DEVELOPMENT OF FUNCTIONAL FOODS FROM UNDERUTILIZED VEGETABLE CROPS

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By

JYOTI SINGH

(Registration No.: 11308193)

Under the Supervision of

Er. Sawinder Kaur (15695)

Assistant Professor and Coordinator (Food Technology and Nutrition)

School of Agriculture

LOVELY PROFESSIONAL UNIVERSITY

PHAGWARA, PUNJAB, INDIA

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LOVELY PROFESSIONAL UNIVERSITY

PHAGWARA , PUNJAB, INDIA

CERTIFICATE

This is to certify that work embodied in the Dissertation-II report entitled "**Development of functional foods from underutilized vegetable crop"** has been carried out by **Jyoti Singh, Registration No.: 11308193** 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 the pre-dissertation has ever been submitted for any other degree or diploma. The work has been carried out by her at the School of Agriculture, Lovely Professional University, Phagwara, Punjab, India. She fulfilled the requirement for the award of the degree Master of Science in Nutrition and Dietetics.

Date: **Er. Sawinder Kaur(15695)**

Assistant Professor and

Coordinator (Food Technology and

Nutrition)

School of Agriculture

Lovely Professional University

Phagwara, Punjab, India.

ABSTRACT

The effect of black carrot powder incorporation (5%, 10%, 15% and 20%) on quality of wheat noodles was studied. The quality parameters studied were cooking, physico-chemical, nutraceutical and sensory properties. One way ANOVA was used to establish the differences among different treatments. As black carrot powder level increased fat, ash, crude fibre and sodium contents of noodles increased. Significant increase in water absorption capacity (WAI) was observed ($p \leq 0.05$) at 10 and 15% was observed. Black carrot noodles were found to be good sources of anthocyanin (3.8 to 10.9 mg/100 g) and flavonoids (3.82-47.76 mg QE eq./100 g). Black carrot noodles also showed higher antioxidant capacity measured by DPPH radical scavenging (13-82.5%). Black carrot powder addition caused significant differences in gruel solid loss and water uptake per cent of noodle samples ($p<0.05$). Overall acceptability scores of control and in only the noodle with 5% black carrot powder (BCP) were found statistically ($p<0.05$) similar. Especially, the usage of 5% BCP in noodle formulation gave satisfactory results in terms of acceptability.

Keywords: black carrot powder, Anthocyanin, Antioxidants, Flavonoids, Nutraceutical.

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Above all I offer countless thanks to the almighty as this modest piece of work has been made possible by his immense grace.

Jyoti Singh

DECLARATION

I hereby declare that the work presented in Dissertation-II entitled "**Development of functional foods from underutilized vegetable crop"** 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. Sawinder Kaur (15695),** Assistant Professor and Coordinator (Food Technology) of School of Agriculture, Lovely Professional University, Phagwara, Punjab, India, for the award of the degree Master of Science in Nutrition And Dietetics.

Date: **Jyoti Singh**

Place: Phagwara, Punjab (India) **Registration No.** 11308193

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

Date: **Er. Sawinder Kaur (15695)**

Place: Phagwara, Punjab (India)

Assistant Professor and Coordinator

(Food Technology and Nutrition)

School of Agriculture

Lovely Professional University

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TERMINOLOGY

α	Alpha
AFB	Amaranth flour blend
ANOVA	Analysis of variance
BSA	Bovine Serum Albumin
BCP	Black carrot powder
β	Beta
Ca	Calcium
Cu	Copper
DPPH	2,2-Diphenyl-1-picrylhydroxyl
ºC	Degree celcius
Fe	Iron
HPLC	High performance liquid chromatography
K	Potassium
Mg	Magnesium
µg	Micro gram
Na	Sodium
OD	Optical density
OAC	Oil absorption capacity
P	Phosphorous
ppm	Parts per million

RTC	Ready to cook
RTE	Ready to eat
SPF	Sweet potato flour
WAI	Water absorption index
WF	Wheat flour
WSI	Water solubility index

CHAPTER-1

INTRODUCTION

The carrot (*Daucus carota* L.) belong to the family Apiaece. It comes in the family of celery, coriander, fennel, parsnips and parsley. Carrot which is grown during the winter season in tropical regions and during the summer season in temperate countries is one of the most cool season root vegetables and is grown extensively in various countries. Carrots provide valuable components which are vital for the development and proper functioning of the human body (Zielinska and Markovsk, 2010). The carrot originated in Asia. Initially, its roots were long and thin, and either purple or yellow in colour. (Beceanu and Chiriac, 2007). It requires less temperature for its growth, so, it is specific for the temperate climate.

Carrot is an important root vegetables which shows high level of functional compounds like carotenoids and dietary fibers . The consumption of carrot and its products has increased due to awareness about its use as an important source of natural antioxidants (Ambeden *et al.,* 1971 and Alklint, 2003). Carrot juice has the therapeutic property which improves the boosting of immunity, helps to heal minor wounds, injuries, reduce the risk of heart disease and blood pressure. It cleans the liver by excreting fats and bile, helps to fight anaemia, improves eye health, reduces the risk of stroke, heart disease, high blood pressure and some types of cancer (Wrolstad, 2004; Bahkru, 1993)

1.1 ORIGIN AND PRODUCTION

Black carrot was firstly originated in Middle Asia 3000 years ago. Till twelth century, it was not cultivated in Europe and was measured to be Archetype among all orange carrots which were bred by Dutch growers in 1750 (Unal And Billur, 2009).

