonda ranged from 5.46 per cent to 6.56 per cent. The ADF content non significantly increase ($p>0.05$) in muffin samples substituted with fresh karonda. ADF increased with increase in fresh karonda fruit substitution. Similar increase in ADF i.e. 1.11 to 8.05 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010).

Hemicellulose content (**Table 5.34**) of wheat flour muffin substituted with fresh karonda ranged from 17.86 per cent to 18.32 per cent. Hemicellulose content increased significantly ($p<0.05$) in muffin samples substituted with fresh karonda. The hemicellulose content was highest in B4 (18.32 %) and lowest in B1(17.86 %). Similar increase in dietary fiber i.e. 19.00 per cent was reported in wheat flour biscuit substituted with grape pomace (Szkudlarz *et al.* 2013).

The cellulose content of wheat flour muffin substituted with fresh karonda ranged from 4.18 per cent to 4.27 per cent. Similar results, i.e. 4.50 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. The cellulose content non significantly increase ($p>0.05$) in cellulose content was observed in muffin samples substituted with fresh karonda. The cellulose content increased with increase in fresh karonda fruit substitution. Similar increase in dietary fiber i.e. 1.44 to 4.24 per cent was observed in wheat flour cookies substituted with unripe plantain flour (Chinma *et al.* 2012). Similar increase in cellulose content i.e. 0.02 to 4.07 per cent was reported in wheat flour cookies substituted with raspberry pomace (Gorecka *et al.* 2010). This increase in dietary fiber might be due to addition of dietary fiber rich fruits in muffin, especially cellulose content (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.34**) of wheat flour muffin substituted with fresh karonda ranged from 1.60 per cent to 1.74 per cent. Similar results, i.e. 1.80 per cent was reported by Thomas *et al*. (2015) in wheat flour muffin. The results of lignin content increased significantly ($p<0.05$) in muffin samples substituted with fresh karonda. The lignin content was highest in B4 (1.74 %) and lowest in B1(1.60 %). Similar increase in dietary fiber i.e. 1.28 per cent was reported in wheat flour mathri substituted with potato flour (Kaur and Kochhar,2014).

5.10 (c) Mineral composition

The calcium content (**Table 5.35**) of wheat flour muffin substituted with fresh karonda ranged from 146.79 mg/100gm to 234.41 mg/100gm. In control it was only 146.79 mg/100gm increased significantly with more replacement of fresh karonda fruit. Maximum value of calcium content i.e. 234.41 mg/100gm was noted in B4. Similar increase in calcium content i.e. 148.33 per cent was reported in muffin substituted with carrot powder (Romjaun and

Prakash, 2015). This increase in calcium content might be due to high mineral content in fruits (Waghray *et al.* 2011).

Table 5.35 Mineral composition of muffin substituted with fresh karonda

Parameters	B1	B2	B3	B 4
Calcium (mg/100gm)	146.79±0.00^{a}	148.16±0.00^{a} (0.93%)↑	172.97±0.00^{a} (17.83%)↑	234.41±51.96^{ab} (59.69%)↑
Iron (mg/100gm)	10.92±0.00^{a}	11.33±0.00^{b} (3.75%)↑	12.07±0.00^{c} (10.53%)↑	13.31±0.00^{cd} (21.88%)↑
Phosphorus (mg/100gm)	62.40±0.00^{a}	72.28±0.00^{b} (15.83%)↑	76.86±0.00^{c} (23.17%)↑	81.74±0.00^{cd} (30.99%)↑

The iron content of wheat flour muffin substituted with fresh karonda ranged from 10.92 mg/100gm to 13.31 mg/100gm. The result of iron content significantly increase ($p<0.05$) in muffin samples substituted with fresh karonda. The iron content increased with increase in fresh karonda fruit substitution. Seleem (2013) also reported similar increase in iron content i.e. 4.80 to 5.03 per cent in wheat flour muffin substituted with doum fruit powder.

The phosphorus content (**Table 5.35**) of wheat flour muffin substituted with fresh karonda ranged from 62.40 mg/100gm to 81.74 mg/100gm.The results of the phosphorus content increased significantly ($p<0.05$)in muffin samples substituted with fresh karonda. The phosphorus content was highest in B4 (81.74 mg/100gm) and lowest in B1(62.40 mg/100gm).

5.10 (d) Organoleptic analysis

Table 5.36 Muffin substituted with fresh karonda

Parameters	B1	B2	B3	B4
Appearance	7.9±0.31 [a]	7.4±0.51 [a]	7.4±0.48 [a]	7.2±0.42 [a]
Colour	7.2±0.42 [a]	7.4±0.51 [a]	7.6±0.51 [a]	7.1±0.56 [a]
Texture	7.3±0.48 [a]	7.7±0.48 [a]	7.5±0.52 [a]	7.4±0.51 [a]
Flavour	7.8±0.42 [a]	7.5±0.52 [a]	7.4±0.51 [a]	7.3±0.48 [a]
Overall Acceptability	7.6±0.51 [a]	7.6±0.51 [a]	7.5±0.52 [a]	7.4±0.51 [a]

Values are mean ± SD from triplicate determinations; different superscripts in the same row are non significant ($p<0.05$)

Where, B1 (control sample) = 100% wheat flour bun, B2=15 % karonda, B3=30% karonda, B4 =45 % karonda)

As shown in Table 5.36, sensory characteristics of wheat flour muffin substituted with fresh karonda B2, B3 and B4 were non significantly ($p>0.05$) different from wheat flour muffin B1. Parameters appearance, colour, texture, flavour and overall acceptability of wheat flour muffin substituted with fresh karonda were not affected by increased concentration of fresh karonda. However, all samples were found to be acceptable.

Fig. 5.17 B1 (control sample) = 100% wheat flour muffin,

B2 =15 % karonda, B3 =30% karonda, B4 =45 % karonda)

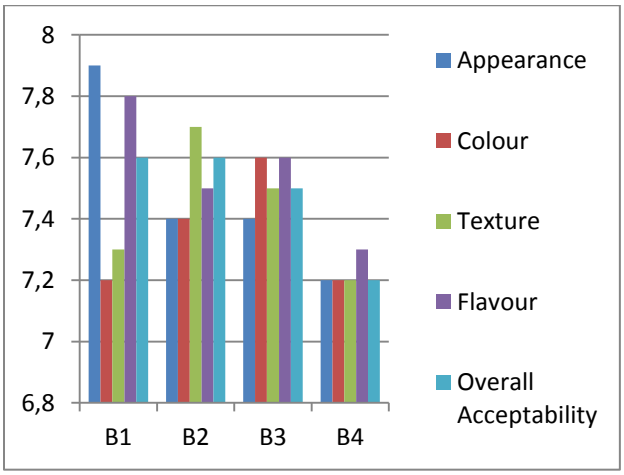

Fig. 5.18 Sensory scores of muffin samples

5.11 Noodles

5.11 (a) Nutritional composition

The moisture content (**Table 5.37**) of wheat flour noodles substituted with dried karonda ranged from 6.61 per cent to 9.88 per cent. In control it was only 6.61 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of moisture content i.e. 9.88 per cent was noted in B4. Similar increase in moisture content i.e. 9.73 per cent in wheat flour pasta substituted with orange fiber (Crizel *et al.* 2015). Similar increase in moisture content i.e. 8.67 per cent was also reported in wheat flour noodles substituted with unripe banana flour (Ritthiruangdej *et al*. 2011). This increase in moisture content might be due to relative increase of moisture content in fruits (Raj and Masih, 2014).

The ash content of wheat flour noodles substituted with dried karonda ranged from 2.00 per cent to 2.13 per cent. Similar results, i.e. 2.21 per cent was reported by Taneya *et al*. (2014) in wheat flour noodles. The ash content non significantly increase ($p>0.05$) in noodles samples substituted with dried karonda. The ash content increased with increase in dried karonda fruit substitution. Similar increase in ash content i.e. 0.87 to 1.64per cent was reported in wheat flour spaghetti substituted with banana flour (Diaz *et al.*2014). This increase in ash content might be due to high ash content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.37**) of wheat flour noodles substituted with dried karonda ranged from 85.53 per cent to 112.56 per cent. In control it was only 85.53 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of carbohydrate content i.e. 112.56 per cent was noted in B4. Similar increase in carbohydrate content i.e. 97.57 per cent was reported in wheat flour bread substituted with breadfruit flour (Alice *et al.* 2012). Ariffin *et al.* (2015) also reported similar increase in carbohydrate content i.e. 86.75 per cent in wheat flour bread substituted with durian fruit flour. This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

Table 5.37 Nutritional composition of noodles substituted with dried karonda

Parameters	B1	B2	B3	B4
Moisture (%)	6.61 ± 0.16 [a]	7.44± 0.01 [b] (12.56%)↑	7.65 ± 0.99 [cd] (49.47%)↑	9.88 ± 0.04 [c] (15.73%)↑
Ash(%)	2.00± 0.05 [a]	2.04 ± 0.10 [a] (2.00%)↑	2.11 ± 0.05 [a] (5.50%)↑	2.13 ± 0.00[a] (6.50%) ↑
Carbohydrate (%)	85.53±0.01 [a]	94.58±0.07 [b] (10.58%)↑	103.05±0.05[c] (20.48%)↑	112.56±0.05 [cd] (31.60%)↑
Protein (%)	6.51±0.11 [a]	6.79±0.08 [b] (4.30%)↑	7.10±0.1 [c] (9.06%)↑	7.52±0.08 [cd] (15.51%)↑
Fat (%)	1.56±0.02 [a]	2.20±0.07 [b] (41.02%)↑	2.70±0.39[bc] (73.07%)↑	3.59±0.03 [cd] (130.12%)↑

The protein content of wheat flour noodles substituted with dried karonda ranged from 6.51 per cent to 7.52 per cent. Similar results, i.e. 6.73 per cent was reported by Ho and Latif (2016) in wheat flour cookies. The protein content significantly increase ($p<0.05$) in noodles samples substituted with dried karonda. The protein content increased with increase in dried karonda fruit substitution. Similar increase in protein content i.e. 6.73 to 7.04 per cent was reported in wheat flour cookies substituted with pitaya peel flour (Ho and Latif, 2016). This increase in protein content might be due to high protein content in fruits (Tiwari *et al.* 2011).

The fat content (**Table 5.37**) of wheat flour noodles substituted with dried karonda ranged from 1.56 per cent to 3.59 per cent. Similar results, i.e. 1.56 per cent was reported by Hardi *et al*. (2007) in wheat flour noodles. The fat content significantly increase ($p<0.05$) in noodles samples substituted with dried karonda. The fat content was highest in B4 (3.59 %) and lowest in B1(1.56 %). Similar increase in fat content i.e. 5.20 per cent was reported in wheat flour noodles substituted with banana peel (Singh *et al.* 2015). This increase in fat content may be due to relative increase of fat content in fruits (Vinod *et al*. 2015).

