Studies on development of multigrain cake fortified with fruit and vegetable waste

Pre- Dissertation Report

Submitted By

JITENDRA PRAKASH GHADGE

Registration No. – 11709260

Program- M.tech. Food Technology

School of Agriculture

Lovely Professional University, Phagwara

Under the Guidance of

Er. Jasleen Kaur Bhasin

Assistant Professor

School of Agriculture

Lovely Professional University, Phagwara

CERTIFICATE

This is to certify that **Jitendra Prakash Ghadge (Registration No.11709260)** *has personally completed M.Tech. Dissertation-I entitled* **"Studies on development of multigrain cake fortified with fruit and vegetable waste"** *under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of pre-dissertation has ever been submitted for any other purpose at any University.*

The project report is appropriate for the submission and the partial fulfillment of the conditions for the evaluation leading to the award of Master of Food Technology.

Signature of Supervisor

Er. Jasleen Kaur Bhasin

Assistant Professor

Department of Food Technology and Nutrition,

School of Agriculture,

Lovely Professional University,

Phagwara, Punjab, India.

DECLARATION

I hereby declare that the work presented in the dissertation- 1 entitled **"Development of fortified fruit and vegetable waste cakes and cookies"** is my own and original. The work has been carried out by me at School of Agriculture, Lovely Professional University, Phagwara, Punjab, India under the guidance of **Er. Jasleen Kaur Bhasin**, Assistant Professor (Food Technology) of School of Agriculture, Lovely Professional University, Phagwara, Punjab, India for the award of the degree of Master of Food Technology.

Date: May, 2018 **Jitendra Prakash Ghadge**

Place: Phagwara, Punjab, India. **11709260**

I certified that the above statement made by the student is correct to the best of my knowledge and belief.

Date: May, 2018 **Er. Jasleen Kaur Bhasin**

Place: Phagwara, Punjab, India. Assistant Professor

Department of Food Technology and Nutrition

School of Agriculture

Lovely Professional University

Phagwara, Punjab, India.

CONTENTS

Chapter- 1 INTRODUCTION

As the human population is widely increasing and so is the income source of individuals a demand for food with a better nutritional content has been observed, looking at the various out breaks of diseases there has been a need for food which might target the nutrient deficiency and lead to a better immune population. In past times fruit pomace was generally used as animal feed *(Singh B et al., 1992).* Industries now days extract pectin from fruit pomace which is a time consuming process, as drying and storage is highly required in this flow process *(Pirmohamodi et al., 2006).*

A high amount of carbohydrates, various minerals and vitamins are found in fruit and vegetable pomace, various baked products are usually made with starches from cereals as a result they have lower micro nutrients present in them, the addition of pomace of fruits and vegetables helps effectively in increasing their nutritive value *(Manoj Panwar et al., 2015).*

1.1 Wheat

On the research done by *(Zuzana Šramková et al., 2012)* they stated that wheat carries an important nutritional importance in the staple crops which are grown, the advantageous property of wheat which makes it popular is its conversion into powder form on fine grinding, this advantage helps in formulation of various bakery products such as bread, cakes, pasta. As a result it acts as an important nutrient source to higher population. They also concluded that nutrient deficiencies such as of Vitamins, iron and few like zinc cause pain for over three billion individuals, the rising trend they observed was that the consumers these days prefer a better nutrient source for well-being rather than just fulfilling normal nutrient requirement.

1.1.1 Nutritional composition

1.1.1.1 Proteins

Water soluble proteins like albumins, water insoluble like globulins which can be dissolved in NaCl solutions, alcohol soluble like gliadins which are soluble in 70% ethyl alcohol, apart of this glutenins which are dilute acid soluble too are predominantly found. *(Šramková et al., 2009)* observed that the amount of amino acids in aleurone layer vary from that of flour, There are large

differences between the levels of proline and Glutamine apart of that lysine content was found to be double in wheat flour than aleurone.

(Hager, Anna-Sophie, et al., 2012) in their work to determine nutrient contents of different flours found the protein content of wheat flour to be 11.54±1.7 g/100g.

1.1.1.2Carbohydrates

Energy in cereals is stored as starch, the total starch content in wheat grain ranges between 60 to 75%. Starch is found in granulated form which can be divided into three different forms large, small and lenticular *(Belderok et al 2000).*

The starch content in wheat flour was found to be 68.06±2.34 g/100g, amongst which Amylose content was 21.10 ± 1.29 %, while the total dietary fiber content was 3.44 ± 0.01g/100g *(Hager, Anna-Sophie, et al., 2012)*

1.1.1.3 Lipids

According to the work performed earlier by *(Zuzana Šramková et al., 2012)* they described the germ to be containing neatly 11% of lipid content while similar amounts were also associated with starch, proteins and the bran. In reference to the tests they conducted they noted that complex polar lipids constitute nearly half of the lipid contents in endosperm while germ exhibited 17% and bran 23%.

(Hager, Anna-Sophie, et al., 2012) found the total fat content in wheat flour samples to be 1.81 ± 0.05 % w/w.

1.1.1.4 Vitamins

They can be simply termed as a diverse group of food –based essential organic substances which aren't synthesized by human body. Smaller organisms such as microbes and other like plants do produce them *(Paredes-López and Osuna–Castro et al., 2006*). A few major examples of vitamins found are Tocols and Carotenoids,

1.1.1.5Minerals

(Hager, Anna-Sophie, et al., 2012) Found the total ash content in wheat flour to be 0.92 ± 0.02% w/w, on other hand they found the calcium content to be 1797.7 ± 10.5 mg/kg, magnesium content to be 244.0 ± 1.0 mg/kg, sodium and potassium content to be 38.1 ± 3.7 mg/kg and 1520.3 ± 8.5 mg/kg respectively, iron amount was determined to be 13.4 ± 0.1 mg/kg.

1.2 Quinoa

It can be termed as one of the Pseudocereal of indigenous variety from southern American region and has a wide importance across the world, the crops having a wide nutritional importance and a good weather resistant, They can be grown at different geographical conditions and surroundings which makes them so important *(Gorinstein, S., Medina-Vargas et al., 2007)(Rosell, C.M., Cortez, G., Repo-Carrasco et al., 2009).* Quinoa contains various functional as well as bioactive components due to a higher proportion of fenolic agents and nature oriented antioxidants *(Gorinstein, S., Medina-Vargas et al., 2007).* Looking at the past times the Ican, Aztec and the mayan civilization too have given a scope for pseudocereal consumption on asian, American and the African continent *(Alvarez-Jubete, L., Arendt, E.K., Gallagher, E t al., 2010)(Qian, J.Y., Kuhn, M et al .,1999)*

1.2.1 Nutritional composition

1.2.1.1 Proteins

According to the work done earlier the protein content in quinoa was found to be 12.9% to 16.5% *(Alvarez-Jubete, L., Arendt, E.K., Gallagher, E et al .,2009) Koziol, M. J et al .,1992)(Schoenlechner, R., Siebenhandl, S., Berghofer, E. Pseudocereals et al ., 2008).* Generally Albumin and globulin proteins are found in them with a very trace amount or a negligible amount o prolamine protein *(Alvarez-Jubete, L., Arendt, E.K., Gallagher, E et al ., 2010)(Grobelnik, M.S., Turinek, M., Jakop, M., Bavec, M., Bavec, F et al ., 2009)(Valencia-Chamorro et al ., 2003).*

(Hager, Anna-Sophie, et al., 2012) found the protein content in Quinoa flour to be 13.48 ± 0.04 g/100g.