28 millions tonnes of carrot and turnips production was estimated in world during year 2009 (FAO Statistics 2009).

China, Russia and the United States contributes almost 50% of the world carrot crop and are the top three producer of carrot globally, and (Arscott *et al.,*2002).

1.2 COMPOSITION AND NUTRITIVE VALUE OF CARROT

Carrots contains considerable amount of vitamins B_1, B_2, B_6 and B_{12} besides being rich in β-carotene and are highly nutritious and inexpensive. High carotenoid intake helps in lowering risk of many cancers especially the prostate cancer. Carrots are highly rich in vitamin A which act as an antioxidant and is key to the growth and repair of tissues and helps the body to fight against infections, keep eyes healthy, nourish epithelial tissues in the lungs, as well as of the skin (Singh *et al.,* 2006).

1.2.1 COMPOSITION

Gopalan *et al*., (1991) reported the proximate composition of carrot as moisture (86%), carbohydrate (10.6%), crude fiber (1.2%), minor quantities of protein (0.9%) and fat (0.2%), total ash (1.1%) and minerals such as Ca (80 mg/100 g), Fe (2.2 mg/100 g) and P (53 mg/100 g) .The moisture content of carrot varieties ranges from 86 to 89% (Anon 1952; Howard *et al.,* 1962; Gill and Kataria 1974; Gopalan *et al*., 1991). Carrots are good source of carbohydrates and minerals . About 10% carbohydrates are present in the edible portion of carrots with soluble carbohydrates ranging from 6.6 to 7.7 g/100 g (Howard *et al.,* 1962). The amount of reducing sugar ranges from 1.67–3.35% , non reducing from 1.02–1.18% and total sugars from 2.71–4.53% total sugars in 6 cultivars of carrot studied by Kaur *et al*., 1976. The reducing sugars accounted for 6–32% of free sugars Simon and Lindsay (1983) . The free sugars identified are glucose, sucrose, fructose and xylose (Kalra *et al*., 1987). The crude fiber consist of 71.7, 15.2 and 13.0% cellulose, lignin and hemicellulose, respectively (Kochar and Sharma, 1992). The characteristic taste of carrot is because of the presence of glutamic acid and free amino acids. The maximum anthocyanins content depending upon the color vary from trace amounts 1,750 mg/kg in black carrots (Mazza and Minizte, 1993).

1.2.2 PIGMENTS AND OTHER COMPOUNDS

Carotenoids imparts yellow, orange and red colours in carrots, while anthocyanins are responsible for the colour of purple carrots only (Sharma *et al*., 2011).

1.2.3 DIETARY FIBRE

Dietary fiber is the indigestible matter found in the structural components of plants. They have no calorific value as they are not absorbed by the body, however, fibres helps in maintaining the human health in many ways. They are associated with prevention of various clinical conditions such as constipation, defence against heart diseases, reducing high levels of and prevention of certain forms of cancers and regulation of blood sugar levels (Anderson *et al*., 1994; Gorinstein *et al*., 2001; Villanueva-Suarez *et al*., 2003). Carrots are rich source of dietary fibres (Bao and Chang 1994) and these fibres play a significant role in maintain human health. Nawirska and Kwasniewska (2005) classified the dietary fibre constituents of fresh carrot on dry weight basis. It was found to be as mentioned; pectin (7.41%), hemi-cellulose (9.14%), cellulose (80.94%) and lignin (2.48%).

1.3 FUNCTIONAL PROPERTIES

Black carrot has good amount of anthocyanin content. Anthocyanins belong to family of flavonoids. The most important properties of anthocyanin pigment are quenching of free radical and antioxidant capacities. Black carrot phenolics possesses high antioxidant activity and contain high nutraceutical value (Elham and Shahrilar, 2013).

Carotenoids are large group of phytochemicals that comprises over 700 compounds in nature which provides colour and numerous properties to the fruits and vegetables. Carrots are rich in carotenoids. Black carrot showed optimum amount of predominant A carotenes that is α and β- carotene that accounts for 13%-40% and 45%-80% of the carotenoids (Simon and Wolff, 1987).

Table 1- Carotenoid content of black carrot (Total ppm)

Carrot colour	α-carotene	β-carotene	Lutein	Lycopene
Purple-orange	62-100	65	8-10	-nd-

(By- Grassmann *et al*., 2007)

There is a large variation in the total anthocyanin concentration in the roots of purple carrots. Total anthocyanin content dark purple carrot was found to be 350 mg/100g fresh weight (Kanmerer *et al.,* 2004).

As black carrot is rich in antioxidants such as vitamin C and E but it have also attracted attention due to presence of phenolic compounds which significantly contribute to the antioxidant capacity (Algarra *et al.*,2014). Besides this, it has been shown that black carrot also contains good amount of phenolic acids including caffeic acids and hydroxycinnamates (Kamerer *et al.,* 1971).

1.4 UTILISATION

1.4.1 PROCESSING/ CANNING

Numerous processed product of carrots are manufactured using several processing and preservation techniques such as canning, dehydration, preservatives in juice and beverages, confection like sugar candy and preserves and various traditional techniques likes picking and freezing are used to make intermediate moisture products and culinary products like halwa (Kalra *et al*., 1987). For canning tender and small carrots are preferred as firmness of carrot helps in the canning process. Ambadan and Jain (1971) reported that better quality canned product could be obtained by blanching the diced carrot at 71 °C for 3–6 min han that of blanching at 87.5 °C for a short time. Canned carrot products in form of diced, halved, quartered or whole are available. With the use of chemicals and heat treatment colour of canned carrots could be enhanced Chiang *et al*., (1971).