5.11 (b) Dietary fiber

The neutral detergent fiber (**Table 5.38**) of wheat flour noodles substituted with dried karonda ranged from 21.93 per cent to 25.16 per cent. NDF increased non significantly ($p>0.05$) in noodles substituted with dried karonda. The NDF was highest in B4 (25.16 %) and lowest in B1 (21.93 %). Similar increase in dietary fiber i.e. 24.2 per cent was reported in wheat flour noodles substituted with watermelon rind powder (Ho and Dahri, 2016). This increase in dietary fiber might be due to high dietary fiber in fruits (Vinod *et al*. 2015).

Table 5.38 Dietary fiber of noodles substituted with dried karonda

Parameters	B1	B2	B3	B4
NDF (%)	21.93±1.90 [a]	23.36±1.53 [a] (6.52%)↑	23.70±1.70 [a] (8.07%)↑	25.16±0.77 [a] (14.72%)↑
ADF (%)	1.53±0.05 [a]	1.63±0.11 [a] (6.53 %)↑	1.70±0.20 [a] (11.11%)↑	1.83±0.11 [a] (19.60%)↑
Hemicellulose (%)	21.4±4.35 [a]	21.73±0.00 [a] (1.54%)↑	23.00±0.00 [a] (7.47%)↑	24.33±0.00 [a] (13.69%)↑
Cellulose (%)	3.14±0.18 [a]	3.18±0.22 [a] (1.27%)↑	3.20±0.02 [a] (1.91%)↑	3.23±0.00 [a] (2.86%)↑
Lignin (%)	1.46±0.05 [a]	1.56±0.05 [a] (6.84%)↑	1.63±0.05 [ab] (11.64 %)↑	1.76±0.05 [b] (20.54 %)↑

The acid detergent fiber (ADF) of wheat flour noodles substituted with dried karonda ranged from 1.53 per cent to 1.83 per cent. The ADF non significantly increase ($p>0.05$) in ADF was observed in noodles samples substituted with dried karonda. The ADF increased with increase in dried karonda fruit substitution.

Hemicellulose content (**Table 5.20**) of wheat flour noodles substituted with dried karonda ranged from 21.40 per cent to 24.33 per cent. Hemicellulose content increased non significantly ($p>0.05$) in noodles substituted with dried karonda. The hemicellulose content was highest in B4 (24.33%) and lowest in B1 (21.40 %).

The cellulose content of wheat flour noodles substituted with dried karonda ranged from 3.14 per cent to 3.23 per cent. The cellulose content non significantly increase ($p>0.05$) in noodles samples substituted with dried karonda. The cellulose content increased with increase in dried karonda fruit substitution. This increase in dietary fiber might be due to addition of dietary fiber rich fruits (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.38**) of wheat flour noodles substituted with dried karonda ranged from 1.46 per cent to 1.76 per cent. Similar results, i.e. 1.08 per cent was reported by Gorecka *et al.* (2010) in wheat flour cookies. The results of the lignin content increased significantly ($p<0.05$) in noodles samples substituted with dried karonda. The lignin content was highest in B4 (0.76 %) and lowest in B1(0.46 %). Similar increase in dietary fiber i.e. 0.75 per cent was reported in wheat flour biscuits substituted with jackfruit powder (Butool and Butool, 2013).

5.11 (c) Mineral composition

The calcium content (**Table 5.39**) of wheat flour noodles substituted with dried karonda ranged from 18.96 mg/100gm to 22.67 mg/100gm. In control it was only 18.96 mg/100gm increased significantly with more replacement of dried karonda fruit. Maximum value of calcium content i.e. 22.67 mg/100gm was noted in B4. Similar increase in calcium content i.e. 20.40 per cent was reported in wheat flour cake substituted with doum fruit powder. This increase in calcium content might be due to high mineral content in fruits (Niemen *et al*. 1992).

Table 5.39 Mineral composition of noodles substituted with dried karonda

Parameters	B1	B2	B3	B4
Calcium (mg/100gm)	18.96±0.00 [a]	19.71±0.00 [b] (3.95%)↑	22.19±0.00 [c] (17.03%)↑	22.67±0.00 [cd] (19.56%)↑
Iron (mg/100gm)	10.92±0.00 [a]	16.04±0.00 [b] (11.11%)↑	19.88±0.00 [cd] (33.33%)↑	23.80±0.00 [b] (77.77%)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	344.83±0.00 [cd] (9.09%)↑	423.54±0.00 [c] (36.36%)↑	513.20±0.00 [b] (45.45%)↑

The iron content of wheat flour noodles substituted with dried karonda ranged from 10.92 mg/100gm to 23.80 mg/100gm. The iron content significantly increase ($p<0.05$) in noodles samples substituted with dried karonda. The iron content increased with increase in dried karonda fruit substitution.

The phosphorus content (**Table 5.39**) of wheat flour noodles substituted with dried karonda ranged from 324.1 mg/100gm to 513.20 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in noodles samples substituted with dried karonda. The phosphorus content was highest in B4 (0.16 mg/100gm) and lowest in B1(0.11 mg/100gm). Similar increase in phosphorus content i.e. 467 per cent was reported in wheat flour cakes substituted with beetroot powder (Pinki and Awasthi, 2014).

Fig. 5.19 B1 (control sample = 100% wheat flour noodles, B2 =15 % karonda, B3 =30% karonda, B4 =45 % karonda)

5.12 Nugget

5.12 (a) Nutritional composition

The moisture content (Table 5.40) of green gram nugget substituted with dried karonda ranged from 19.68 per cent to 21.83 per cent. In control it was only 19.68 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of moisture content i.e. 21.83 per cent was noted in B4. Similar increase in moisture content i.e. 22.98 per cent was reported in composite pulse flour chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in moisture content might be due to high moisture content in fruits (Raj and Masih, 2014).

Table 5.40 Nutritional composition of nugget substituted with dried karonda

Parameters	B1	B2	B3	B4
Moisture (%)	19.68±0.09 ^{ac}	19.80±0.1 ^{a} (0.60%)↑	20.66±0.05 ^{b} (4.97%)↑	21.83±0.00 ^{c} (10.92%)↑
Ash (%)	1.10±0.05 ^{a}	1.13±0.10 ^{a} (2.72 %)↑	1.16±0.05 ^{a} (5.45 %)↑	1.19±0.05 ^{a} (8.18 %)↑
Carbohydrate (%)	65.64±0.22 ^{a}	74.53±0.40 ^{b} (13.54%)↑	82.99±0.24 ^{c} (26.43%)↑	93.30±1.04 ^{cd} (42.13%)↑
Protein (%)	13.34±0.08 ^{a}	14.00±0.1 ^{b} (4.94%)↑	14.10±0.1 ^{bc} (5.69%)↑	14.37±0.12 ^{cd} (7.72%)↑
Fat (%)	1.85±2.71 ^{a}	2.74±0.05 ^{b} (48.10%)↑	3.31±0.24 ^{c} (78.91%)↑	3.96±0.30 ^{cd} (114.05%)↑

The ash content of green gram nugget substituted with dried karonda ranged from 1.10 per cent to 1.19 per cent. Similar results, i.e. 1.64 per cent was reported by Sharma and Chopra (2015) in nugget. The ash content non significantly increase ($p>0.05$) in nugget samples substituted with dried karonda. The ash content increased with increase in dried karonda fruit substitution. Similar increase in ash content i.e. 0.76 to 2.30 per cent was reported in green gram

dal substituted with bathua leaves (Singh *et al.* 2007). This increase in ash content might be due to high ash content in fruit (Babiker, 2013).

The carbohydrate content (**Table 5.40**) of green gram nugget substituted with dried karonda ranged from 65.64 per cent to 93.30 per cent. Similar results, i.e. 65.50 per cent was reported by Aziz *et al*. (2012) in nugget. In control it was only 65.64 per cent increased significantly with more replacement of dried karonda fruit. Maximum value of carbohydrate content i.e. 93.30 per cent was noted in B4. Similar increase in carbohydrate content i.e. 70.72 per cent was reported in bengal gram dal substituted with kondhara leaves (Singh *et al.* 2014). This increase in carbohydrate content may be due to high carbohydrate content in fruits (Raj and Masih, 2014).

The protein content of green gram nugget substituted with dried karonda ranged from 13.34 per cent to 14.37 per cent. Similar results, i.e. 12.86 per cent was reported by Singh and Sharma (2003) in bengalgram roll. The protein content significantly increase ($p<0.05$) in nugget samples substituted with dried karonda. The protein content increased with increase in dried karonda fruit substitution. Similar increase in protein content i.e. 11.48 to 30.44 per cent was reported in bengal gram dal substituted with kondhara leaves (Sultana *et al.* 2014). This increase in protein content might be due to high protein content in fruits (Waghray *et al.* 2011).

The fat content (**Table 5.40**) of green gram nugget substituted with dried karonda ranged from 1.85 per cent to 3.96 per cent. Similar results, i.e. 1.30 per cent was reported by Pardeshi *et al*. (2013) in nugget. The fat content significantly increase ($p<0.05$) in fat content was observed in nugget samples substituted with dried karonda. The fat content was highest in B4 (3.96%) and lowest in B1(1.85 %). Similar increase in fat content i.e. 1.28 per cent was reported in gram flour based chapatti substituted with jack fruit seed (Sultana *et al.* 2014). This increase in fat content may be due to high fat content in fruits (Vinod *et al*. 2015).

5.12 (b) Dietary fiber

The neutral detergent fiber (**Table 5.41**) of green gram nugget substituted with dried karonda ranged from 23.56 per cent to 25.30 per cent. NDF increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The NDF was highest in B4 (25.30 %) and lowest in B1 (23.56 %). This increase in dietary fiber might be due to high dietary fiber in fruits (Choo and Aziz, 2010).

Table 5.41 Dietary fiber of nugget substituted with dried karonda

Parameters	B1	B2	B3	B4
NDF (%)	23.56±0.11 [a]	23.93±0.32 [a] (1.57%)↑	24.30±0.95 [a] (3.14%)↑	25.30±0.86 [ab] (7.38%)↑
ADF (%)	21.06±0.92 [a]	21.73±0.23 [a] (3.18%)↑	21.76±1.85 [a] (3.32%)↑	22.63±1.45 [a] (7.45%)↑
Hemicellulose (%)	1.97±0.00 [a]	2.20±0.00 [b] (11.67%)↑	2.33±0.00 [c] (18.27%)↑	2.54±0.00 [cd] (28.93%)↑
Cellulose (%)	11.88±0.65 [a]	12.23±0.00 [a] (2.94%)↑	12.67±0.58 [a] (6.64%)↑	12.97±0.63 [a] (9.17%)↑
Lignin (%)	1.68±0.00 [a]	1.72±0.01 [a] (1.17%)↑	1.73±0.01 [a] (1.76%)↑	1.74±0.01 [ab] (2.35%)↑

The acid detergent fiber (ADF) of nugget substituted with dried karonda ranged from 21.06 per cent to 22.63 per cent. The ADF increased non significantly ($p>0.05$) in nugget samples substituted with dried karonda. The ADF increased with increase in dried karonda fruit substitution.

Hemicellulose content (**Table 5.41**) of nugget ranged from 1.97 per cent to 2.54 per cent. Hemicellulose content increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The hemicellulose content was highest in B4 (2.54 %) and lowest in B1(1.97

%). Similar increase in hemicellulose content i.e. 0.25 to 5.75 per cent was reported in dietary fiber in bengal gram dal substituted with kondhara leaves (Singh *et al.* 2014). Singh *et al.* (2007) also reported similar increase i.e. 0.38 to 0.51 per cent in green gram dal substituted with bathua leaves.