1.2.1.2 Carbohydrate

Quinoa carbohydrats showed results to have a heavy nutraceutical significance due to their hypocholestrolemic properties *(Danz, R.A., Lupton, J.R et al .,1992)(Qureshi, A.A., Lehman, J.W., Peterson, D.M et al., 1996).* Apart of this properties quinoa too can be suggested for people for individuals having celiac disorder, here the glycemix index in case of quinoa was observed to be relatively low as compared to gluten less bread *(Berti, C., Riso, P., Monti, L., Porrini, M et al ., 2004).* From the comparative study done *by (Beatriz Valcárcel-Yamani , Suzana Caetano da Silva Lannes et al .,2012)* he stated the carbohydrate content in quinoa to be around 69.00(61.2-76.6).

(Hager, Anna-Sophie, et al., 2012) found the total starch content in quinoa flour to be 48.88 ± 2.07 g/100g, while the total dietary fiber content was estimated to be 7.14 ± 0.23g/100g

1.2.1.3 Lipids

On the research done by *(Koziol, M. et al ., 2003)(Schoenlechner, R., Siebenhandl, S., Berghofer et al., 2008)(Alvarez-Jubete, L., Arendt, E.K, Gallagher, E et al., 2010)* they found out the total lipid content in quinoa be nearly double or triple times the amount present in wheat and maize. The amount of fat present in quinoa was observed to be ranging from 5.2%-9.7% *(Koziol, M. Quinoa et al .,1993)(Ruales, J., Nair, B.M. et al .,1992)(Schoenlechner, R., Siebenhandl, S., Berghofer, et al ., 2008)*

(Hager, Anna-Sophie, et al., 2012) described the total lipid content in quinoa flour to be 8.59 ± 0.25 %w/w.

1.2.1.4 Vitamins

(Beatriz Valcárcel-Yamani , Suzana Caetano da Silva Lannes et al .,2012) described a chart according to which they exhibited a similarity in between vitamins present in quinoa and that of other cereal grains, also they described the thiamin content to be in between 0.29% to o.36% while the riboflavin content was noted to be in between 0.30% to 0.32%, others included vitamin B6 which was aroun 0.487 % and the total folate content which was 0.18%.

1.2.1.5 Minerals

Mineral contents in quinoa vary from region to region, some other factors like variability in climatic conditions, various conditions during plant growing phase, variety of seeds, specially the total mineral amount in soil where the plant is grown etc highly influence the mineral content in final quinoa obtained *(Alvarez-Jubete, L., Arendt, E.K., Gallagher, E. et al., 2009).* According to the charts described by *(Beatriz Valcárcel-Yamani , Suzana Caetano da Silva Lannes et al., 2012)* the total calcium content was found to be in between 32.9 to 874.0, Iron 5.5-81.0, Magnesium 206.8-2620.0, zinc 1.8-36.0, Manganese 33.0, potassium 1201.0, (mg/100 g dry-weight basis).

(Hager, Anna-Sophie, et al., 2012) estimated the Ash content in quinoa flour to be 2.43 ± 0.03 %w/w, while the Calcium, magnesium, sodium, and iron content were found to be 497.3 ± 1.2 mg/kg, 2299.0 ± 17.0 mg/kg, 37.0 ± 0.2 mg/kg and 53.5 ± 0.4 mg/kg respectively.

1.3 Buckwheat

Buckwheat in common terminology is an annual crop scientifically named *(Fagopyrum esculentum Moench*), due to its similarity with other cereals and its nutritional parameters its generally considered to be cereal even after being a Pseudocereal *(Campbell et al.,1997)* From the research conducted by *(Christa, Karolina, and Maria Soral-Śmietana et al ., 2008)* they stated that buckwheat grain has been introduced into human diet as an substitute reason being good in nutritive value as well as health enhancing value, results based on animal models described by them show a relative action of buckwheat in reduction of various disorders such as hypercholesterolemia, diabetes and few like hypertension.

1.3.1 Nutritional significance

A wide variety of nutrients like proteins, carbohydrates in form of polysaccharides, fibre, fats or lipids various micro as well as micro nutrients are found in grain of buckwheat(Kim et al., 2004).

1.3.1.1Protein

According to the work conducted earlier by (*Karolina CHRISTA and Maria SORAL-ŚMIETANA et al., 2008)* they described the protein content in buckwheat to be in between 12-18.9%. A relatively lower protein content was noted in hull, nearly 4%, while in embryo it was around 55.9% *(Pomeranz & Sachs et al., 1972).* The flour obtained from buckwheat was found to be containing about 8.5-19% valuable proteins yet fluctuations might be possible depending on variety *(Fornal et al., 1999).*

(Hager, Anna-Sophie, et al., 2012) in their study determined the protein content in buckwheat flour to be 12.19 ± 0.38 g/100g.

1.3.1.2 Carbohydrates

(Karolina CHRISTA and Maria SORAL-ŚMIETANA et al., 2008) stated that starch is the largest component in grain of buckwheat and is concentrated in endosperm as an energy yielding compound and helps in regular growth of plants, they described the total starch content in grain of buckwheat which on dry mass basis was found to be ranging in between 59 to 70%.

The latest work conducted by *(Stempińska & Soral-Śmietana et al., 2006)* they analyzed three varieties of polished buckwheat grains and reported the starch content to be in between 63 to 66%.

(Hager, Anna-Sophie, et al., 2012) stated the total starch content in buckwheat flour to be 61.35 ± 2.15 g/100g, while on other side the total dietary fiber content was found to be 2.18 ± 0.11g/100g, where 0.48 ± 0.17 g/100g was the soluble dietary fiber.

1.3.1.3 Lipids

(Steadman et al. 2001) found the lipid content in buckwheat to be in between 1.5-4%, on other hand *(Soral-Śmietana 1987)* stated that the amount of fat content in raw form is higher than 3%, they also described that buckwheat made flour had a higher proportion of lipids in free form as compared to those in bound form.

(Hager, Anna-Sophie, et al., 2012) described the fat content in buckwheat flour to be 4.21 ± 0.74 %w/w.

1.3.1.4 Vitamins

The work conducted by *(Fabjan et al. 2003).*describes presence of various vitamins such as B1,B2,B6, These vitamins are generally accumulated in the outer sections of embryo and the endosperm portion which stated that a larger amount of b series vitamins are present in the bran section.