1.4.2 JUICE

Blended juices with incorporation of carrots as basic ingredients are consumed popularly as non-alcoholic beverages around the worldwide. There is a gradual increase in carrot juice consumption amongst various countries (Schieber *et al.*, 2001) especially in Germany.

1.4.3 PICKLES

With the help of lactic acid fermentation, carrots could be pickled. Pruthi *et al.* (1980) reported long term storage of carrots is possible at room temperature in good situation for at least 6 months in non air tight containers through acidified brine solution of potassium metabisulfite and can be used for the preparation of good quality pickles.

1.4.4 BY PRODUCT UTILISATION

About 50% of the raw material from carrot juice production such as pomace is utilized as feed or manure. However, this product is rich in numerous valuable compounds such as carotenoids, dietary fibre (Nocolle *et al*., 2003), uronic acids and neutral sugars (Stoll *et al*., 2003). Much efforts have been concentrated on utilizing the carrot pomace in foods such as bread, cake, dressings, pickle, fortified wheat bread (Filipini 2001), production of functional drinks (Oshawa *et al.*, 1995) and preparation of high fiber biscuits (Kumari and Grewal, 2007).

1.5 FORTIFICATION OF BLACK CARROT AND ITS BY PRODUCTS

Black carrot can be added to many products to impart nutritional qualities, color etc. Fortification is the process of addition of nutrients directly to the food for the improvement of its quality or for the delivery of nutrient to group of people or community to correct the existing nutritional deficiency.

NOODLES

Noodles are type of staple food made from unleavened dough of various types. It has many shapes waves, helices, tubes, strings or shells or folded over. Noodles can be fortified with black carrot to add good amount of anthocyanin and dietary fiber which will increase its binding properties. Noodles can also be referred to as a type of pasta, generally made from flour with the addition of salt and water. However, farina or semolina could be also used (Hosoney, 1998). Noodles and pasta differ in their processing technique and compostion. Wheat flour is added as main ingredient in noodle products by a process of cutting and sheeting whereas coarse semolina milled from durum wheat are used to manufacture pasta products by the process of extrusion (Nagao 1996).

ICE CREAM

Ice cream is a frozen food usually made from dairy products can be combined with fresh fruits and other ingredients. The mixtures of chosen ingredients is stirred continuously and slowly taking care that no large ice crystal are formed while cooling and sufficient air is incorporated in it. Ice cream can be fortified with black carrot to increase its nutritional qualities, antioxidant properties and colour.

JAMS AND MARMALADES

Anthocyanin in black carrot can be used as a natural colorant in the manufacture of confectionery products like jams, jellies, preserves and frozen desserts. (Birks 1999). Black carrots are rich in nutraceutical properties (Alasalvar *et al*., 2001). Enhancement in the health preventing effects can be achieved by the addition of anthocyanin sources (cyanidin, delephindin and petunidin). Due to presence of cyandin based pigments, purple carrot are used to develop various health promoting nutraceutical foods.

POMACE

Carrot pomace which is rich in fiber is the left over product during juice preparation. The insoluble fiber-rich fractions (IFrF) of carrot can act as hypocholesterolemic functional ingredient in fiber-rich food products. HSU *et al*., 2006 reported significant reduction in cholesterol levels in population with fiber-free diets. Ascorbic acid and β-carotene in the dried carrot pomace ranged from 13.53 to 22.95 mg and 9.87 to 11.57 mg and per 100 g respectively (Upadhyay *et al*., 2008).

NATURAL COLORANT

Recently, purple or black carrot has received so much of interest as a source of natural food color, because of the legal restrictions for artificial or synthetic food colors and high consumer demand for natural colors. Presence of high levels of anthocyanin in carrots, gives it an attractive bluish purple color. Black carrot has high pH, light, and heat stability hence they can be used as a natural food colorant (Kirca *et al*., 2006).

CHAPTER- 2

REVIEW OF LITERATURE

Nutraceuticals, sometimes referred as ―functional foods, are the dividing line between medicine and food. Functional foods provide optimum amount nutrition in the form of macronutrients proteins, carbohydrates, fats and micronutrients such as vitamins which are essential for better health and survival. Therefore, nutraceutical are functional food which helps in the prevention or treatment of diseases or disorders other than deficiency conditions like anemia. Thus, a functional food for one consumer may act as nutraceutical for another. Black carrot can be used for the production of many products which can act as a nutraceutical and can help in the cure of many diseases (Choudhary and Grover, 2012).

4.1. EXTRUDATES

Food extrusion is a process by which a set of mixed ingredients are forced through an opening in a perforated plate and is then cut by specified size of blades into required shape. The machine which forces the mixture to come through the die is an extruder and the mix is known as the extrudate. Food products manufactured using extrusion generally has high starch and fibre content. These include breads, pasta, ready to eat snacks, pre-made cookies dough, etc.

Sulaeman *et al.,* 2001 worked upon deep fried carrot chips. They investigated carotenoid content as affected by deep frying, types of oils and temperatures. No significant differences was found in the retention of of α-carotene, β-carotene, total carotenoids and vitamin A among the chips fried in different types of oil. Lowest retention in α-carotene, β-carotene, total carotenoids were observed in chips fried at 185°C. Crispiness of the fried chips was affected by the temperature of frying. They concluded that as frying temperature increased the carotenoid contents, redness (a) value, hardness value decreased and darkened the color of chips.