The cellulose content of nugget ranged from 11.88 per cent to 12.97 per cent. The cellulose content non significantly increase ($p>0.05$) in all nugget samples substituted with dried karonda. The cellulose content increased with increase in dried karonda fruit substitution. This increase in dietary fiber might be due to presence of high dietary fiber in fruits (Thorvaldsen and Skjoldebrand, 1998).

The lignin content (**Table 5.41**) of nugget ranged from 1.68 per cent to 1.74 per cent. The results of the lignin content increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The lignin content was highest in B4 (1.74 %) and lowest in B1(1.68 %). Similar increase in lignin content i.e. 1.28 per cent was reported in besan laddu substituted with mushroom powder (Verma and Singh, 2014).

5.12 (c) Mineral composition

The calcium content (**Table 5.42**) of nugget ranged from 146.79 mg/100gm to 204.41 mg/100gm. In control it was only 146.79 mg/100gm increased significantly with more replacement of dried karonda fruit. Maximum value of calcium content i.e. 204.41 mg/100gm was noted in B4. Similar increase in calcium content i.e.116.93 per cent was reported in legume based pan cake (thalipeeth) substituted with shepu dried greens (Gupta and Prakash, 2011).

The iron content of nugget ranged from 10.92 mg/100gm to 13.31mg/100gm. The iron content significantly increase ($p<0.05$) in nugget samples substituted with dried karonda. The iron content increased with increase in dried karonda fruit substitution. Similar increase in iron content i.e. 3.90 to 8.99 per cent was reported in legume composite flour thalipeeth (pan cake like product) substituted with green leafy vegetables (Gupta and Prakash, 2011). Singh *et al.*(2014) also reported similar increase in iron content i.e. 7.25 to 28.77 per cent in bengal gram dal substituted with kondhara leaves .

Table 5.42 Mineral composition of nugget substituted with dried karonda

Parameters	B1	B2	B3	B4
Calcium (mg/100gm)	146.79± 0.00 [a]	148.16±0.00 [b] (0.93%)↑	172.97±0.00 [c] (16.74%)↑	204.41±0.00 [cd] (39.25%)↑
Iron (mg/100gm)	10.92±0.00 [a]	11.33±0.00 [b] (3.75%)↑	12.07±0.00 [c] (210.53%)↑	13.31±0.00 [cd] (21.88%)↑
Phosphorus (mg/100gm)	324.1±0.00 [a]	422.81±0.00 [b] (30.45%)↑	468.62±0.00 [c] (44.59%)↑	517.43±0.00 [cd] (59.65%)↑

The phosphorus content (**Table 5.42**) of nugget ranged from 324.1 mg/100gm to 517.43 mg/100gm. The results of the phosphorus content increased significantly ($p<0.05$) in nugget samples substituted with dried karonda. The phosphorus content was highest in B4 (517.43 mg/100gm) and lowest in B1(324.1 mg/100gm). Similar increase in phosphorus content i.e. 320 to 378 per cent was reported in gram composite flour roti substituted with methi powder (Kadam *et al*.2012).

Fig. 5.20 B1 (control sample) = 100% green gram nugget,

B2 =15 % karonda, B3 =30% karonda, B4 =45 % karonda)

2. REVIEW OF LITERATURE

A review of the literature related to different aspects of the present thesis is presented in this chapter. This includes the importance of underutilized fruits, fig and karonda fruit characteristics (morphological, nutritional and phytochemical), value added products development, experimental designs and influence of processing methods on selected fruits are also discussed.

Importance of fruits

Fruits are known as protective foods (Nicoli *et al.*, 1999). According to the Recommended Dietary Allowances (RDA), the consumption of fruits may increased in our daily diet. World Health Organization (2003) reported that fruits are richest source of dietary fiber, antioxidants and phytochemicals. As underutilized fruits contained folic acid, dietary fiber, proteins, vitamins, carbohydrate, minerals (Nandal and Bhardwaj, 2014) and contributed to control many chronic diseases of ageing (Pandey *et al*., 2014). Its increased fruit consumption has been recommended for the primary prevention of many diseases. Underutilized food crops are lesser known plant species in terms of marketing and research (Thakur, 2014). Underutilized crops are contributed 3.14 per cent of the total geographical area (Rai *et al*., 2005). According to Indian Government Economics statistics the area and production data for the underutilized crops was estimated 25.67 million ha and 43.05 tons in 2013-2014 (Ahmad and Raj, 2012). Today, consumers are becoming more conscious for their health and nutrition. Underutilized fruits are proved beneficial, therapeutically and nutritionally to satisfied consumers demand (Gajana and Godwa, 2010) and played very important role to control many diseases (Gajanana *et al*., 2010). These fruits are contributed great role to supplement human diet also (Vazhacharickal *et al*., 2015). Some fruits, which are at present underutilized and poorly addressed by the researcher (Gajanana *et al*., 2010) and needs to be acknowledged, employed and explored today's for future generation (Padulosi, 2008).

2.2 *FICUS CARICA* (FIG)

Fig characteristics (Morphological, nutritional and phytochemical)

Ficus carica is commonly known as "Fig "(Jander and Machado, 2008). Fruit has different colour (green, brown and purple) and contained numerous seed from 30-1600 per fruit bound with jelly like flesh (Joseph and Raj, 2011). It is a deciduous and cultivated fruit tree which belonging to Moraceae family. It is 50 feet tall and cultivated in Southwest Asia, India commercially only in some centres near Pune (Maharastra) and Anantpur district (South India). Mostly it is grown in Uttar Pradesh, Mysore, Punjab and Himachal Pradesh (The Wealth of India, 2001) ; (Tous and Ferguson,1996). It is richest source of mineral elements, calcium and fiber content (Vinson, 1999). Fig fruits are very nutritious and mainly used to made food products (Guesmi *et al.*,2006). It can be consumed in dried and as well as in preserved forms (Neal, 1965) because of limited intake due to seasonal availability, market accessibility and shelf life (Schmidt *et al.*, 2005). Dried fig could be stored for 6-8 months (Venkatartnam, 1988).

According to United States Department of Agriculture (USDA) dried figs are rich in fiber content and potassium content (Gilani *et al*., 2008) and also contained high quality of calcium (Vinson *et al.,* 2005). It contained total carbohydrate (24.27 mg/100gm), protein content (1.27 mg/100gm), calcium content (44.00 mg/100gm); (Zaenuri *et al.*,2014), iron content (4.09 mg/100gm) and potassium content (194 mg/100gm) in fresh fig fruit, respectively (Morton,1987). Fig fruits are fat as well as sodium free and cholesterol free (Vinson *et al*., 2005; Lianju *et al.*,2003). Dried fig contained higher polyphenol content and it is considered as functional foods (Solomon *et al.,* 2006; Vinson *et al.*,2005). It contained moderately higher content of crude fiber (5.8 %) and more than (28 %) of it is soluble type, which has been supported to control blood sugar (Sadhu,1990). *Ficus carica* have an antioxidant effect, which act as antibacterial, hypoglycemic effect, anti cancerous effect and hypotriglyceridaemic effects etc. (Wang *et al*., 2004). For that reason, it is consumed as fresh, dried and in the preserved form also (Mehraj *et al*., 2013).

In morphological characteristics of fig (*Ficus carica L.)*; Darjazi *et al.* (2011) showed that fresh fig fruit has (8.0 to 43.5 gm/100gm) weight and (21 to 45mm) diameter. Shobaki *et al.*

(2010) reported 82.20 per cent-moisture content, 0.65 per cent-ash content, 12.90 per cent-carbohydrate content, 1.00 per cent - protein content, 1.70 per cent- fat content and 1.55 per cent-fiber content in fig fruit. Similarly Khan *et al*. (2011) mentioned the nutritional composition of local variety of Pakistan fig contained 1.90 g/ 100 gm-ash content, 78.84mg/100gm- calcium content and 5.95 mg/100gm-iron content. Bhogaonkar *et al*. (2014) studied the nutritional potential of fresh *Ficus carica L*. fruits and reported 88.1 gm/100gm- moisture content, 1.3 gm/100gm- protein content, 0.2 gm/100gm-fat content,7.6 gm/100gm- carbohydrate content, 80 mg/100gm- calcium content, 30 mg/100gm- phosphorus content and 1.0 mg/100gm-iron content. Aljane *et al*. (2007) evaluated the atomic absorption analysis of mineral salts in fresh *Ficus carica* (Tunisian cultivars) and mentioned (304.57 mg/100gm) calcium content.

Solomon *et al*. (2006) mentioned that edible portion of fig contained 21.5 mg/100gm-flavonoids content and 11.0 mg/100gm – anthocyanins content. Duenas *et al*. (2008) reported *Ficus carica* fruit skin contained (97 µg/100gm) and pulp (15 µg/100gm) anthocyanin content.

Value added product development

Fruits are perishable in nature (Pathak *et al*., 2009), have short life span (7-10 days of post harvest life); (Sozzi *et al.,* 2005) and it affects the storage ability, physiological, nutritional and chemical properties of fruits (Orsat *et al.,*2006). Some fruits are astringent in taste and accepted less. Nowadays, these fruits are commonly used to prepared value added products, which improves nutritional value and acceptance level of the products (Goyal *et al.,* 2008; Singh *et al*.,2009). However, given studies have shown that the formation of innovative value added product with the incorporation of fruits. Khapre and Satwadhar, (2010) estimated the physico-chemical characteristics of *Ficus carica* fruit cv. DINKAR and its cabinet dried powder. Result showed fig fruit which was dried in a cabinet at temperature 60 °C (20-24 hours) contained 15.41 gm/100gm – fiber content, 22 gm/100gm – potassium and utilized in various value added products viz., icecream, milk shake, burfi and toffee. Chauhan *et al.* (2010) determined the development of food products incorporated with dried fig powder. Five products *viz., Idli, Biryani,* cake, *Gujiya* and *Ladoo* were prepared with the incorporation of *5* per cent, 10 per cent and 15 per cent dried fig powder. Results revealed that in case of sensory attributes, all the products which were incorporated by fig powder were accepted well. Khapre *et al.* (2011)