1.3.1.5 Minerals

*(Li & Zhang et al., 2001)*described the casual mineral content in grains of buckwheat ie in various grain sections and found them to be 2 to 2.5% in complete grain, while other sections like kernel showed 1.8 to 2%, it reduced in case of flour and was estimated to be around 0.9 %.

A statement made by *(Wei et al. 1995)* describes that buckwheat has higher calcium, potassium, sodium and magnesium contents while a larger portion of minerals are found in bran portion.
In the research by *(Hager, Anna-Sophie, et al., 2012)* they determined the Ash content in buckwheat flour to be 1.65 ± 0.01 %w/w, while the calcium, sodium, magnesium and iron content were described to be 148.2 ± 1.7 mg/kg, 1736.0 ± 13.0 mg/kg, 10.8 ± 2.6 and 28.5 ± 0.0 mg/kg respectively.

1.4 Pineapple pomace

According to the FAO data which gave a account in million tons of pineapple production showed 21.8 MT of pineapple production in 2011*(FAO, 2013), (Larrauri, Ruperez, & Calixto, 1997)* stated that a larger amount of pineapples which are produced are utilized in production of various products such as juices, jams, various preserves etc, and nearly 25 to 30% of waste is generated out of this processing which includes pomace section and the peels.

(Miriam Mabel Selani et al., 2014) Carried out various tests on pomace and found the moisture content to be 3.77%, the ash content to be 2.24%, fat content to be 0.61%, dietary fiber content to be 45.22%, soluble dietary fiber content to be 0.78, insoluble dietary fiber to be 44.44%, protein content to be 4.71% and lastly the carbohydrates to be 43.46%, all of the readings they calculated were based on dry basis.

Chapter-2 PROBLEMS BACKGROUND

Cakes are consumed in whole of the world, they can be manufactured by use of different multigrain flours taken together, they can also be made by incorporation of various fruit wastes, vegetable wastes generated out of pulp processing industries, various small and large juice outlets, general cakes manufactured from wheat flour (whole or refined) have a restricted amount of nutrients and fiber contents their fortification can lead to nutrient fulfillment in the individuals who consume them. Proper utilization of industrial byproducts or vestigial portions of edible products can lead towards less biomass accumulation in environment while resulting into beneficial utilization of those nutrients in human diet.

As the market trend now days is moving towards nutrient fulfilling products use of multigrain flour results into formulation of a nutrient rich product while relatively lesser gluten content in cereals helps into an improved cake texture.

The current study has been structured in order to formulate or manufacture Cakes from multigrain flours which is a composite of Pseudocereals (Buckwheat and Quinoa) along with use of pomace from fruits which include Muskmelon (*Cucumis melo*), Pineapple *(Ananas comosus)* and Beetroot (*Beta vulgaris*) from vegetable category.

Chapter-3 OBJECTIVES

1. To standardize the formulation for preparation of cakes using composite flour fortified with fruit and vegetable waste.

2. To study the physiochemical, microbiological, sensory and nutritional properties of formulated cakes.

3. To study the shelf life of formulated product.

3.1 DETAILED PLAN OF WORK-

Objective no.1

To standardize the formulation for preparation of cakes using composite flour fortified with fruit and vegetable waste.

Basic ingredients required in cake preparation:

All- purpose flour or maida	120g
Sugar	120g
Whole milk powder	70-100g
Whole egg	70g
Margarine	60g
Baking powder	1.85g
Salt	Pinch

Table 3.1 Ingredients for control sample cake preparation *(Sreenath, Hassan K., et al. 1996)*

A composite flour made of 70% refined wheat, 15% Quinoa flour and 15% Buckwheat flour will be mixed up with a combined pomace mass of 50% beetroot pomace and 50% pineapple pomace in different proportions or ratios as follows,

COMPOSITE FLOUR 70%(Refined wheat flour) 15%(Buckwheat flour) 15%(Quinoa flour)	**COMPOSITE POMACE 50%(Beetroot pomace) 50%(Pineapple pomace)**
90%	10%
80%	20%
70%	30%
60%	40%
50%	50%

Table 3.2 Different proportions of pomace and composite flour blends to be used.

Chapter-4 REVIEW OF LITERATURE

4.1 Market survey on fruit waste:

In an studies carried out by *(Vasanthi .P et al., 2014)* observed, keeping the prospective of surveying the fruit juice outlet in Coimbatore city of India they the calculated the amount of fruit pomace wastage for a span of one week and found various fruit waste percentage parts which were highly rich in fiber, phyto-chemicals and other nutrient content which subsequently shows the wastage of these essential nutrients, from the above made observations they concluded that this waste pomace can be effectively used in production of various products and counter risk of diabetes, various other heart diseases and syndromes, they also concluded that the utilization of these would generate a heavy self employment opportunity.

(Manoj Panwar et al., 2015) stated that Many agricultural produce by products which can be utilized in a better manner are available in all over the local market but they are not completely utilized on consumption purpose these include pomace of various fruits like pomegranate, grapes, tomato, bran portion of rice, bran portion of maize etc. These products have in them various types of toxic components which can be effectively removed by various treatments, since the main course products are pretty costly the need for such byproducts have widely increased, these methods also help in reducing the industrial waste.

4.2 Utilization of composite flour:

The food products made using composite flour have been increasing the attention from various researchers commonly in the sectors like bakery industries. In the article produced by *(Noorfarahzilah, M et al., 2014)* they described the use of composite flours in producing various products like biscuits, cookies, with improvements in various properties like rheology, quality characteristic, nutritional quality and finally the overall acceptance. They observed that composite flour when used gave various similar characteristics with better and improved results physic chemical properties as well as other properties.

(Shittu et al., 2007) elaborated that composite flours are a complex mixture of nearly two or three flours taken together which may or may not include wheat. *(Berghofer, 2000; Bugusu et al., 2001)* stated a few examples which made the composite flours an important aspect in recent developing countries, these included helping of cash saving, enhancing the local variety growth of crops, helping in supply of good nutrient source to individuals specifically proteins.

(Hugo et al., 2000; Hasmadi et al., 2014). Made it clear by elaborating that composite flours used helped in decreasing the wheat grain or flour imports from other sections directly enhancing the use and importance of local varieties

4.3 Fruit and vegetable waste used in baked product preparation:

In research carried out by *(Sharoba, A.M et al., 2013)* they used a combination of orange waste, potato peels, carrot pomace and peels of pea which are potential by products from food industry and utilized it in manufacture of flour in an order to utilize it in production of fiber rich cakes for people usually suffering from diabetes, obesity. Later they also studied the rheological characteristics of flour by substituting wheat flour with different proportions of PP, OW, CP, and GPP. The observations they made were like the water absorption increased, resistance to extension, dough stability was increased, the calorie percentage of caked showed a reduction, texture properties were found to be changed in cake. In final preparation they prepared cakes with a 72% of wheat flour with 5, 10, 15, 20% of by-products of vegetables and fruits, here the volume of cakes was observed to decrease and an increase in fruits and vegetable by-product quantity was observed.