Kumar *et al.,* 2010 worked upon the development of extruded product of carrot pomace. Equal ratios of dehydrated carrot pomance and pulse powder (CPPP) mixture were added to make extrudates. The extrudates were optimised at the pomace content 16.5 % by numerical optimization. Carrot pomace incorporation proved to be acceptable at the level of

8.25% pomace and therefore, was concluded as a good source of dietary fibre and vitamins encrichment.

Hussain *et al.,* 2013 worked upon carrot pomace based unfried, fried and seasoned extrudates. They reported changes in cellular component of the fried, unfried and seasoned extrudates and their structural orientation. Hardness of the extrudates increased from 13.78 to 45.80 N for fried and 8.62 N to 21.85 for seasonal extrudates respectively. They observed decrease in L- value from 66.22 to 62.53, 38.58 to 36.38 and 34.95 to 33.78 for unfried, fried and seasonal extrudates respectively.

Singh *et al.,* 2006 explored the possibility of utilisation of pomace for the manufacture of value added products. The average particle size of pomace for incorporation was selected in the range of 2-3nm and Gazrella was prepared by rehydrating the osmotically dehydrated carrot pomace in limited volume (1:1) hot/ boiling water for 10-15 minutes. Increase in convective dehydration time and lowering of drying rates was obtained at osmotic pretreatment of carrort pomace before convective dehydration. A possible shelf life of 6 months at room temperature was thus predicted at room temperature.

Pardeshi *et al.,* 2013 worked upon the ready-to-cook Mung (*Vigna radiata L.*) nuggets. Mung flour was added with wheat flour for the development of cold extruded Ready-to-cook (RTC) mung nuggets. The extrudates were steamed at cooking pressure and then dried for further experiment. The observed minimum leaching loss and maximum overall acceptability were found to be at 24% wheat content, 36.28% wet basis initial moisture content. The final moisture content observed was 7.73% wb. These mung nuggets could be prepared in one third time than that required for preparation of traditional mung nuggets (wadi), besides reduced cost of processing. These could be stored for 114 days at 30 °C.

Srikanth *et al.*, 2013 developed the guava pomace and rice flour based extrudates. Guava pomace (residue) is incorporated into ready-to-eat expanded product and their effect on functional properties was studied. The different independent variables taken for the preparation of extrudates were moisture content (17-21%) on wet basis, temperature (110-130°C), screw speed (270-310 rpm). The observed results was increased feed moisture content which shows that the extrudates developed were of lower expansion, higher density, higher WAI, lower WSI and higher hardness. The addition of guava pomace resulted in increase in WAI, hardness and decrease in bulk density, expansion as well as WSI. The product was optimised at guava pomace content of 10% in rice flour, moisture content of 21%, temperature at 112 °C and screw speed of 280 rpm.

Rubio *et al.,* 2014 worked upon replacing semolina with amaranth flour in pasta. Semolina was replaced by raw: popped (90: 10) amaranth flour blend in pasta and significant differences were observed on cooking quality and texture of different samples of pasta. They found that as they increased the AFB level, the pasta solid loss (11.5 g/100 g), weight gain (188.3 g/100 g) and firmness (1.49N) also get increased. They concluded that AFB proved to be best for enhancing the quality of nutrition through dietary fiber and high quality protein. Pasta made up of AFB can also be used as gluten-free pasta with acceptable cooking quality.

Yadav *et al.,* 2014 studied the possibility for blending of wheat flour, sweet potato, colocasia and water chestnut flours to make noodles. Sweet potato flour (SPF) and water chestnut flour (WCF) were incorporated in refined wheat flour (RWF) which decreases the viscosity of flour blends. Significant changes observed in the noodles made from the blends of SPF and CF with RWF were lower cooking timing, higher water uptake, higher cooked weight and higher gruel solid loss in comparison to control sample (RWF noodles). On the basis of organoleptic characteristics of slipperiness, firmness appearance RWF and SPF blend noodles were rated superior. They concluded that these blends of SPF, WCF and CF can be used to make gluten free products.

Fiorda *et al.,* 2013 developed and analysed gluten- free pasta made with amaranth flour, cassava starch and cassava bagasse. They analysed the quality of gluten free pasta formulated pre gelatinized cassava flour and bagasse (70:30). The pasta made from these blends showed the significant characteristics of high fiber (9.37 g/100 g), good protein (10.41 g/100g), ample firmness (43.6 N) and low stickiness (3.2 N). They concluded that the fibre content was increased as increase in the addition of cassava bagasse.

Carini *et al.,* 2014 studied the changes in the properties of ready to eat, shelf stable pasta during storage. A multianalytical and multidimensional approach was used to study and understand the ageing process of the product, changes in physico- chemical properties of ready to eat (RTE) shelf stable pasta during storage. The changes observed were increased hardness, amylopectin recrystallisation, changes in proton rotational molecular mobility indicators during storage. They reported that there was not much difference in the storage of RTE pasta and other cereal-based products.

Porwal *et al.,* 2014 studied the effect of hydrocolloid blends on noodle processing. The ingredients used for blending were chickpea flour (CF) and drum semolina (0-60 %). The developed noodles were subjected for different physico-chemical, cooking quality nutritional, and sensory analysis and scanning electron microscope (SEM). They have noticed that on the addition of hydrocolloids, the sensory and cooking quality characteristics were improved. They observed that on the addition of guar gum, cooking loss was reduced to 5.9 %. Sensory scores were observed to be above 8 in 15 cm scale. Addition of CF changed the texture of noodles and made it more firm. In vitro starch digestibility (IVSD) was also found to be reduced from 71 to 29 %. Thus, they justified that hydrocolloids can be substituted in noodles and can also be given to the population suffering from malnutrition and diabetes.