studied the development of technology for the preparation of *Ficus carica* fruit powder and its utilization in toffee. Fresh sample of Dinkar variety of figs were dried at temperature 60 °C in a cabinet drier for 20–24 hours. The products were prepared by processing of figs *viz.* fig powder and fig toffee. Sakhale *et al.* (2012) evaluated the consistency of fig- mango mixed toffee preparation process. In this study, mango and fig pulp was used in different proportions to prepare mixed toffee. In result, they mentioned that the toffee (80:20) proportions which made with the substitution of fig and mango pulp reported better organoleptic evaluation. Mhalaskar *et al.* (2012) studied the development of technology for fortification of fig (*Ficus carica*) fruit into its value added product- fig toffee. It was prepared with the incorporation of ground fig pulp and other ingredients (liquid glucose, sucrose, edible fat and skim milk powder) were added in suitable amounts. The fig pulp was incorporated with soy protein isolate, ragi powder, papaya pulp and mixture was heated in a cabinet drier for 2 hours at 60 °C temperature. Result showed that the products prepared by the incorporation of figs *viz.*, fig toffees were assessed and found rich in their physico-chemical and sensory parameters. Reddy *et al.* (2014) studied the utilization of an underexploited fruit fig as a preserved product. They studied the process for the preparation of preserved product jam from fig by using pectin source from apple. They found that fig fruit contained calcium, iron, and low fat content and high amount of fiber content. Due to its high nutritional value it was considered to preserve the fruit by preparing jam with many textures, flavors and colours. In this study, fig jam was developed and the quality parameters were assessed. Mule *et al.* (2014) described the preparation, proximate composition and sensory evaluation of buffalo milk shake was incorporated with dried fig fruit with proportion of 5 per cent, 7.5 per cent and 10 per cent. In result, proximate composition of 10 per cent fig contained 4.52 per cent - protein content and 12.78 per cent - sugar content as compared to 5 per cent and 7.5 per cent fig. Result revealed that the overall acceptability score (8.3) was the highest in the sample with 7.5 per cent fig and milk shake prepared from buffalo milk with the incorporation of 5 per cent. *Ficus carica* was more consumer-friendly than buffalo milk shake (control) due to its high nutritive value and better sensory attributes. Tanwar *et al*. (2014) studied the effect of different processing methods on fig product (physicochemical, nutritional and phytochemical composition). They mentioned that processing of fig fruit pulp into jam and nector was resulted to increase the carbohydrates content. Verma and Gupta, (2015) studied the estimation of

phytochemical, nutritional and antioxidant activity of figs (*Ficus religiosa*) and formulated value added product (Hard Candy). Result showed that fig was used for the preparation of hard boiled candies was made with the incorporation of glucose syrup and lemon juice with dried powder of fig incorporated with flavoring and coloring agents. In sensory evaluation, it showed very good acceptability by the panelists. Khapre *et al.* (2015) studies the standardization of *Ficus carica* powder enriched cookies and its composition. In this study fig powder was incorporated in cookies at 0,6,12 and 18 per cent level for nutritional and sensory evaluation. Result showed that cookies were incorporated with 12 per cent fig powder showed that 3.1 per cent- dietary fiber, 6.9 per cent- protein content, 1.1per cent- potassium content and organoleptically accepted well.

Experimental design

Ficus carica have an antioxidant effect, which act as antibacterial, hypoglycemic effect, anti cancerous effect and hypotriglyceridaemic effects etc. (Wang *et al*., 2004). They are used as a source of traditional medicine (Jain *et al.*, 2013) to cure many health problems (Mahapatra *et al.*, 2012). The reports of different studies have shown that therapeutical used of fruits. Perez *et al.* (2000) studied the hypoglycemic effect of fig leaves to control sugar levels in rats and observed for 3 weeks. They selected four groups and each groups contained 13 rats. Result revealed that given aqueous extract was decreased the sugar levels in diabetic rats as compared to other groups. In conclusion, fig leaves proved beneficial for hypoglycemic effect. Shobaki *et al*. (2010) studied the effect of different level of fig leaves on diabetic rats. In this forty eight male rats were divided into two groups. Group first contained (n=6) which was fed on basal diet. Second group (n=46) was injected with 150 mg/kg body weight alloxan to induce hyperglycemia and further divided into seven equal subgroups. One subgroup (n=6) was fed on basal diet and other six subgroups (1-3) were fed on basal diet contained (5%,10%, 20%) levels of *Ficus carica* leaves groups (4-6) were also fed on basal diet contained (4%, 6%, 8%) levels of *Ficus carica* leaves, respectively. Result revealed that Ficus *carica* leaves act as antidiabetic effect. Choudhary *et al*. (2011) studied *Ficus religiosa* Linn effect on diabetes. In this study, the ethanolic extract of fruits was orally given to diabetic and normal rats. They measured of their blood glucose lowering activity. Rats were treated with higher dosages of 250 mg and lower dose of 100 mg according to body weight of rats. Result reported that ethanolic extract of fruits with

higher dose was proved effective for antidiabetic activity as compared to lower dose and showed no effect on the normal rats. Rashidi and Noureddini, (2011) studied the effect fig leaves on sugar levels of diabetic rats. Result showed that diabetic rats that were administered with 0.4 mg/dl of extract proved effective to decrease the blood glucose levels. Statin *et al.* (2012) studied effect of fig extract to control diabetes in diabetic rats. They administered methanolic *Ficus carica* extract dose of 100 mg and dose of 200 mg according to body weight of rats. In result, dose of 200 mg reduced more diabetes as compared to dose of 100 mg. Results indicated that, dose of fig proved to be very effective for antidiabetic activity. Ahmad *et al*. (2013) studied the effect of stem bark of fig to control diabetes. They administered orally prepared extract to diabetic induced rats. Study, concluded that stem bark showed effective results to control diabetes. Kanuur *et al.* (2014) found dried Ficus *carica* fruits were subjected to extraction using (90 %) ethanol and this extract was further evaluated for the adaptogenic activity in rats. In this study, they were analyzed sugar levels. In results, Ficus *carica* extract treated rats were proved effective to reduce sugar levels and act as antidiabetic activity. Ibrahmin *et al*. (2014) determined the effect of fig leaves to control diabetes in rabbits. They selected diabetic rabbits for the study. They have been started to given different selected dosages after seven days of alloxan injection and observed for 6 weeks. They had given 0.3gm fig leaves prepared extract to rats according to their body weight. Study concluded that, *Ficus carica* leaves aqueous extract proved very effective for the reduction of glucose level. It showed better effect by supplementing with insulin to cure diabetes. Jayakumar *et al*. (2014) studied the effect of leaves of *Ficus carica* to control diabetes. In this study, extract was orally given to diabetic rats with selected dosages 200 mg and 400 mg according to body weight of rats. Result mentioned that *Ficus carica* leaves extract proved beneficial to control over polyphagia.

2.3 *CARISSA SPINARUM (*KARONDA)

Karonda characteristics (Morphological, nutritional and phytochemical)

Carissa spinarum is an erect thorny shrub with forked branches (light brown to green colour) usually about 2-3 meter height. Fruits (ovoid berry) are blue in colour, 9 mm in length and 6mm in diameter. Seed has black colour, 5-6 mm in length and 4 mm in diameter (Fatima *et al.*, 2013). Karonda has 1.08 cm-length, 219.6 mg-fresh weight, 2.53 per cent- ash content, 16.0 per cent-

protein content and 16.0 per cent- calcium content (Mishra and Gupta, 2005). *Carissa spinarum* is proved to be an important source of nutrition for the poor people. It contained 73.2 per cent-moisture content, 12.43 per cent-carbohydrate, 3.64 per cent- protein content and 0.72 per cent-phenolic content (Mahapatra *et al.,* 2012). Fresh riped fruit contained (0.73g GAE/100gm) phenolic content, (2118 µM AEAC/g dry wt.) ferric reducing power assay and (1013 mg AEAC/100g dry wt.) DPPH antioxidant activity on dry basis as milligram of ascorbic acid equivalent per 100 grams of sample (Nayak and Basak, 2015).

Value added product development

Value added products played very important role to improve nutritional value and acceptance level of the products (Singh *et al*., 2009). Mentioned studies are explained the formation of many innovative value added products. Hanwate (2005) studied extracted *Carissa caranda* juice at different per cent level of milk along with suitable stabilizer gelatin (0.5%) were added. Result revealed that according to 9 point hedonic scale *Carissa caranda* 10 per cent juice and 7.5 per cent sugar were produced the flavoured milk which was accepted with the highest score of 7.60 amongst the nine different combinations. It was highly accepted in flavoured milk prepared with the use of 10 per cent *Carissa caranda* juice and 7.5 per cent sugar along with 0.5 per cent gelatin on the basis of overall acceptability. Yadav *et al*. (2005) explored the feasibility of the incorporation *Carissa caranda* pulp used as natural flavouring agent in ice-cream. In this study, (0%), (10%), (20%) and (30%) selected fruit pulp was used to prepared for different types of ice-cream. The sample which made with the incorporation of (20%) pulp had contained highest rating (49.15%) and overall acceptability was (7.515) as compared to control and other treatments. Result showed that the incorporation of fruit pulp in ice-cream as natural flavouring agent at 20 per cent was proved to be most desirable and acceptable. Wani *et al.* (2013) studied the shelf life of Karonda jams (*Carissa caranda*) under ambient temperature. The study was based on the variations of sugar and the 5 levels of addition of sugar (850 gm, 950gm, 1050 gm,1150 gm and 1250 gm) were mixed with 1.0 kg of fruit pulp .They were known as 1, 2, 3, 4 and 5 treatment, respectively to obtained data and analyzed it. Result showed that treatment 4 (1150 gm sugar) possessed an ideal value of moisture content, ascorbic acid and overall acceptability. Study concluded that treatment 4th was the best as compared to other treatment in

case of physical, chemical and sensory parameters of jam. Shaheel *et al*. (2015) evaluated the effect of blending of karonda (*Carissa caranda*) juice incorporated with guava, papaya and pineapple juice on its quality and organoleptic evaluation. They evaluated their physico-chemical properties and organoleptic evaluation. They incorporated 25 per cent karonda juice with 75 per cent pineapple juice. Result revealed that it was contained 10.35 per cent- total sugar, 6.96 per cent- reducing sugars and 7.42 - organoleptic score was followed by 50 per cent karonda juice with 50 per cent guava juice of 7.18.

2.3 (e) Experimental designs

Fruits are nutritionally beneficial for the people and play an important role to improve human health (Williams *et al*., 2002). Given studies are well explained, the effects of fruits effects to control diseases. Swami *et al.* (2010) studied *Carissa caranda* effect on diabetic rats. Different dosages (250, 500 and 1000 mg) were selected according to body weight of rats and given orally to rats for the examination of glucose level. The 500 mg and 1000 mg of extract was proved to be very effective to decrease the blood glucose levels after 4 hours, 8 hours and 24 hours in normoglycemic rats as compared to 250 mg/kg extract. In result it revealed that doses of extract proved beneficial to control sugar. Itankar *et al.* (2011) evaluated the unripe *Carissa caranda* fruits effect to control diabetes. They studied the effect of selected fruit effect in alloxan induced diabetic rats. In this study, 400mg according to body weight of rat's drug was orally given to diabetic rats. After that it was observed for 24 hours and decreased the blood glucose levels by 48 per cent and 64.5 per cent. Rahman *et al*. (2011) studied the antihyperglycemic effect of *Carissa caranda L*. leaves in swiss albino mice. Selected extract was administered orally to glucose-loaded mice at dosages 50 mg, 100 mg and 400 mg according to body weight of rats. Result revealed that serum glucose levels were found to be reduced by 15.6 per cent, 17.8 per cent, 20.0 per cent and 47.8 per cent. Present study, concluded that selected methanolic extract was proved very effective to diminished the glucose parameters and act as antidiabetic drug. Fatima *et al.* (2013) examined the effect of *Carissa spinarum* leaves to control sugar levels in alloxan-induced diabetic rats. The extract was given orally at dosages 200,400 and 600 according to body weight of rats. Result revealed that extract at higher dose was proved to be effective than lower dosages.