4.4 Cakes made from pomace:

(Sreenath, Hassan K et al., 1996) formulated sponge cake by fiber incorporation which were extracted from various fruit pomace samples, these included Pineapple waste pulp, fibers from whole wheat flour, the hull portion of field beans. They observed the fiber content amount obtained to be 2g/100g in pineapple, 7.0g/100g in whole wheat flour and nearly 16.8% in hull from field beans. They included these fibers in a proportion of 5 %(w/w). Along with the same

they also analyzed various other properties such as change in pH, the color, other textural characters and the sensory characteristics.

In the research conducted by *(Eastwood, M. A. et al., 1992)* he concluded that due to the noticeable advantages of fibers in diet, its various disease preventing characteristics the importance and scope for fiber intake has been increasing, as fibers have a wide roe in curing acute and chronic disorders such as colon cancer, cardiovascular disorders, intestinal diverticulosis, hemorrhoids, metabolism related disorders like excessive weight gain and diabetes etc, their importance has been consequently increasing.

In the work carried out by *(Sharoba, A.M et al., 2013)* they used a combination of orange waste, potato peels, carrot pomace and peels of pea which are potential by products from food industry and utilized it in manufacture of flour in an order to utilize it in production of fiber rich cakes for people usually suffering from diabetes, obesity. Later they also studied the rheological characteristics of flour by substituting wheat flour with different proportions of PP, OW, CP, and GPP.

The observations they made were like the water absorption increased, resistance to extension, dough stability was increased, the calorie percentage of caked showed a reduction, texture properties were found to be changed in cake. In final preparation they prepared cakes with a 72% of wheat flour with 5, 10, 15, 20% of by-products of vegetables and fruits, here the volume of cakes was observed to decrease and an increase in fruits and vegetable by-product quantity was observed.

4.5 Specific gravity and pH of cakes made from fiber incorporation:

In the sponge cake preparation done by *(Sreenath, Hassan K et al., 1996)* they noted the changes regarding various parameters like pH of formulated cakes and specific gravity the observations they made were that the fiber incorporation reduced the pH scale of the batter made along with the crumb and crust portion when compared to the other cakes having no fiber content and just the all purpose flour.

(Fondroy, E. B et al., 1989)(Dworshak, E et al., 1980)(Johnson, J. M et al., 1989) stated that the elevation of acidity towards a increasing scale results into subsequent decrease in browning reaction taking place during baking.

According to *(Sreenath, Hassan K et al., 1996)* work the specific gravity of batter made from All purpose flour and fibers from pineapple pomace was found to be 0.9364 while the pH of batter was 6.46, the pH for crust and crumb was 6.17, 6.28 respectively.

4.6 Role played by gluten in cake manufacture and analysis tools used:

(Edith Wilderjans et al., 2007) designed various gluten to starch ratios with a varied range from the standers available, they observed that a higher viscosity batter helped in air expansion and subsequent rise in cakes which resulted in required volume rise of cakes, an increased gluten content resulted into an increase in the span of oven spring, they also observed that the cakes which had starch content more than 92.5% resulted into a fall down when cooled down and had a rough coarse texture of crumb with a sticky layer at the portion of base.

A device named Rapid visco-analyzer was used by them to analyze the batter properties in the baking procedure and simultaneously in the early stage thermocouples were used to measure the temperature of the batter at the central portion which in addition gave an digital data output.

They used an otsu thresholding algorithm in order to get a segmented view of image and the cells from crumb were studied by an tool system of Matlab, they also used the differential scanning calorimetric device in order to gain the color idea. In order to know the temperature scale for gelatinization of starch and the property of egg protein denaturation simple pound cake manufacture recipe was brought in use. ANOVA test was used by them in final stages for the statistical analysis.

4.7 Cookies manufactured from fruit and vegetable pomace:

Cookies having low moisture content as a result are not usually prone to microbial contamination; they are convenient being compact in nature and also possess properties like palatability and can be considered ideal in availability of nutrients *(Wade et al., 1988).*

Earlier attempts of apple pomace obtained from juice industries incorporation in cookies was done to attain positive results *(Kaushal et al., 1995),* Regarding fibers, consumption of fibers is related to increase a wide antioxidant activity and a better nutrition in a daily food intake improving the health of human beings *(Maćkowiak et al., 2016).*

A effort was made by *(Sahni et al., 2016)* earlier regarding preparation of cookies having rich fibers by putting refined flour, along with it they added beetroot pomace powder in it at various levels like five, ten, fifteen, twenty and twenty-five percent and later studied it for physical chemical and textural properties, similar tests like sensory tests were also carried out.

Another such attempts have been seen where *(Ritika, B. Y et al., 2014).* Conducted study on powder of carrot pomace in production of biscuits by mixing it with chickpea flour which was obtained from germinated seeds together mixing it, resulting in making composite flour.

Chapter-5 MATERIAL AND METHODS

5.1 Proposed Research Methodology:

procurement

Quinoa Flour

Quinoa flour is one of the Pseudocereal used in cake preparation in altered proportions with refined wheat flour.

(Abugoch, Lilian, et al., 2009) procured a 2kg seeds of quinoa from a larger lot and a cold washing treatment was given to them in order to remove the Saponin constraints, oven drying treatment was employed by them in order to reduce the moisture content to 15 g per 100g of sample, later on a impact mill was employed in order to finely grind it to sixty mesh.

Buckwheat flour

(Skrabanja, Vida, et al., 2004) exposed the grains to milling procedure in order to obtain fractions of seven different varieties of flours, in their work they used roller mills which date back to 1930s (F. Bergant mill, Psata, Ljubljana).

Pomace From beetroot and pineapple.