Shreenithee and Prabhasankar 2013 studied the effect of different shapes on the quality of yellow pea flour incorporated pasta. Different blends of yellow pea flour were prepared. They observed that noodles in which 20 % yellow pea flour was added showed favourable sensory attributes, good protein content, good texture, and reduction in the glucose release, yellowness values, and increased protein digestibility. For comparison, shell pasta (Conchiglie), noodle and vermicelli were extruded with the optimized 20 % pea flour. They observed that composition of blends showed an increased in protein content for all the samples (~2.5 %) compared to control. They reported that noodles retained high sensory scores, yellowness and good protein digestibility. Among all the preparation, Conchiglie pasta showed the lowest cooking loss (4.21 %) and the good firmness. They concluded that vermicelli and Conchiglie pasta reduced the glucose release and also slower starch digestibility.

Kumar and Prabhasankar, 2013 studied the effect of low glycemic index ingredients on noodle dough rheology. For the preparation of noodles in Lab, processed pea flour was used. The parameters which were analysed were physico-chemical propteries, noodle making properties, rheological properties, in-vitro starch digestibility (IVSD) and microstructure of noodle. They observed no significant difference in cooking quality between the samples and solid leach out was 6.7 to 7.2 % against control. Incorporation of pea flour in the samples were greenish in colour. They noticed that fresh noodle had firmer texture (5.52 Newton (N)), and dried noodles compared to control. The sensory analysis results showed that samples incorporated with 20 and 40% pea flour were acceptable and overall quality scored was >8.5.

Aydin and Gocmen (2011) investigated the effect of oat flour supplementation in noodles. They studied the effects and oat flour addition on the quality characteristics of noodles. The parameters of evaluation were cooking quality, colour, chemical and sensory properties. They noticed that as the flour level increased in the noodles, protein, crude fat, ash, zinc, iron, manganese and magnesium also increased. They observed that noodles supplemented with 10% oat flour got the highest sensory score among all noodles samples containing oat flour and was moderately acceptable and it was statistically ($p < 0.05$) similar with control ample in terms of overall acceptability.

Kim *et al.*, 2009 studied the cholesterol lowering action of mushroom noodles. A diet containing 1% cholesterol was given for 7 weeks to the rates. The control group received the high cholesterol diet only, while two other groups received high cholesterol diet supplemented with oak mushroom noodle powder (OMN). They observed that, the rats fed with OMN showed lower plasma total cholesterol and triglycerides and higher HDL-cholesterol concentration then that of the control and general noodle fed rats. They concluded that consumption of unmarketable oak mushroom could be effected in lowering atherosclerosis cardiovascular disease risk.

Krishnan *et al*., 2012 studied quality parameters of dietary fibre- enriched sweet potato pasta. Fortification was done with oat bran. Wheat bran and rice bran alleviated the crude protein content to 5-10% in the pasta. They observed that total and insoluble dietary-fibre fraction were more in the pasta from Sree Arun (6-17 and 5-14 % respectively) as compared to Sree Kanaka (5.25-15 and 3.7-11 & respectively) with the highest value in the wheat bran fortified pastas. They noticed that 70% of the total starch were rapidly digestible in the case of control pastas from both the varieties, that was drastically reduced to 45- 54 % in the test pasta from Sree Arun and 37-50% in Sree Kanaka. They observed increased in the firmness and toughness as the fortification level was increased and fortified sweet potato pasta can be proved as an ideal food for the diabetic an obese people.

Beak and Lee, 2014 worked on the development of functional noodles using brown rice. Brown rice was used as an ingredient for the preparation of gluten- free noodles. They observed that structural matrix of the noodles got weakened by brown rice flour which further reduced the breaking strength and tensile properties of the noodles and increased their cooking loss. It was found that brown rice noodles exhibited significantly higher 2,2-dipheryl-1-picrylhydrazyl radical scavenging activity, ferric reducing powder, and 2,2-azinobis-3-ethylbenzothiazoline-6-sulfonic acid radical-scavenging activity by 21-, 28-, and 21-fold, respectively, than white rice noodles. It was concluded that with the addition of brown rice flour noodles with high antioxidant properties can be prepared successfully.

Shukla *et al.,* 2012 developed carrot pomace powder enriched defatted soyflour fortified biscuits. Different concentrations of carrot pomace powder were used. Five flour blends prepared from wheat flour and defatted soy flour (DSF) were 95:5, 92.5:5, 90:5, 87.5:5 and 85:5 and 0, 2.5, 5, 7.5 and 10 % of carrot pomace powder (CPP) was used respectively for biscuit making. They reported that crude fibre content of sample showed highly improved nutritional value of carrot pomace powder incorporated biscuits and the highest value of crude fibre (2.92%) was observed in 10% sample. Increase in the beta carotene content ranged from 0.10 to 2.49 mg was observed due to increase in the level of carrot pomace powder and defatted soyflour, which proved to be beneficial in providing daily dietary requirement of beta-carotene to the consumer.