Influence of processing methods on fruits

Fresh fruits are classified as perishable commodities due to presence of higher moisture content (Orsat *et al.* 2006). Locally available fruits are very cheap, fresh but have short life span. Therefore, processing methods are used to enhance their shelf life. Nowadays, perishable crops are dried in the world (Grabowski *et al.* 2003).

Sun drying

Drying is a technique which is used mainly to dry agricultural products, storage and to extend shelf life. Drying method proved to be one of the oldest method for food preservation (Papu *et al.* 2014). The reports of different studies have shown the influence of drying on nutritional and phytochemical composition of fruits. Farsi *et al.* (2005) studied the comparison of fresh and dried date was grown in Oman for the phenolic content. Selected fruit sample was sun dried at temperature 50°C for 7-10 days. Result showed that after drying process phenolic content was increased and proved that sun dried dates have higher phenolic content as compared to fresh sample. Similar result were reported by Jung *et al*. (2005) for fresh and dried persimmon fruits for their phytochemicals and the antioxidant compounds. Result concluded that dried fruit contained higher amount of bioactive compounds as compared to fresh. Noutchogoue *et al*. (2005) studied the biochemical changes related to hardening phenomenon in Aiele fruit (*Canarium schweinfurthii Eng)*. Sample was collected from West Cameroon and kept for 7 days for the storage, given heat treatment at 45°C temperature for 40 minutes, 70°C for 40 minutes and room temperature at 22°C for a period of 7 days and fourth group was raw fruits. Result revealed that after storage and heating treatment was responsible to increase the lignin content and cellulose content as compared to controlled sample. Xu *et al*. (2007) evaluated the effect of heat treated citrus peel extract for their phenolic compounds and antioxidant capacity. Huyou fresh fruit sample was selected from a farm in China and dried by hot air at temperature 45 °C for 48 hours. After that it was again, oven dried at temperature 120 °C for 60 minutes and 90 minutes. Result revealed that there was found enhancement in antioxidant capacity and phenolic content. Dangcham *et al*. (2008) studied temperature effect on lignin content of mangosteen fruit (red-brown stage) at low storage temperature. Sample was collected from Thailand and stored at temperature 6 °C and 12 °C for 12 days. Result reported that lignin content was increased from

0.57 to 0.725 g/100kg and 0.587 to 0.643 g/100kg at storage temperature 6 °C and 12 °C from 0 to 12 days. Monica *et al*. (2009) evaluated the antioxidant activity of heat treated apricots. Selected sample was air dried at different temperature 55°C and 75°C. In this study they reported higher antioxidant activity at temperature 75°C as compared to 55°C. Wang *et al*. (2009) studied blueberry changes in the phenol and antioxidant capacity by the exposure of ultraviolet light (UV-C). Sample was collected from the orchards in Maryland and illuminated by UV-C device with different UV dosages (6.45 kJ/m^2) at temperature 20°C as compared to control. Result showed that after UV treatment increased phenol from 3.12 to 4.72 mg/100gm and antioxidant capacity from 30.5 to 34.6 µ mol gallic acid equivalent/gm. Patras *et al*. (2010) determined the effect of heat treatment on anthocyanin stability. Thermal processing was responsible for the reduction of anthocyanin pigment and caused major effect on the colour quality due to the presence of some conjugated bond in their structures, which absorbed light at 500 nm , on the basis of red, blue and purple colour in the fruits. In result, study concluded that heating played an important role for the degradation of the anthocyanin pigments. Slatnar *et al.* (2011) studied the impact of fig (*Ficus carica*) drying on the contents of organic acids and phenolic compounds. Selected fruits were processed under sun-drying and oven-drying method. Phenolic compounds of the samples were analyzed three times in a year by using high-performance liquid chromatography. Result mentioned that dried fruits contained higher source of organic acids and phenolic compounds as compared to fresh one. Zivkovic *et al*.(2011) estimated the temperature effect on physical changes in Plum (*Prunus domestica L*.) "Pozegaca variety". In this study selected fruits were dried at temperature 75°C . Result showed that physical characteristics (length and width) was decreased after drying as compared to fresh. Sharifian *et al*.(2012) studied the microwave drying effect on moisture content of fig fruit (*Ficus carica).* In this study weight and temperature of the sample was recorded at regular intervals of 10 seconds to investigate the moisture variation. The result reported that raised the temperature in the microwave proved better removal of the moisture content. Kamiloglu (2012) studied the effect of sun drying on polyphenols and in *vitro* bioavailability of "*Bursa Siyahi"* figs *(Ficus carica L.).* Sample was collected from orchards located in Turkey. Fruits were dried in the sunlight for 8 days at temperature 31°C to 34°C in day time. In this study, they estimated sun drying effect on moisture content, flavonoid content and anthocyanin content. Result revealed

that heating treatment was responsible to reduced the moisture content from 81.4 to 49.7 per cent and also showed reduction in the flavonoid content, anthocyanin content. Mithanka(2012) studied the polyphenol content of *Pseudolachinostylis Maprouneifolia Pax Var* Dikindtii. Fruit sample was selected from a village in Eastern Botswana from a city Gaborone. Fruit sample was sun dried for eight days and used for further analysis. Result showed that phenolic content of sun dried sample was higher (1240.3 mg gallic acid equivalents/l) as compared fresh (838.6 mg gallic acid equivalents/l) and flavonoid content was higher i.e. 159.9 mg quercetin equivalents/l for sun dried sample, 139.1 quercetin equivalents/l for fresh fruit. Amalina *et al*.(2013) evaluated the modification of oil palm mesocarp fiber characteristics using superheated treatment. Sample was collected from Malaysia and dried in the sun light and kept at temperatures 190°C, 210°C and 230°C to analyzed lignin content. Result showed that lignin content of oil palm mesocarp fiber was increased from 28.44 per cent, 45.19 per cent and 49.73 per cent at different temperatures 190°C, 210°C and 230°C. Garcia *et al*. (2013) studied the drying effect on functional properties of (*Ficus carica L.)* var mission. In this study, *Ficus carica* was dried at temperature 45℃ in a thin layer drying equipment for 24 hours. Result revealed that drying process was mainly contributed to increase the phenolic content, antioxidant activity and decreased the anthocyanin content. Moldovan and David, (2014) studied the effect of heat treatment on anthocyanin stability of "Cornelian" cherries. Sample was selected from a local market in Romania and studied its anthocyanin degradation at 2°C temp., 22°C temp. and 75° C temp. Result showed that highest degradation rate of anthocyanin content was at temperature 75°C as compared to 2°C and 22°C. Anantawat (2015) determined the antioxidant activity of gac fruit aril powder by the effect of spray drying condition. Fully riped fruit was used as a sample and dried in a spray dryer at temperature 120°C, 150°C and 170°C. Result revealed that antioxidant activity was increased with increased temperature and ranged from (2758.33, 2797.50 and 2808.33) μg Trolox equivalent/100 gm at temperature 120°C, 150°C and 170°C. Mrabet *et al*.(2015) studied the effect of hydrothermal treatments on date varieties (*Phoenix dactylifera L*.) Garen Gaze. This variety was selected from Southern Tunisia. Dates were treated with direct heating contact at temperature 190°C and analyzed their lignin content and cellulose content. Result showed that increased lignin was 50.38 per cent, 60.80 per cent and cellulose content was 14.36 per cent, 16.34 per cent at temperature 180 °C and 200°C.

Hussain *et al*.(2015) reported the effect of sun drying methods on dates. Sample was selected from Pakistan and dried for 6 to 8 days by direct exposure of sun light during the day time. They analyzed the total phenolic content with their antioxidant activity. Result revealed that, drying process was responsible to increase the total phenolic compounds from 166.80 to 181.50 mg gallic acid equivalent /100 gm and antioxidant activity from 32.35 to 51.31 per cent. Kamiloglu and Capanoglu, (2015) investigated the sun drying effect on anthocyanin content of *Ficus carica.* Samples were collected from Aydin and dried in the sunlight for 8 days at temperature 31 to 34 °C. In result, drying process helped to decrease the anthocyanin content. Sieminska *et al.* (2015) studied the content of phenol and antioxidant activity of wild "Yellow Wonder" strawberry fruits *(Fragaria vesca L.).* Sample was air dried at temperature 40°C till constant weight achieved. They analyzed the content of phenol and antioxidant activity, DPPH (diphenylpicrylhydrazine) in fresh and air died sample. Result revealed that after drying the phenolic content was increased from 1.64 to 4.483 mg/100gm and antioxidant content (DPPH) was also increased from 13.63 to 25.70 per cent.

2.4 (b) Microwave drying

Drying method played very important role for food preservation and to increase the shelf life of the product (Papu *et al.* 2014). Ariffin *et al*. (2000) studied the effect of heat treatment on cellulose content of oil palm empty fruit bunch fiber. Sample was selected from Selangor and dried by using thermal treatment. First sample was dried at temperature 121°C for 15 minutes and another sample was heated at temperature 240°C for 1 hours and 15 minutes. Result reported that heating temperature was responsible to increase the cellulose content. It showed that cellulose content was 51.49 per cent at heating temperature 121°C and increased 54.67 per cent with heating temperature 240°C. Pragati et *al*. (2003) evaluated the heat treatment on nutritional composition of aonla fruit *(Emblica officinalis Garten)* during storage. Fruit samples (riped) were dried by using different methods viz., direct solar and oven drying. Result showed that the level of tannin content was found to be lower in solar drying method (13.60 %) as compared to oven drying method (14.60 %) due to leaching process. Jeong *et al*. (2004) studied the phenolic content and antioxidant activity of citrus peels extract under heat treatment. 5 gm weighed sample was taken in a Pyrex petri dishes and heated at different increased heating temperature in

a pre heated muffle furnace. Result indicated that the antioxidant activities were increased with increased heating temperature. In case of selected sample total phenolic content was also increased from 84.4 to 204.9 mg/100gm and reducing power from 0.27 to 0.96 mg/100gm at temperature 150 °C for 60 min. Study mentioned that heating proved to be a major tool to increase the antioxidant activity. Laleh *et al.* (2006) studied the temperature effect on anthocyanin stability in *Berberis.* Sample was dried in a vacuum evaporator at different heating temperatures. Result reported that anthocyanin content degradation was increased with increased heating temperature. Anthocyanin content loss was observed 41.05 per cent at 5°C temperature, 52.09 per cent at 15°C temperature, 62.33 per cent at 25°C temperature and 89.42 per cent at temperature 35°C. Clary *et al.* (2007) determined the improving grape quality by using microwave vacuum drying. In this study, fresh seedless grapes were dried at temperature 66°C in the microwave. Result showed that microwave dried grapes contained higher nutritional composition. Pacco *et al.* (2007) studied the drying treatment influence on kinetics of 'Gigante de Valinhos' figs. Fig sample was selected from Brazil and dried at temperature 60 °C in an oven for 24 to 48 hours. Result showed that moisture content was decreased from 1.9 to 0.03 per cent with increased temperature and decreased relative humidity. Drying process was caused to increase the apparent density (1.025 to 1.186 gm/ml). Result showed that drying temperature proved effective for the maintance of quality products. Mori *et al*. (2007) studied the loss of anthocyanins in *Vitis vinifera* L. cv. *Cabernet Sauvignon* red- wine grape berries under high temperature. Sample was dried at (15°C, 25°C and 35 °C) temp. in an oven. Result revealed the concentration of anthocyanin (3-glucoside,3-acetylglucoside and3-p-coumaroylglucoside) content was decreased at higher temperature. Anthocyanin content was degraded more at temperature 35 °C as compared to 15°C and 25°C temperature. Data suggested that higher heating temperature was proved effective for the degradation of anthocyanin content due to the inhibition of mRNA transcription of the anthocyanin biosynthetic genes. Elhana (2008) determined microwave drying of apple. In this study, sample was dried in an oven at temperature 100 W and 200W to observe product drying time. Result showed that at 55 per cent of water was removed from the sample at temperature 100W. At 200W, drying constantly increased with the increased microwave output power. Study concluded that 35 per cent drying rate increase with relative increased of density power (W/g). Wojdylo *et al*. (2009) evaluated the influence of