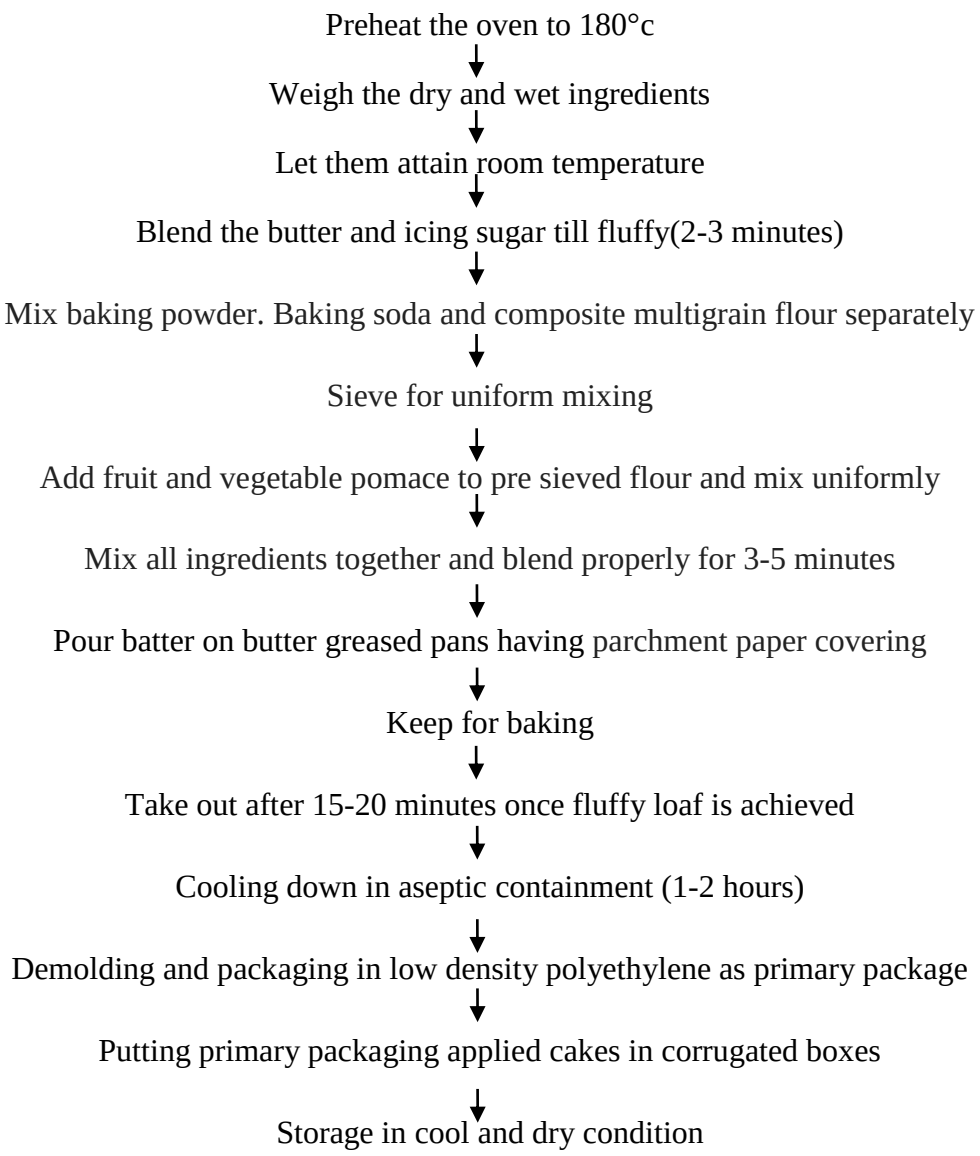
Beet root pomace isolation was carried out simply by washing the beetroots which were earlier peeled and the heads removed and later on separating the juice from them by extraction *(Sahni et al., 2016).*

(Selani et al., 2014) procured various batches of fully matures samples of pineapple and in first step did their sanitization using 220 ppm NaOCl (sodium hypochloride) later on they did the rinsing process with clean water and cutting was facilitated with hands, obtained mass was put into a electric juice extractor and henceforth the juice and pomace separated.

Muskmelon pomace can be procured from local market fruit juice stalls.

Other materials like refined wheat flour, Icing sugar, Eggs, Baking powder and Baking soda can be procured from local market bakery ingredient stores.

5.1. Proposed flow chart for preparation of multigrain cake made by pomace incorporation



5.2 Physico - Chemical analysis

Moisture Content

Weigh about 3 g of the prepared sample in the moisture dish, previously air dried in the oven and weighed. Placed the dish in the oven maintained at the 105 ± 5°C for 4 hours. Cooled in the desiccators and weighed. Repeated the process of drying, cooling and weighing at 30 minute intervals until the difference between the two consecutive weighing is less than 1 mg. record the lowest weight.

$$M.C. = \frac{(\text{Wt. of the sample at desired time}) - (\text{Wt. of bone dry material})}{(\text{Wt. of sample at any time})} * 100$$

It will be analyzed in Hot air oven at 103°C and will be calculated by formula.

Determination of Ash Content by Muffle Furnace *(AOAC, 1986)*

The ash of the food stuff is the organic residue remaining after the organic matter has been burnt away. When a high ash figure found it suggests the presence of an adulterant, it is often advisable to determine the acid insoluble ash also.

3 g of the sample was weighed. It was tare, cleaned, dried and pre-weighed porcelain dish or silica dish or platinum dish was taken. The sample was ignited in the dish with the flame of a suitable burner (oxidizing agent) for about one minute. Ignition was completed by keeping it in a muffle furnace at 550-6000°C until the grey ash results. It was cool in a desiccator and weigh. The process was repeated till constant weight was obtained. The final weight was noted.

$$Ash\ \% = \frac{W2 - W1}{W} * 100$$

Where,

W2 = Final weight of dish + Ash

W1 = Weight of dish

W = Weight of sample

Determination of fat content by Soxhlet method *(AOAC, 1986)*

Firstly weight of empty round flask. Weight 05 g of pineapple pomace, wheat bran biscuits in a dry cellulose thimble and covered with cotton and kept into the Soxhlet assembly. The fat extraction was carried out with petroleum ether (60°C-80°C) for four hours. After evaporating the solvent, flask were kept into the hot air oven for one hour and cool into desiccators and weight again.

$$\% \text{ Fat Content} = \frac{W1 - W2}{W} * 100$$

Where,

W_1 = Initial weight of round flask

W_2 = Final weight of flask + fat

W = Weight of sample

Determination of Protein Content by Micro-Kjeldhal Method *(AOAC, 1986)*

Protein was determined using the micro-Kjeldahl method AOAC 2000. The concentration of protein in the digested sample was determined spectrophotometrically and calculated as

$$\% \text{ crude protein} = \frac{(\text{Titre of sample} - \text{blank}) \times 0.01 \times 14.007 \times 6.25}{10 \times \text{weight of sample}} \times 100$$

Determination of Fiber *(AOAC, 1986)*

When a fat free sample of weighed 2g taken in the triplicate and digest with 200 ml of 1.25% sulphuric acid by gentle boiling for half an hour. Now the contents of the sample filtered and policed by a muslin cloth under suction. Then it washed the residue free of acid using hot distilled sodium hydroxide. Digest the content again for half an hour, filtered and wash free of alkali using hot distilled water. Dry the residue in an oven overnight at 105ºC. Now weigh it and

place in the muffle furnace at 600ºC for four hrs. The loss in weight after ignition represents the crude fiber in the sample.

$$\% \text{ of Fiber} = \frac{(W2 - W1) - (W3 - W1)}{W}$$

Where,

W =Weight of sample

W1 = Weight of crucible

W2 = Weight of empty crucible + sample before ignition

W3 = Weight of empty crucible + sample after ignition

Swelling capacity (SWC):

SWS was measured using the bed volume technique described by Kuniak and Marchessault (1972). Approximately 0.2 g of the sample material was weighed into a 50 ml graduated glass cylinder. After making up the volume to 50 ml with de-ionized water and the mixtures were then vigorously stirred, the material was left overnight at room temperature for equilibration. The volume of the swollen sample was noted. Results of SWC were expressed as the ratio of volume (mL) of swollen sample to the weight (g) of dry initial sample. Triplicate measurements were taken for all WHC,OHC and SWC.