Kumar and Kumar 2011 worked upon the addition of dried pomace to wheat flour in order to develop cookies. Dried carrot pomace was added in different proportions (0-9%) to fine wheat flour, sugar, shortening and water. This formulation was baked at 175°C for 12 minutes in the gas oven with air circulation. Ten panelists were selected for the sensory evaluation. It was observed that moisture content varied from 4.03 to 4.79%. The hardness was ranged from 41.047 to 116.1 N with an average value of 81.49 N. It was reported that as the percentage of carrot pomce increased, moisture content, hardness and L*, a *, values also increased.

Ritthiruangdej *et al.,* 2011 worked upon supplementation of wheat noodles with unripe banana flour. Five treatments of dried noodles were prepared by substituting wheat with 10, 20, 30, 40, and 50% banana flour and 100% wheat flour was taken as control. They reported that the stickiness of the noodles decreased as the amount of banana flour increased and the appearance became darker. Uncooked dried noodles contained 13.7% protein, 0.12% fat and 4.8% dietary fiber (including 2.8% resistant starch). The optimal cooking loss and cooking time were 11.15% and 14.5 minutes respectively. Reported breaking length and tensile strength of cooked noodles was 67.2 mm and 16.4 g respectively. It was concluded that unripe banana flour is a potential source of fiber and can be substituted for wheat flour in dried noodle products.

Baskaran *et al.,* 2011 studied physical properties of noodles enriched with skim milk powder, whey protein concentrate and a combination of skim milk powder and whey protein concentrate at different levels i.e 5, 7.5 and 10%. They reported decrease in volume, weight and swelling ratio of the enriched noodles as level of replacement was increased. Total solids loss in gruel was increased as the levels of substitution increased.

Thao *et al.,* 2011 used sweet potato and mung bean starch for noodle production. They accessed physiochemical properties of four types of sweet potato starch (SPS) and mung bean starch (MBS), and their blends for noodle production. The observed that MBS was significantly higher in amylose content (40.69%), hot paste stability, cold paste viscosity and gel hardness; but has substantially lower content of protein, lipid, ash content, and gel stickiness than those of all sweet potato starches . They reported that increase of solid content of starch slurry resulted in considerable increasing in cooking time, cooking loss, rehydration and tensile strength of noodles. They observed that noodles prepared from mixture of 20% SPS and 80% MBS has the most suitable initial solid content of starch slurry and their aging time at 4°C were 35% and 10-20 hours respectively.

4.3. <u>FUNCTIONAL INGREDIENTS</u>

Kaur and Kapoor 2001 studied the antioxidant activity and phenolic content of common vegetables. They used a model system consisting of β-carotene and linoleic acid to check the antioxidant activity of extracts from 36 vegetables. The vegetables were washed, cleaned, chopped into small pieces and finally homogenized. Total phenolics were determined using Folin Ciocalteau reagent. They reported that the total phenolic content in mint, beetroot and black carrot were highest and the anti-oxidant activity % were highest in fresh turmeric, Broccoli, Kachmar and Aonla.

Khan *et al.,* 2011 worked on the effect of beta-carotene on human serum retinal level. HPLC (High Performance Liquid Chromatography) method was used to investigate the content of beta-carotene in different kind of vegetable To test the effect of carotene on blood serum retinol level, carotene rich diet was fed to 10 volunteers for one week and then serum was analysed for retinol by HPLC. They reported that β-carotene content in green vegetables ranges from 80-9204 µg/100 gm and lowest β-carotene content in carrot (5340 µg/100 g) and higher content in tomato (3500 µg/100g).

Simon *et al.*, 2008 studied the effect of intake of biofortified carrot on the liver antioxidant capacity and vitamin A status The antioxidant potential and vitamin A bioefficacy of four biofortified carrot varieties (purple/ orange, purple/ orange / red, orange/ red and orange) in Mongolian gerbils were measured. Carrots were cut into chips, freeze-fried and ground into fine powders. They reported that the efficiency of provitamin A carotenoid is not hindered by presence of anthocyanins.

Karki *et al.*, 2012 highlighted the application and properties of carrot and its by products. They observed that blanching of diced carrot at 71°C for 3-6 min resulted in better quality of canned product. They reported that during commercial juice processing only 30-50 % of carrot remains as pomace and carotenoid loss was approximately 50%. They also reported the compostion of dietary fibre of carrot pomace (on dry weight basis) as pectin (3.88%), hemi cellulose (12.3%), cellulose (51.6%) and lignin (32.1%).

Gupta *et al.*, 2005 used hurdle technology for the development of high moisture carrot product. They infused additives comprising 3.0% NaCl, 0.9% citric acid, 1.0% sodium citrate and 0.2 % sodium benzoate. Fresh grated carrot was subjected to partial drying in cabinet dryer at 65°C for 1 hour and then equilibrated with additives. Then the product was stored in flexible polymeric pouches. The physical, chemical and pathological stability during storage at ambient temperature (19-33°C) was observed. The study recommended that the partially dehydrated grated carrot (moisture 66%) was acceptable for more than 6 months at ambient temperature and the retention of carotenoid was observed upto 82.5 %.

Leja *et al.*, 2013 assessed the carrot collection of 35 cultivators for phenolic compounds and radicals scavenging activity. The trials compromised 15 accession developing orange roots, 8 yellow, 5 white, 5 red and 2 purple roots. One kg of healthy, intact roots from each field replication were selected for the analysis of antioxidant activity and total phenolic compounds. Approx 10-15 roots (per field replication) were cut, freeze-dried, milled and store until analysed. The content of phenolic compounds observed were in the range from 19.8 to 342.2 mg/100 g. The result revealed that purple roots showed almost 9 times more phenolics than roots of other colour, 311.5 and 34.9 mg/100 FW respectively. Radical scavenging activity (RSA) varied considerably among accessions and High anti-radical activity was observed for purple root extracts.