microwaves heat (480 W) on strawberry fruits bioactive compounds. Whole fresh and dried fruits were determined for phenolics (anthocyanins, flavanols and flavonols). Result revealed that heating process affect the ellagic acid, caused degradation of the flavanols and anthocyanins content. Simonyan *et al.* (2009) studied the influence of water content on physical parameters of *Lablab purpureus* (L.) sweet seeds. Sample was oven dried at 130 ^{o}C temperature for 24 hours. They measured the density of the sweet seeds. Result showed that the bulk density was decreased with the improvement of the moisture content. Somsong *et al*. (2010) estimated the influence of preconditioning on dried blueberries. Selected mature fruits were dried at high temperature 70ºC and 90 ºC in a cabinet dryer. Result revealed that the anthocyanin content was decreased by heating process as compared to non heating process i.e. 14.5 mg/100gm-fresh (non heating), 4.9 mg/100gm- dried (at 70ºC) and 6.2 mg/100gm (at 90 ºC) heating temperature. Khanal *et al.* (2010) evaluated the effect of heating on grapes and blueberry pomace fruit anthocyanin content stability. These selected samples were heated in an oven. Result showed reduction in anthocyanin content. In result, total anthocyanin loss was highest at temperature of 105°C, 120°C as compared to temperature 40°C and 60°C. Musto and Satriano, (2010) studied the characteristics of heat- treated strawberry (*Fragaria xananassa*) cv. '*Candonga*' fruits. Selected sample was oven dried at temperature 45°C for 0 hour and 4 hours to analyzed the phenolic content and anthocyanin content. Result revealed that after heat treatment phenolic content was increased from (1.968 to 2.576) mg gallic acid equivalent/100 gm and anthocyanin content was decreased from (0.201 to 0.170) mg of pelargonidin-3-glucoside/ 100gm at temperature 45°C for 0 hour and 4 hours of heating treatment . Akhijahani and Khodaei, (2011) studied some physical properties of strawberry fruit (Kurdistan variety). Sample was selected from a local market in Iran (June, 2010). Fruit sample was oven dried at 75°C temperature for 24 hours. In this study, they determined the physical properties as a function of moisture content. Result revealed that length of the selected fruit was 18.22 mm, 19.54 mm and width was 11.01mm, 13.62 mm at moisture content 24.85 per cent and 66.33 per cent. Study concluded that physical properties (length and width) were improved as the moisture content was increased. Borchani *et al.* (2011) studied the influence of heat treatment on physical and chemical properties of date "Alligh" fiber concentrates. Sample was selected from Tunisia and dried by using sun dried and oven dried method for 48 hours at temperature 40 °C. In this study,

they analyzed the total dietary fiber. Result revealed that drying method contained significantly higher dietary fiber. Cheng (2011) studied the influence of heating treatment on citrus fruit peel phenolic content. They investigated the effects of different drying temperatures in an oven to analyzed the phenolic content and antioxidative activities. Result revealed that at lower temperature (50, 60) °C phenolic content was decreased and at higher temperature (70, 80, 90) °C and 100°C the phenolic content was increased. Jin *et al*. (2011) studied the influence of cultural and temperature on strawberries phenolic compounds and antioxidant activity. In this study, sample was selected from a United States Department of Agriculture (USDA), which was certified organic farm and stored at different temperature in a plastic trays in conventional cultural system. Result revealed that strawberry stored at higher temperature 10°C, had higher antioxidant activity and phenolic content as compared to less storage temperature 0°C and 5°C. Sunmola *et al*. (2011) analyzed the biochemical influence of processing treatment on under-utilized *Carissa papaya* seed. These seeds were dried in oven at temperature 50°C for 48 hours. Result revealed that mature riped fruit seed was contained 1.46 mg/100gm-tannin content and 0.18 mg/100gm- protein content. After processing the tannin content was found to be decreased (1.31 mg/100gm) and protein content was increased (0.41 mg/100gm). Nithiyanantham *et al*. (2012) investigated the differential effects of processing methods on antioxidant activity of species Solanum. Selected samples were dried at temperature 40°C. Result reported that raw fruit was contained 5.3 gm/100gm- tannin content and 7.2 mmol Fe(II) /micromol extract-FRAP (antioxidant activity). After drying tannin content (4.5 gm/100gm) was decreased and antioxidant activity was (28.9 2 mmol Fe (II) /micromol extract, ferric reducing scavenging activity) was increased. Johnson *et al.* (2012) studied the evaluation of anti-nutrient contents of watermelon *Citrullus lanatus.* In this study fresh sample was oven dried at temperature 50°C to measure the phenolic content and flavonoid content. Result revealed that drying process led to increase the phenolic content and decreased the flavonoid content. Sultana *et al*. (2012) analyzed the influence of drying techniques on phenolic content of fruits and their antioxidant activity. Fresh apricot was dried at ambient temperature 30°C for 7 days and oven dried at temperature 80°C for 2 days. Result revealed that after drying the phenolic content and DPPH scavenging capacity was increased from 0.59 to 0.72 gallic acid equivalent gm /100g and 58.7 to 60.8 per cent. Avil *et al*. (2012) studied the effect of different time duration of heat processing on

"Murtanr" berries fruit. Sample was selected from a local market of Poland and lyophilized for 48 hours and dried in an oven at temperature 100°C for different period of time as 10 minutes and 60 minutes. They analyzed the bioactive compounds (flavonoids, tannins and anthocyanins) of berries. Result showed that heat treatment affect the bioactive compounds i.e. flavonoid content was 11.47 mg catechin equivalent/gm and 5.99 47 mg catechin equivalent/gm, tannin content was 8.91 catechin equivalent/gm and 4.94 catechin equivalent/gm, anthocyanin content was 16.7 cyanidin-3-glucoside equivalent/gm and 9.9 cyanidin-3-glucoside equivalent/gm at heating period 10 minutes and 60 minutes. Liu *et al.* (2012) investigated the influence of heating time on citrus fruit (*Citrus sinensis* (L.) by products phenolic content. Sample was selected from Taiwan and orange extract was prepared with heating process. Samples were oven dried at temperature 50 ºC. After 40 hours, the dried by-products were heated again at temperature 100 ºC for (0, 30, 90 and 180) minutes and converted into a fine powder. Phenolic content was (21.65, 24.16, 26.59 and 27.99) mg gallic acid equivalents/100gm at (0, 30, 90 and 180) minutes heating time. Result reported that phenolic content was increased with increased heating temperature. Sharifian *et al.* (2012) reported the effects of microwave heat intensity and pulsing ratio on *Ficus carica* fruit drying process. Weighed sample at regular intervals of ten seconds. Result showed that at pulsing ratio of 1.5 W/g to 4 W/g the drying time of products 200 per cent was increased. And, at pulsing ratio 0.5 W/g to 2.5 W/g the drying time of product 500 per cent was decreased. Study concluded that microwave heat intensity resulted in the raised temperature was responsible for the better removal of moisture content. Wich *et al*. (2012) studied the effect of drying on *Carissa spinarum.* The sample was oven dried at different temperatures in an oven to reach the final moisture content (not more than 5 per cent). Selected fruits were dried at optimum condition, 60°C for 200 minutes. Result revealed that dried *Carissa spinarum* contained highest antioxidant properties and total phenolic content. Lopez *et al.* (2013) estimated the heating effect on phenols and antioxidant activity of goldenberry (*Physalis peruviana* L.). Sample was purchased from Chile and dried at temperature 90 ºC in a convective dryer to analyzed the phenols and antioxidant activity (FRAP). Result showed that heating process increased the phenolic content from 321.05 to 356.68 mg gallic acid/100 gm and antioxidant activity (FRAP) from 99.70 to 109.81 milimoles of Trolox equvivalents/100gm. Irondi *et al*. (2013) evaluated the influence of heat treatment on *Carica papaya* seed

phytochemical composition and antioxidant activities. Fresh sample was collected from Nigeria, June (2012). Sample was dried by two methods. First it was dried for 3 days under direct exposure of sunlight and second was oven dried. Result predicted that oven dried sample led highest phenolic content and antioxidant activity (FRAP) as compared to sun dried sample. Sarkis *et al*. (2013) studied the effects of electric heating on anthocyanin content degradation during the processing of blueberry pulp. Sample was purchased from Italbraz Company (Brazil) and dried by using the selected heating treatment at temperature 60 Hz. The anthocyanin content was studied by using high performance liquid chromatography. Result reported that degradation of anthocyanin content was noticed higher with increased voltage and also showed reduction with decreased voltage. Study, concluded that heating treatment was helped to decrease the anthocyanin content. Kamiloglu *et al.* (2013) estimated the polyphenol composition of black mulberry (*Morus nigra L.).* Sample was selected from a local market in Turkey and converted into fine powder for storage at temperature −80°C. They measured the flavonoid content and anthocyanins content by using Spectrophotometric method. Result showed that after drying flavonoid content and anthocyanin content was decreased from 768.0 to 380 mg catechin equivalent /100gm and 1221.0 to 61.3 mg cyanidin-3-O-glucoside equivalent /100 gm. Candrawinata *et al*. (2014) studied apple pomace fruit for its total phenolic content and antioxidant activity. Apple pomace was selected from a local commercial juice manufacturer (Australia). It was homogenized at temperature (20-90) °C for 5 - 60 minutes. Result revealed that the phenolic content and antioxidant activity was increased with increased heating temperature. Bernard *et al*. (2014) mentioned the influence of heating treatment on phytochemical composition of orange fruit peel. The fruit sample was sun dried at temperature 16.5°C and oven at temperature 50°C. Result reported that orange fruit peel sun dried sample was contained 0.72mg/100gm- tannin content and oven dried sample was contained (0.91 mg/100gm). Alkaloid content of sun dried sample - 0.81 mg/100gm and oven dried sample- 0.99 mg/100gm. Study concluded that tannin and alkaloid content was increased in oven dried sample as compared to sun dried sample. Alfaro *et al*. (2014) evaluated the effects of heating techniques on polyphenol and antioxidant activity of Murtilla (*Ugni molinae* Turcz) fruit. Sample was selected from an Agricultural Research Institute (INIA-Carillanca) and dried by using convective dryer at temperature 65 ºC. Result revealed that after drying the total polyphenolic content and