Physical characteristics for cakes:

The weight (g) for cake was determined individually within one hour after baking the average was recorded. The volume (cm3) of different types of produced cakes was determined by rape seeds displacement method according to *(AACC, 2000)*. Specific volume was calculated according to the method of (AACC, 2000) using the following equation

Specific volume = Volume (cm3)/Weight (g).

Texture characteristics:

The texture of the cakes was measured objectively using food texturometer (TAHDi, Stable Micro System, UK) as per the standard *(AACC 2000).* A test speed of 2.0 mm s-1 were used. A 35 mm diameter cylinder aluminum probe (P-35), was used to measure the required compression force. Force required to compress 25% of the cake slice (2.54 cm) was recorded. All measurements were performed at ambient temperature 25±2°C according to Gomez et al. (2007).

Mechanical properties measurements:

All mechanical properties were measured using the Instron Universal Testing Machine (Model 4401) equipped with: 5-mm diameter tip probe for penetration test (with 100, 500, 1000 and 5000 N load cell). All testing was performed at room temperature (25±2°C).

Penetration test (PT):

Each piece of tested cakes was placed in a hole of the beveled ring. The pin penetrated with a constant speed 10 mm.min-1 into each piece of cakes tested. Three penetration points at different parts for each piece of cakes and 5 pieces for each sample were taken for each test condition, recording the force profile at 1 cm of probe penetration. Force – deformation curves were recorded and hardness was derived as indicators of textural properties. Each sample was used for only one measurement *(Femenia et al., 1997).*

Mechanical measurements analysis:

1- The force corresponding to the maximum puncture is defined as the maximum force (Fmax). The maximum puncture force (Fmax) was measured in Newton's (N), as mentioned by *(Sharoba et al. 2012)* and *(Saleh et al. 2012).*

2- Maximum deformation: the distance from beginning to distance at maximum force.

3- Hardness = Maximum force (N) / Maximum deformation (mm), as mentioned by Sharoba et al. (2012) and Saleh et al. (2012).

Sensory analysis:

Sensory evaluation of cakes were carried out in a standardized test room in morning sessions (11:00-13:00 h) by a 12 trained sensory panel, and were carried out by a properly well trained panel of 12 panelists. They were selected if their individual scores in 10

Different tests showed a reproducibility of 90%.The 12 member internal panel evaluated on a five point hedonic scale, scoring was based on a 100 point scale (10-100) where (90-100) = excellent,(70-80) = very good, (50-60) = good, (30-40) =fair and (10-20) = poor. Mineral water was used by the panelists to rinse the mouth between samples, according to the method described by (AACC, 2000), cake samples were left to cool at room temperature for 1 hr. after baking. Then cake was cut with a sharp knife and subjected to panel test. Cells 30 (uniformity 10, size of cells 10, and thickness of walls 10), grain 20, texture 30 (moistness 10, tenderness 10, and softness 10), crumb color 10, flavor 10 and overall acceptability 100 degrees.

Microbiological Analysis

Standard Plate Count (SPC) ***(Govt. Of India, 2012)***

The following media and reagents (1-4) are commercially available and are to be prepared and sterilized according to the manufacturer's instructions.

- Plate count agar (PC)/Nutrient Agar (NA)
- Peptone water diluent (0.1%)(PW)
- Sodium 2, 3, 5 triphenyltetrazolium chloride, TTC (0.1%) (optional)
- 1N HCl and 1N NaOH
- pH meter or paper capable of distinguishing to 0.3 to 0.5 pH units within a range of 5.0 to 8.0 Stomacher, blender or equivalent for sample preparation/homogenization.

- Incubator capable of maintaining the growth temperature required for the specific type of aerobic bacteria being enumerated (i.e. for psychrophilic bacteria: 15 – 20°C, for mesophilic bacteria: 30 – 35°C, and for thermophilic bacteria: 55°C) and 45°C waterbath
- Colony counting device (optional)

Coliform Count Analysis *(Govt. Of India, 2012)*

The following media and reagents are commercially available and are to be prepared and sterilized according to the manufacturer's instructions.

- Violet Red Bile Agar
- Peptone water diluent (0.1%)(PW)/ N-Saline
- pH meter or paper capable of distinguishing to 0.3 to 0.5 pH units within a range of 5.0 to 8.0 Stomacher, blender or equivalent for sample preparation/homogenization.
- Incubator capable of maintaining the growth temperature required for the specific type of aerobic bacteria being enumerated i.e. at 35°C.
- Colony counting device (optional)

Yeast and Mould Count *(Govt. Of India, 2012)*

The following media and reagents are commercially available and are to be prepared and sterilized according to the manufacturer's instructions.

These agars are suitable for yeast and mould count in food products:

- Chloramphenicol Yeast extract Glucose Agar (CYGA)
- Potato dextrose agar with chloramphenicol (PDA-C)
- 20% sucrose (diluent additive for osmophiles)
- Malt extract agar containing 50% (w/w) sucrose

Other materials:

- Peptone water (0.1%) (PW)
- 1N HCl and 1N NaOH
- Gram stain solutions
- Stomacher, blender or equivalent

- pH meter or paper capable of distinguishing to 0.3 to 0.5 pH units within a range of 5.0 to 8.0
- Light microscope
- Colony counting device (optional)
- Incubator (darkened) capable of maintaining 22 to 25°C

Chapter-6 EXPECTED RESEARCH OUTCOMES

1. A strategic optimized process for the production of Cakes from multigrain flour and pomace.
2. Achieved or obtained product will be having a high shelf life, better sensory characteristics and a good overall acceptability.

CHAPTER-7 RESULT AND DISCUSSION

The study which is being done on 'Development of multigrain flour cakes incorporated with fruit and vegetable pomace' in Department of Food Science and Technology, Lovely Professional University, Punjab, India aims to study the nutritional properties of three different flour samples along with pomace of pineapple and beetroot which are the basic raw materials utilized in further cake preparation, these properties have been later on compared with the standards found by individuals who have earlier performed work on it.