Joshi and Sharma, 2009 worked on lactic acid fermentation of carrot, cucumber and radish with cultures of *Lactobacillus plantarus* (NCDC 020), *Pedicoccus cerevisiae* (NCDC

038) and *Streptococcus lactus* var diacetyjactus(NCDC 061) . They found that the titrable acidity (TA) ranged from 1.3 to 1.4% as acetic acid with a pH of 3.2, 1.2 to 1.3% TA with a pH of 3.4 to 3.5 in carrot and radish respectively. On the basis of physico-chemical and sensory characteristics, the overall acceptability score of carrot (75%) and pear (25%) indicates the suitability of this blend for preparation of fermented carrot based sauce.

Sam *et al.,* 2013 investigated the changes in the quality and antioxidant activity of probiotic yogurt supplemented with black carrot, pumpkin, and strawberry. Black carrot, pumpkin and strawberry in the form of jam were added to yoghurt at several concentrations. Jams of these fruits were added separately in the 3 portions of standardised cow's milk at 0.5, 1.0 and 1.5%. All milk portions were first heated at the temperature of 90°C for 15 minutes and then cooled to 42°C and then inoculated with 2 % yoghurt culture and 2% *Bifidobacterium lactis* B6-12 culture under septic conditions. The effect of addition of black carrot was studied on pH, viscosity, viability of probiotic stains. It was found that black carrot and strawberry decreases the pH value to 4.10 and 4.19 respectively after 10 days of storage to 350 and 4.06 respectively. Addition of black carrot and strawberry decreased the viscosity of the flavoured yoghurt after 10 days of storage to 285 and 399 cP. The result showed that the fresh yoghurt under investigation was highly accepted scoring 93.3-98.0 out of 100.

Kirca *et al.,* 2007 studied the stability of anthocyanin content of black carrot during heating at 70-90 °C and storage at 4-37°C. They found that during heating with increased in the solid content the monomeric anthocyanin increased and it decreased during storage. They observed that at 30-64° Brix, increasing pH from 4.3 to 6.0 improved the degradation of anthocyanins during heating. A significant decrease in anthocyanin content was observed at pH more then 5.0. Higher activation energies (E_a) at 30-64° Brix, ranged from 68.8 to 95.1 kJ mol^{-1} during heating and from 62.1 to 86.2 kJ mol^{-1} during storage. They concluded to decrease or minimize the anthocyanin degradation, black carrot concentrates should be cooled to possibly refrigeration temperatures as soon as they are produced.

Hadi *et al.,* 2014 studied the color stability of strawberry jam fortified by purple carrot puree. The contents of anthocyanins in purple carrot and strawberry were analyzed by HPLC. The highly stable acylated anthocyanins pigments showed 66.64% of total anthocyanins in purple carrot compared to 20.6 % from strawberry. 15, 20 and 30% of purple carrot puree were added to strawberry puree during jam processing. The jams were analysed over a period of 6 month of storage under normal conditions of room temperature and light exposure. They reported that pH value, total anthocyanin. Viscosity and total phenol contents were increased amount of purple carrot was increased and markedly decreased degradation of anthocyanin during storage period by 53.2, 52.9, 18.0 and 7.3% in control 15, 20 and 30% samples respectively. L∗, a∗, b∗, hue° and chroma values showed that the color of strawberry jams containing purple carrot was improved and showed stability. The results of sensory evaluation revealed that the jam of 20% purple carrot treatment obtained the highest overall acceptability score at the end of storage period therefore they concluded that the addition of purple carrot up to 20% during strawberry jam processing maintained the color and appearence of jam without any effect on their acceptance.

4.4 <u>JUICES</u>

Juice is a liquid that is naturally present in fruits and vegetable. It can also refer to liquid that are flavoured with other biological food sources such as meat and seafood. Juice is prepared mechanically by squeezing fruits and vegetables flesh without the application of heat or solvent. Many commercial juices are filtered to remove fiber or pulp. Common methods for preservation and processing of fruit juices include canning, pasteurization, concentrating, freezing, evaporation and spray drying.

Jones *et al.*, 1997 evaluated a suitable extraction method for a wide range of sample matrices in carotenoid analysis. Canned tomato juice was used as a representive sample. The use of double extraction, each with 35 ml of ethanol hexane mixture (4:3 by volume) resulted in good recoveries of carotenoids. They reported that the average percentage of added carotenoids from canned tomato juice, carrot and spinach were: 101, 99.8 and 101% for α-carotenee and 98.1, 99.7 and 96.1% for β-carotene respectively.

Elham and Shahriar, 2013 used different temperature like 70, 80 and 90°C to check the stability of juices and storage at 4 and 37°C was done. They reported that during heating black carrot anthocyanins in apple and grape juices showed higher stability than in citrus juices at 70 and 80°C after 10 hours. They concluded that stability of black carrot anthocyanins found to be in temperature 4°C after 180 days in all samples.

Jan and Masih, 2012 worked on blended beverage which were then stored for 21 days in pet bottles at refrigerated temperature. Physio-chemical and sensory analysis was performed. Increased proportion of carrot juice increased the β-carotene content of juice (1583µg).

Estimation of vitamin C content of sample (19.50mg) showed high improvement in nutritional value of pineapple juice supplemented with carrot and orange juice. The overall acceptability scores were more than 8. The shelf life of juice was established within 21 days.