antioxidant (DPPH) activity was increased from 0.51 to 2.16 mg/100gm and 2111.1 to 3567.41µmol Trolox equivalent /100 g. Anthocyanin content was decreased from 0.106 to 0.012mg cyanidine-3-glucoside equivalent per 100 gram. Ertekin *et al*. (2014) studied the drying of strawberries. Fruit sample was selected from Turkey and oven dried at temperature 60°C, 70°C by infrared radiation (radiator). They evaluated the total phenolic content at different drying temperature. Result revealed that highest amount of total phenolic content of fruit sample were obtained at different drying temperature i.e. 4.44 mg gallic acid equivalent /100 gm – fresh, 11.03mg gallic acid equivalent /100 gm - at 60°C , and 13.96 mg gallic acid equivalent /100 gm - at 70°C temperature. Oancea *et al*. (2014) determined the effect of frozen storage and oven drying on the total anthocyanin content and antioxidant capacity of raspberries. Selected sample was freezed at temperature – 18 °C, oven dried at temperature 60°C. Result revealed that frozen sample was proved to be effective to maintained good anthocyanin content. In case of anthocyanin content, after drying it was decreased as compared to dried. Oven dried sample was also showed better retension of antioxidant activity. Lutz *et al*. (2015) studied the phenolics and antioxidant capacity of fresh and dry blackberry fruits. Fruits were oven dried at temperature 60°C in an oven for 36 hours. Result revealed that moisture content of fresh sample was 841.3 g/100 kg and after dehydration it was decreased 2.1g/100 kg. Drying process was increased the phenol content (22.1mg gallic acid equivalent/100gm –fresh and 126.3 mg gallic acid equivalent/100gm - dried). In case of antioxidant activity (DPPH) was 295.8 µ mol Trolox equivalent/100gm -fresh and after dehydration it was found to be increased by 1203.8 µ mol Trolox equivalent/100gm. In result, dehydrated food proved to be good as functional foods. Adiletta *et al*. (2015) studied the effect of abrasive pretreatment on hot dried goji berry. Fresh fruit sample was selected from Spa farm in Italy and oven dried at temperature 60 °C for 21 hours. In this study, they evaluated the antioxidant DPPH activity. They showed that after drying antioxidant activity was increased. In result, drying method proved to be very effective for the preservation of nutrients. Rabeta and Lin, (2015) studied the influence of different drying techniques on the antioxidant activities of berries fruit. In this study, sample was selected from Malaysia. Sample was oven dried at temperature 30°C for 2 to 3 days. Result revealed that drying method was increased the antioxidant DPPH activity and phenolic content in selected sample i.e. FRAP value 47.1 µmol Fe II/gm- fresh, 537.0 µmol Fe II/gm - dried, DPPH value

42.22 per cent-fresh, 89.64 per cent- dried, phenolic content was 2.9 gallic acid equivalent /100gm-fresh and 24.7 gallic acid equivalent /100gm - dried. Arslan (2015) evaluated the effects of degradation preventive agents on anthocyanins stability in sour cherry fruit. Sample was stored in a room at temperature 24°C (room temperature), oven dried at temperature 45 °C and refrigerated at temperature 4°C. They analyzed the anthocyanin content (cyanidin-3-glucosylrutinoside) in fruits. Result revealed that anthocyanin content was 77.0 mg/l at temperature 24°C, 63.0 mg/l at temperature 45 °C and 80 mg/l at 4°C (refrigerator). Study, concluded that heating process led anthocyanin content degradation. Zaidel *et al*. (2015) studied the anthocyanin stability of red dragon fruit (*Hylocereus polyrhizus*) by using microwave-assisted technique. Sample was dried in a microwave at different temperature 60°C and 80°C with different drying time 2 minutes and 3 minutes. Result showed that higher temperature was proved more effective for the degradation of anthocyanin content as compared to lower temperature. Anantawat (2015) determined the effect of spray drying on antioxidant activity of gac fruit aril powder. Fully riped fruit was dried in a spray dryer at temperature 120°C, 150°C and 170°C. Result revealed that antioxidant activity was increased with increased temperature, that was (2758.33, 2797.50 and 2808.33)µg Trolox equivalent/100 gm at temperature 120°C, 150°C and 170°C . Sharma and Gupta, (2013) determined the antioxidant activity and polyphenols of *Carissa spinarum* (non- edible parts). Sample was dried by microwave at temperature 300 W for 2 minutes. Antioxidant activity was evaluated by using Ferric reducing activity power (FRAP) assays. Results showed that Carissa *spinarum* contained highest antioxidant activity and polyphenols compounds. Nakilcioglu and Hisil, (2013) studied the research on the flavonoid compounds in Sarilop (*Ficus carica L.)* Fig variety. In this study, fruit sample was selected from Turkey, oven dried at temperature 65℃ in an oven till constant weight. Result revealed that fresh sample was contained 82.69 per cent- moisture content and 147.51 mg/ rutin equivalent/100gm – total flavonoid content. After drying these parameters were decreased i.e. 16.73 per cent- moisture content and 52.23 mg/ rutin equivalent /100gm – total flavonoid content. In result, flavonoid content was decreased after drying as compared to fresh. Reyes *et al.* (2013) investigated the inactivation (polyphenol oxidase) in loquat (*Eriobotrya Japonica)* fruit by microwave heat and its phenolic profile. Fresh and dried sample was selected for the study. Result showed that phenolic content was increased after drying as compared to fresh ones. Study

concluded that drying process proved very effective for the enhancement of phenolic content as compared to fresh sample. Garcia *et al.* (2013) studied the effect of heating temperature 45°C and 55°C (in a convective hair dryer) on functional properties figs (*Ficus carica* L., var. Mission). Result showed that after drying the total phenolic content was increased, 2.62 mg/100gm, 3.13 mg/100gm at temperature 45°C, 55°C. In case of anthocyanin content it was decreased, 1.20 mg/100gm and 1.12 mg/100gm at temperature 45°C and 55°C. Safy (2014) studied the density, phenolic content of loquat slices by using dehydration method. Riped fresh loquat (*Eriobotrya japonica*) fruit samples were obtained from local market in Egypt (May, 2012) and oven dried at temperature 80 °C and 90 °C for 50 minutes. Result revealed that density was increased from 0.846 to 0.861 gm/cm^3 and phenolic content was also increased from 312.66 to 320.31 mg/10gm was increased with the rising heating system from 80 to 90 °C. Ayadi *et al.* (2014) analyzed the influence of microwave and solar drying methods on physicochemical properties of kiwifruit. In this study sample was sun dried and microwave dried. They studied the effect of different drying methods on moisture content and total phenolic contents. Result showed that sun dried and microwave dried sample was contained less moisture content and higher phenolic content as compared to fresh. Duan *et al.* (2015) studied the microwave-assisted extraction of anthocyanin content (Cyanidin-3-O-glucose) of Chinese bayberry. Mature fruit sample was collected from China (June, 2013). Sample was heated in a microwave at temperature (800 W). They studied antioxidant activity and anthocyanin content. Result revealed that microwave heat was increased the antioxidant activity from 63.43 to 64.60 per cent at temperature 40°C and 80 °C for 15 minutes. And, anthocyanin content was decreased from 97.00 to 48.00 mg/100gm at temperature 40°C and 80 °C for 15 minutes. Mechlouch *et al.* (2015) evaluated the changes in the physico-chemical properties of palm date of 'Alligh' cultivar at different drying methods. Sample was dried by using different method i.e. sun drying, solar drying and microwave drying at different temperature 90 °C. Result revealed that after drying the polyphenol content was increased, 244.42 mg/100g - open air sun drying, 140.48 mg/100g - direct sun drying, 540.48 mg/100g - microwave drying and 77.37 mg/100g - fresh sample. In result, microwave heating was responsible to increase the antioxidant activity as compared to other methods. Udomkun *et al.* (2015) investigated the drying effect on sorption behavoiur of papayas fruit Sample was selected from Thailand and dried by convective dryer at

temperature 70°C. Result showed that fresh fruit sample was contained 7.74 kg/kg - moisture content, 0.968 gm/cm^3 - apparent density and 1.038 gm/cm^{3-} solid density. Result showed after drying moisture content was decreased 0.15 kg/kg, apparent density and solid density was found to be increased by 1.124 gm/cm^3 and 1.425 gm/$cm^{3.}$

2.4 (c) Freezing

Freezing is a process which help to reduce the temperature of food and help to increase its storage ability. The reports of different studies have shown the influence of freezing on nutritional and phytochemical composition of fruits. Ramaswamy and Tung, (1981) studied the thermophysical properties of apples in relation to freezing. Sample (Golden and Granny Smith apples) were selected for the study and stored at temperature (1-2) °C. In this study, the density was studied under freezing conditions. Result revealed that in unfrozen state, the density of the Golden apple and Granny apple was 8.45 kg/m^3 and 7.88 kg/m^3 but it was decreased, 829 kg/m^3 and 7.86 kg/m^3 respectively after freezing. Ancos *et al.* (2000) estimated the influence of frozen storage temperature on ellagic acid, total phenolic contents and radical scavenging capacity of raspberry fruit. In this study, the four raspberries from different cultivars were selected and quantified by using high performance liquid chromatography. Fresh, frozen and stored fruits were evaluated at temperature -20 °C for the duration of one year. Result showed that the frozen storage process slightly affect the ellagic acid and total phenolic content. Result showed that 12 months frozen sample (ellagic acid) found to be decreased from 14 per cent -21 per cent. Mullen *et al.* (2002) evaluated the effect of frozen storage red raspberries on phenolic, ellagitannins, flavonoids and antioxidant capacity. Result showed it was contained total flavonols content for fresh- 1.0 nmol/g , frozen- 0.8 nmol/g. Total anthocyanin content in fresh sample was 156 cyanidin-3-glucoside equivalents/100gm and 1049 cyanidin-3-glucoside equivalents /100 gm was in frozen sample. In case of fresh sample total phenolic content was 3383 nmole/gallic equivalent and frozen sample was contained 3321 nmole/gallic equivalent. In result, freezing process proved effective to improve the flavonols and anthocyanin content and caused degradation in phenolic content. Zavala *et al.* (2004) studied the influence of storage temperature on anthocyanin content and aroma compounds in strawberry fruit. Fruit sample was selected from Butler,s Orchards (USA) and stored at different temperature in a cold room. Result