Table 7.1 Results for different flours:

Sr. no	Sample name	Moisture content (%)	Ash content (%)	Fat Content (%)	Fiber content (%)	Protein content (%)
1	Wheat flour	13.4 ± 0.02	1.2 ± 0.02	1.6 ± 0.09	4.6± 0.013	13 ± 0.23
2	Buckwheat flour	11.5 ± 0.03	1.8 ± 0.04	2.9 ± 0.02	3.1 ± 0.36	14.6 ± 0.1
3	Quinoa flour	9.1 ± 0.02	3.2 ± 0.09	5.3 ± 0.03	8.3 ± 0.06	9 ± 0.05

Wheat flour was found to have higher amount of moisture content as compared to buckwheat flour and quinoa flour while quinoa flour exhibited to have a higher proportion of ash content, next to this the fat and fiber content in quinoa to were found to be in higher proportion as compared to wheat and buckwheat flour.

Table 7.2 Results for pomace:

Sr. no	Sample name	Moisture content (%)	Ash content (%)	Fat Content (%)	Fiber content (%)	Protein content (%)
1	**Pineapple pomace**	24.7 ± 1.4	2.6 ± 0.3	0.5 ± 0.2	48 ± 2.1	4.37 ± 0.22
2	**Beetroot pomace**	28.6 ± 1.66	2.8 ± 0.4	1.05 ± 0.1	43.5 ± 2.6	8.7 ± 0.14

The moisture, ash, protein and fat content in beetroot pomace was found to be relatively high in beetroot pomace as compared to pineapple pomace while the amount of fiber content was less in beetroot pomace as compared to pineapple pomace.

CHAPTER-8 REFRENCES

1. A.A.C.C., Approved methods of American Association of Cereal Chemists (10th ed.). published by American Association of Cereal Chemists, Ins. Saint Paul, Minnesota, 2000, USA.
2. A.O.A.C., Official Methods of Analysis (17th ed.). Arlington, VA: Association of Official Analytical Chemists, AOAC International, 2000
3. Abugoch, Lilian, et al. "Stability of quinoa flour proteins (Chenopodium quinoa Willd.) during storage." *International journal of food science & technology* 44.10 (2009): 2013-2020.
4. Alvarez-Jubete, L., Arendt, E.K., Gallagher, E. Nutritive value and chemical composition of pseudocereals as gluten-free ingredients. International Journal of Food Sciences and Nutrition, vol.60, pp.240-257, 2009.
5. Alvarez-Jubete, L., Arendt, E.K., Gallagher, E. Nutritive value and chemical composition of pseudocereals as gluten-free ingredients. International Journal of Food Sciences and Nutrition, vol.60, pp.240-257, 2009.
6. Alvarez-Jubete, L., Arendt, E.K., Gallagher, E. Nutritive value of pseudocereals and their increasing use as functional glúten-free ingredients. Trends in Food Science and Technology, vol.21, pp.106-113, 2010.
7. Berghofer, E. 2000. Brot als funktionales Lebensmittel. Getreide Mehl Brot 54(3):175-179.
8. Berti, C., Riso, P., Monti, L., Porrini, M. *In vitro* starch digestibility and *in vitro* glucose response of gluten-free foods and their gluten counterparts. European Journal of Nutrition, vol.43, no.4, pp.198-204, 2004.
9. Bugusu, B. A., Campanella, O. and Hamaker, B. R. 2001. Improvement of sorghum-wheat composite dough rheological properties and breadmaking quality through zein addition. Cereal Chemistry 78(1): 31-35.
10. Campbell C.G. (1997): Buckwheat *Fagopyrum esculentum* Moench. International Plant Genetic Resources Institute, CAB International.
11. Christa, Karolina, and Maria Soral-Śmietana. "Buckwheat grains and buckwheat products–nutritional and prophylactic value of their components–a review." *Czech J Food Sci* 26.3 (2008): 153-162.

12. Christa, Karolina, and Maria Soral-Śmietana. "Buckwheat grains and buckwheat products–nutritional and prophylactic value of their components–a review." *Czech J Food Sci* 26.3 (2008): 153-162.
13. Danz, R.A., Lupton, J.R. Physiological effects of dietary amaranth (*Amaranthus cruentus*) on rats. Cereal Food World, vol.37, pp.489–494, 1992.
    Database – Agriculture, 2013. URL <http://faostat.fao.org/>. Accessed 10.05.13.
14. Dworshak, E.: CRC Crit. Rev. Food Sci. 13 (1980), 1-40.
15. Eastwood, M. A.: Ann. Rev. Nutr. 12 (1992), 19-65.
16. Fabjan N., Rode J., Košir I.J., Zhang Z., Kreft I.(2003): Tatary buckwheat (*Fagopyrum tartaricum* Gaertn.) as a source of dietary rutin and quercetin. Journal of Agricultural and Food Chemistry, 51:6452–6455.
17. FAO (Food and Agriculture Organization of the United Nations). FAOSTAT Statistics
18. Femenia, A., et al. "Physical and sensory properties of model foods supplemented with cauliflower fiber." *Journal of food science* 62.4 (1997): 635-639.
19. Fondroy, E. B., P. J. White, and K. J. Prusa: Cereal Chem. 66(1989), 402-404.
20. Fornal Ł. (1999): Chemizm nasion gryki i kierunki spożywczego wykorzystania. Biuletyn Naukowy, **4**:7–17.
21. Gorinstein, S., Medina-Vargas, O., Jaramillo, N., Arnao Salas, I., Martinez Ayala, A., Arancibia-Avila, P., Toledo, F., Katrich, E., Trakhtenberg, S. The total polyphenols and the antioxidant potentials of some selected cereals and pseudocereals. European Food Research and Technology, vol.225, pp.321-328, 2007.
22. Grobelnik, M.S., Turinek, M., Jakop, M., Bavec, M., Bavec, F. Nutrition value and use of grain amaranth: potential future application in bread making. Agricultura, no.6, pp.43-53, 2009.
23. Hager, Anna-Sophie, et al. "Nutritional properties and ultra-structure of commercial gluten free flours from different botanical sources compared to wheat flours." *Journal of Cereal Science* 56.2 (2012): 239-247.
24. Hasmadi, M., Siti Faridah, A., Salwa, I., Matanjun, P., Abdul Hamid, M. and Rameli, A. S. 2014. The effect of seaweed composite flour on the textural properties of dough and bread. Journal of Applied Phycology 26:1057–1062.

25. Hugo, L. F., Rooney, L. W. and Taylor, J. R. N. 2000. Malted sorghum as a functional ingredient in composite bread. Cereal Science 79(4): 428-432.
26. Johnson, J. M., and C. H. Harris: Cereal Chem. 66 (1989), 158-161
27. Kaushal NK, Joshi VK (1995) Preparation and evaluation of apple pomace based cookies. Indian Food Packer 49(5):17–24
28. Kim S.L., Kim S.K., Park C.H. (2004): Introduction and nutritional evaluation of buckwheat sprouts as a new vegetable. Food Research International, **37**:319–327.
29. Koziol, M. J. Chemical composition and nutritional evaluation of quinoa (*Chenopodium quinoa* Willd). Journal of Food Composition Analysis, no.5, pp.35-68, 1992.
30. Koziol, M. Quinoa: A potential new oil crop. In: "New crops". J. Janick and J.E. Simon, Eds., Wiley, New York, pp.328-36, 1993.
31. Larrauri, J. A., Ruperez, P., & Calixto, F. S. (1997). Pineapple shell as a source of dietary fiber with associated polyphenols. Journal of Agriculture and Food Chemistry, 45, 4028–4031.
32. Li S., Zhang Q.H. (2001): Advances in the development of functional foods from buckwheat. Critical Reviews in Food Science and Nutrition, **41**: 451–464.
33. Maćkowiak, Kalina, Natalia Torlińska-Walkowiak, and Barbara Torlińska. "Dietary fibre as an important constituent of the diet." Advances in Hygiene & Experimental Medicine/Postepy Higieny i Medycyny Doswiadczalnej 70 (2016).
34. Manoj Panwar, Prof. (Dr.) Arif. A. Broadway. "development of value added biscuits by incorporation of fruit pomace and other ingredients: a survey" International Journal of Advanced Technology in Engineering and Science Volume No.03, Issue No. 02, February (2015).
35. Noorfarahzilah, M., et al. "Applications of composite flour in development of food products." *International Food Research Journal* 21.6 (2014).
36. Paredes-López O, Osuna–Castro JA (2006) In: Shetty K, Paliyath G, Pometto AL, Levin RE(eds) Functional foods and biotechnology. 650 p, Marcel Dekker Inc., New York
37. Pomeranz Y., Sachs I.B. (1972): Scanning electron microscopy of buckwheat kernel. Cereal Chemistry, **49**: 23–25.
38. Qian, J.Y., Kuhn, M. Characterization of *Amaranthus cruentus* and *Chenopodium quinoa* starch. Starch/Starke, vol.51, no.4, pp.116-120, 1999.

39. Qureshi, A.A., Lehman, J.W., Peterson, D.M. Amaranth and its oil inhibit cholesterol biosynthesis in 6-week-old female chickens. Journal of Nutrition, vol.126, no.8, pp.1972–1978, 1996.
40. Ritika, B. Y., S. Y. Baljeet, and K. Reena. "Effect of incorporation of carrot pomace powder and germinated chickpea flour on the quality characteristics of biscuits." (2014).
41. Rosell, C.M., Cortez, G., Repo-Carrasco, R.). Breadmaking use of the Andean crops quinoa (Chenopodium quinoa), kañiwa (Chenopodium pallidicaule), kiwicha (Amaranthus caudatus), and tarwi (Lupinus mutabilis). Cereal Chemeistry, vol.86, no.44, pp.386-392, 2009.
42. Ruales, J., Nair, B.M. Nutritional quality of the protein in quinoa (*Chenopodium quinoa*, Willd.) seeds. Plant Foods for Human Nutrition, vol.42, pp.1-11, 1992.
43. Sahni, Prashant, and D. M. Shere. "Physico-chemical and sensory characteristics of beet root pomace powder incorporated fibre rich cookies." International Journal of Food and Fermentation Technology 6.2 (2016): 309.
44. Schoenlechner, R., Siebenhandl, S., Berghofer, E. Pseudocereals. In: Arendt, E.K., Bello, F.D. editors. Gluten-free cereal products and beverages. Academic Press. Chapter 7. pp. 149-190, 2008.
45. Selani, Miriam Mabel, et al. "Characterisation and potential application of pineapple pomace in an extruded product for fibre enhancement." *Food chemistry* 163 (2014): 23-30.
46. Selani, Miriam Mabel, et al. "Characterisation and potential application of pineapple pomace in an extruded product for fibre enhancement." *Food chemistry* 163 (2014): 23-30.
47. Sharoba, A. M., M. A. Farrag, and A. M. Abd El-Salam. "Utilization of some fruits and vegetables waste as a source of dietary fiber and its effect on the cake making and its quality attributes." *Journal of Agroalimentary Processes and Technologies* 19.4 (2013): 429-444.
48. Sharoba, A. M., M. A. Farrag, and A. M. Abd El-Salam. "Utilization of some fruits and vegetables waste as a source of dietary fiber and its effect on the cake making and its quality attributes." Journal of Agroalimentary Processes and Technologies 19.4 (2013): 429-444.
49. Shittu, T. A., A. O. Raji, and L. O. Sanni. "Bread from composite cassava-wheat flour: I. Effect of baking time and temperature on some physical properties of bread loaf." *Food Research International* 40.2 (2007): 280-290.

50. Singh, B., and M. P. Narang. "Studies on the rumen degradation kinetics and utilization of apple pomace." *Bioresource technology* 39.3 (1992): 233-240.
51. Skrabanja, Vida, et al. "Nutrient content in buckwheat milling fractions." *Cereal Chemistry* 81.2 (2004): 172-176.
52. Soral-Śmietana M. (1987): Kompleksy amylozowo – tłuszczowe w zbożowych produktach ekstrudowanych. Przemysł Spożywczy, **41**: 288–290.
53. Šramková, Zuzana, Edita Gregová, and Ernest Šturdík. "Chemical composition and nutritional quality of wheat grain." *Acta Chimica Slovaca* 2.1 (2009): 115-138.
54. Sreenath, Hassan K., et al. "Characteristics of some fiber incorporated cake preparations and their dietary fiber content." *Starch‐Stärke* 48.2 (1996): 72-76.
55. Steadman K.J., Burgoon M.S., Lewis B.A., Edwardson S.E., Obendorf R.L. (2001): Buckwheat seed milling fraction: description, macronutrient composition and dietary fibre. Journal of Cereal Science, **33**: 271–278.
56. Stempińska K., Soral-Śmietana M. (2006): Składniki chemiczne i ocena fizykochemiczna ziarniakow gryki – porownanie trzech polskich odmian. Żywność Nauka Technologia Jakość, **13** (2/47) Supplement: 348–357.
57. Survey on wastage of fruit pomace among selected fruit juice outlets V Vasanthi,P and Saradha Ramadas International Journal of Science andResearch, 3 (10), 2013-2015
58. Valencia-Chamorro, S. A. Quinoa. In: Caballero B. Encyclopedia of Food Science and Nutrition, vol. 8. Academic Press, Masterdam. pp.4895-4902, 2003.
59. Wade, Peter. Biscuits, cookies, and crackers. Elsevier applied science, 1988.
60. Wei Y., Zhang G.Q., Li Z.X. (1995): Study on nutritive and physico-chemical properties of buckwheat flour. Nahrung, **39**: 48–54.
61. Wilderjans, Edith, et al. "The role of gluten in a pound cake system: A model approach based on gluten–starch blends." Food Chemistry 110.4 (2008): 909-915.
62. Yan, Huitong. *Vacuum belt dried apple pomace powder as a value-added food ingredient*. Diss. University of Georgia, 2012. {singh narang}