revealed that sample which was stored at higher frozen temperature showed higher anthocyanin content as compared lower frozen storage temperature. Lohachoompol *et al*. (2004) estimated drying and freezing effect on anthocyanins and their antioxidant effect of blueberries. Fresh sample was stored for two weeks at temperature 5°C and frozen sample was stored at 0°C for three months and in another treatment fruit was dried in a cabinet dryer. Result revealed that total anthocyanin content was 7.2 mg/100gm- fresh, 5.7 mg/100gm - fresh (2 weeks storage), 4.3 mg/100gm- dried and 7.9 mg/100gm –frozen (1 month storage), 7.9 mg/100gm - frozen (3 months storage). Study, concluded that drying process was helped to decrease and freezing caused improvement in the anthocyanin content. Skupien (2006) studied the chemical composition of fresh and frozen stored blueberry fruit *(Vaccinium corymbosu L.).*In this study samples were stored for 6 months at temperature -25°C. They analyzed the phenolic content. Result revealed that after frozen storage, phenolic content was decreased from 258.8 to 236.4 mg/100gm. Rickman *et al*. (2007) evaluated the phenolic compounds difference in fresh and frozen stored fruits. These samples were stored at temperature -20°C for one year. Result revealed that frozen product lose fewer nutrients. In case of raspberry and blackberries, freezing caused reduction in the phenolic compounds. It contained phenolic compounds was 0.576 gm gallic acid equivalents/kg – fresh and in frozen state it was decreased 0.565 gm gallic acid equivalents/kg. In case of blackberries phenolic content was 9.777 gm gallic acid equivalents/kg (fresh) and 9.036 gm gallic acid equivalents/kg (frozen) sample. The findings indicated that frozen fruits were contained less phenolic content as compared to fresh. Scibisz *et al. (*2007) studied the influence of long-term frozen storage on antioxidant activity of blueberries (*Vaccinium corymbosum L*.). Selected samples were stored for six months at frozen temperature -18°C for the determination of anthocyanin content and phenolic content. Result revealed that sample contained phenolic content was 427.8 mg/100gm- fresh, 427.0 mg/100gm- freezing (at temperature -18°C). Anthocyanin content was 137.6 mg/100gm - fresh, 140.6 mg/100gm - freezing (at -18°C). Study, concluded freezing process caused reduction in the phenolic content and increased the anthocyanin content. Wetwitayaklung et *al*. (2008) studied fresh and preserved fruits of *Ellaeocarpus hygrophilus Kurz*. for their phenolic content and antioxidant activity. Sample was selected from a local market in Nakhon- Pathom province. The fruits were stored at frozen temperature -4°C for 6 months. Result revealed that after freezing the phenolic content

was decreased and antioxidant activity was also low. Poiana *et al*. (2010) examined the effect of freezing method on antioxidant activity of fruits. They selected strawberry as a sample and refrigerated at temperature 5 °C (for 12 hours) and stored for ten months at temperature -18°C. Result revealed that after freezing phenolic content was decreased, 109.212 mg gallic acid equivalent/100gm as compared to fresh 177.43 mg gallic acid equivalent /100gm. Antioxidant activity of fresh sample was 24.37 mM F^{e2}+/kg, after freezing it was decreased (14.22 mM F^{e2}+/kg). Study, concluded that after freezing phenolic content was decreased upto 28 per cent to 47 per cent and caused small losses in the antioxidant activity was recorded. Zheng and Fujan, (2010) studied the fresh *Ficus carica* by treating it with different methods of cold-shock treatment at temperature 0 ℃ for 1.5 hours. Result showed that the effect of the treatment with cold shock at 0 ℃ for 1.5 hours was significantly better to save fruit quality. Study concluded that the fresh keeping effect of cold shock treatment for 1.5 hours was the best, easy and simple way to handle the fruits and not influenced the quality of the *Ficus carica*. Mohammadian *et al*. (2011) determined the bioactive compounds and antioxidant capacities of two citrus cultivars *Citrus sinensis* 'Siavaraz' and *Citrus limon* 'Lisbon'. Fresh sample was collected from Iran and stored at different temperature i.e. (15, 3, 0, -3 and -6) ºC for ten hours to analyze the total flavonoids content and antioxidant capacity. Result reported that freezing temperature was increased the flavonoids content and decreased the antioxidant capacity for both the cultivars. Leong *et al*. (2012) studied the effects of processing on anthocyanins in summer fruits. In this study, they evaluated the effect of freezing at temperature -20°C. Cherries were selected as a sample from Otago region. Result revealed that after processing it was contained anthocyanin content i.e. 207.00 mg/100gm- fresh and 570.08 mg/100gm- freezed. In conclusion, freezing enhanced the release of membrane bound anthocyanins, resulted processing was increased the anthocyanin content as compared to fresh sample. Jan and Rab, (2012) examined the effect of storage period on physical and chemical differences changes in apple fruit. Mature apple was selected as a sample and stored in a cold room for 0, 30, 60, 90, 120 and 150 days. In this study physico-chemical changes were observed in 30 days intervals. Result showed that fruit density was decreased with increased storage period, it was (0.82g/cm^3- at 0 days storage, 0.81 g/cm^3- 30 days storage,0.80 g/cm^3 - 60 days storage, 0.78 g/cm^3 - 90 days storage,0.78 g/cm^3 – 120 days storage, 0.05 g/cm^3 - 150 days storage). Chaparzadesh and Yavari, (2013) evaluated the

antioxidant activity of Golden delicious apple under frozen storage conditions. Sample was selected from orchards in Iran and stored at temperature 1°C for 45 days, 90 days and 135 days in a cold house. Result revealed that during cold storage the content of phenol and antioxidant activity diphenylpicrylhydrazine radical (DPPH) was decreased as storage time increased. Sikora *et al.* (2013) examined chemical composition of fresh and frozen storage blackthorn fruits (*Prunus Spinosa L.).* Fresh sample was collected from a mountain village, in South and frozen at temperature of -18°C. In this study, fresh blackthorn fruit was contained 0.8 gm/100gm- protein content, 0.37 gm/100gm- fat content, 396.19 mg/100gm- anthocyanin content. After freezing it was contained, 0.34 gm/100gm- protein content, 0.33 gm/100gm-fat content, 415.04 mg/100gm-anthocyanin content. In result, due to frozen storage the protein content, fat content was decreased and anthocyanin content was increased.

6. SUMMARY AND CONCLUSIONS

Fruits are important source of vitamins, minerals and fibers. Fresh fruits are classified as perishable commodities due to presence of higher moisture content (Orsat *et al.* 2006). Nowadays, perishable crops are dried in the world (Grabowski *et al.* 2003) and due to their international trade, consumers have access to various unseasonable fruits around the world. In comparison of imported fruits, locally available fruits are very cheap, fresh but short life span. Therefore, processing methods must be use to enhance their shelf life.

So, present investigation entitled **"Influence of processing on nutritional and phytochemical composition of Fig (*Ficus carica*) and Karonda (*Carissa spinarum*)"** was undertaken the thesis work on locally available two underutilized fruits, fig and karonda with following objectives:

1. To evaluate proximate, nutritional, physical and phytochemical composition of fresh fig and karonda fruits.
2. To assess the influence of processing methods viz. sun drying, microwave drying and freezing on physicochemical, nutritional and phytochemical composition of selected fruits.
3. To evaluate the effect of fruit extract of fig and karonda on FBG level of normoglycemic and diabetic wistar rats.
4. To develop various value added products from the selected fruits and analyze their nutritional composition during 6 months of storage.

These two local varieties of fruits were procured from Bilaspur (Himachal Pradesh), India and processed under the influence of freezing, sun drying and microwave drying method and studied for physical composition, nutritional composition, anti- nutritional composition and mineral composition. Results demonstrated a wide variation in the nutrient composition of fresh and processed fruit. Drying method reduced the length, width and density in fruits. Drying method increased significantly ($p<0.05$) the ash content, carbohydrate content, fat content, protein content and dietary fiber (NDF, ADF, hemicellulose, cellulose, lignin) and showed reduction in the moisture content. After processing, microwave dried method

exhibited significantly ($p<0.05$) higher phytochemical composition (phenolic content and flavonoid content). The antioxidant activity was also found to be increased in microwave dried method. Drying method decreased significantly ($p<0.05$) the tannin content, alkaloid content, anthocyanin content and increased the calcium content, iron content and phosphorus content.

Underutilized fruits also proved beneficial to control many diseases. Traditional point of view these fruits are popular with hypoglycemic activities (Perez *et al.* 1999). So, present study examined the influence of these selected fruits (fig and karonda) on FBG level in normoglycemic and diabetic rats.

Animal trial was carried out by using fourty two male albino rats. The rats were weighed and allotted twelve for toxicity test and after that distributed into seven groups (n=6) for further study purpose. Group I as normoglycemic rat group, group II as diabetic group having 35 mg streptozotocin according to body weight of rat, group III as diabetic group having 50 mg metformin according to body weight of rat, group IV as diabetic group having 500 mg fig methanolic extract according to body weight of rat , group V as diabetic group having 500 mg karonda methanolic extract according to body weight of rat, group VI as normoglycemic group having 500 mg fig methanolic extract, group VII as normoglycemic group having karonda methanolic extract (500 mg/kg b.wt.). Fasting blood glucose (FBG) level and body weight of rats were measured after 0 day, 7^{th} day, 14^{th} day and 21^{th} day. In result, methanolic extract of fig and karonda extract decreased significantly ($p<0.05$) higher FBG level on 21^{th} day as compared to 0 day in diabetic control group as well as in normoglycemic group of rats. And, also proved effective to improve higher body weight of rats on 21^{th} day as compared to 0 day in diabetic control group as well as in normoglycemic group of rats.

This study also proved beneficial to explored the possibilities of the utilization of nutrient rich under-utilized fruits to make innovative food products. According to objectives of the study these underutilized fruits were selected for the development of value added products because of their higher nutritional quality and easy availability. Different value added products such as bun, muffin, noodles and nuggets were formulated with the substitution of

15 per cent, 30 per cent and 45 per cent of karonda and fig to improve the overall nutritional quality. And, increased significantly ($p<0.05$) the moisture content, ash content, carbohydrate content, protein content, fat content, dietary fiber (ADF, NDF, hemicellulose, cellulose, lignin), iron content, calcium content and phosphorus content. The value added products, bun and muffin were also evaluated organoleptically for appearance, colour, texture, flavour, overall acceptability and accepted well by panel of judges. Thus, these underutilized fruits could be successfully used in the production of the value added products and proved to be nutritious convenience products for the human consumption.

The study concludes that drying method proved to be more effective for nutrient retension and significantly ($p<0.05$) reduced FBG level in diabetic control group as well as in normoglycemic group of rats. Further, the substitution of fruits showed significant effect to increase the nutritional quality in developed value added products.

TABLE OF CONTENTS

TERMINOLOGY

g	=	Gram
µm	=	Microgram
kg	=	Kilogram
°C	=	Degree Celsius
%	=	Percentage
g/ml	=	gram per milliliter
et al	=	And others
i.e.	=	that is
etc.	=	Et cetera
DPPH	=	2,2-Diphenyl-1picrylhydroxyl
Rpm	=	rotation per minute
WF	=	Wheat flour
CS	=	*Carissa spinarum*
FC	=	*Ficus carica*

INFLUENCE OF PROCESSING ON NUTRITIONAL AND PHYTOCHEMICAL COMPOSITION OF FIG *(FICUS CARICA*) AND KARONDA (*CARISSA SPINARUM)*

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by

Ambika Chauhan

Supervised by

Dr. Beenu Tanwar

Assistant Professor

Department of Food Technology & Nutrition
School of Agriculture
Lovely Professional University, Phagwara
Punjab

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