Donaldson, 2006 studied the effect of carrot juice on blood glucose level. They measured the glycemic index of carrot juice to be 86, on a scale where the glycemic index of bread was 100. He reported that the glycemic response of carrot juice was lowered to 66 by consuming oil along with the juice. He concluded Chromium showed a beneficial effect to 4 of 6 people who participated in a 1-week supplement test.

CHAPTER-3

SCOPE OF STUDY

Black carrot is a seasonal fruit which is highly perishable with short keeping quality especially in its fresh nature. However it is unique because of its high phytochemical content particularly the anthocyanin and other phenolic acids, that play an important role in reducing the disease risk. This phytochemical diversity present a major challenges to the area of functional food and nutraceutical research and development.

Although, many works were undertaken regarding incorporation of red carrot in different food products but no work has been repeated of black carrot. Thus, this research is undertaken to develop new products by incorporating black carrot in fresh and dried conditions.

CHAPTER-4

OBJECTIVES

The main objectives are following:-

- To determine the influence of black carrot powder incorporation on the chemical properties of noodles.
- To determine the influence of black carrot powder incorporation on the cooking quality and sensory properties of noodles.
- Standardization of formulation for incorporation of black carrot in ice-cream.

CHAPTER-5

RESEARCH METHODOLOGY

5.1 MATERIAL

Black carrot of variety(*Daucus carota ssp. Sativus)* was procured from local market of Jalandhar, Punjab. The carrots were washed in running tap water number of times to remove extraneous materials. Trashes were removed with a plane stainless steel knife and trimming was also done. Whole wheat flour was purchased from the local market Jalandhar, Punjab. The composition of wheat flour was as follows: 12.87% moisture, 12.1% protein, and 0.54% ash(Aydin and Gocmen, 2011).

5.2 METHODS

5.2.1 DRY CARROT POWDER PREPARATION-

A mechanical dryer was used for drying grated carrot. The dryer consisted of a heating chamber with thermostat based control unit, an electric fan and measurement sensors. The grated carrot were spread over the trays and the temperature of the dryer was set to 60°C. The drying procedure continued till the moisture content of the carrot was reduced to about 5 %. A juicer mixer grinder cum food processor was used to ground the dried grated carrot. The powder was stored in a sealed polythene bag till further use.

5.2.2 NOODLE PREPARATION

To prepare noodle samples at laboratory conditions, different blends were prepared first in which different ratios of rice flour and black carrot powder were taken. The following treatments were made:-

Table 5.1- DETAILS OF TREATMENT COMBINATION

TREATMENTS	WHEAT FLOUR	BLACK CARROT POWDER (BCP)
T_1	100%	0%
T_2	95%	5%
T_3	90%	10%
T_4	85%	15%
T_5	80%	20%

Plate 6.1- Different treatments of noodles after drying

Five treatments were made and control samples included no black carrot powder. 50 gms of each blend was taken and the dried ingredients were sieved through 1-mm sieve. Water was added by doing water holding capacity test to make a hard dough.

The dough was rounded and allowed to rest at ambient temperature for 20 minutes. The dough was passed through reductional rolls of a noodle making machine. The thickness of dough is maintained upto 2 mm. They were kept for 15 min. After that dough sheet were cut into noodle and the strips were dried at 50°C for 5 h in an hot air oven. The dried noodles were packed in polyethylene bags (Aydin and Gucmen, 2011).

5.3 COMPOSITIONAL ANALYSIS

5.3.1 MOISTURE CONTENT-

Procedure: 5 g sample was taken previously dried and weighed in a dish . The dish was placed in an electric air oven maintained at 100°C for one hour. The dish was cooled to room temperature in a dessicator. The process of heating, cooling and weighing were repeated until the loss in weight between two successive weighings do not vary by more than 3-5 mg. The lowest weight obtained was recorded (Ranganna, 1995).

CALCULATIONS

Weight of the weighing dish with lid = W_1

Weight of the dish with lid and material = W_2

Weight of the dish with lid and dried material = W_3

Weight of the material = (Weight of the dish with sample – weight of the dish)

= $(W_2 - W_1)$

Quantity of moisture in the material = (Weight of the material before drying − weight of the material after drying)

= $(W_2 - W_3)$

Per cent moisture in the material = Quantity of moisture in the material $(W_2 - W_3)$ X 100

Weight of the material (W_2- W_1)

5.3.2 ASH CONTENT

TOTAL ASH

Tare weight of three silica dishes were taken. 5-10 g of sample were weighed into each dish. The dish and the contents were ignited on a Bunsen burner. The material were ashed at not more than 525°C for 4 to 6 hour. The dishes were cooled and weighed again. The difference in weights gave the total ash content and expressed as percentage.

5.3.3 PROTEIN

Protein content was determined by Lowry's method.

PROCEDURE

Different dilutions of BSA solutions were prepared by mixing stock BSA solution (50 mg/ 50 ml) and water in a standard flask. Extraction of sample was carried out with buffers used for enzyme assay. 0.5 gm os sample was weighed and ground in a pestle mortar with 5 ml of buffer. The mixture was centrifuged and supernatant was collected. 0.2, 0.4, 0.6, 0.8 and 1 ml of working standard was taken into series of test tubes. 0.1 ml of sample was taken in other test tube. 5 ml of alkaline copper solution was added in each test tubes including blank (1 ml distilled water). Mixture were mixed properly and were allowed go stand for 10 minutes. 0.5 ml of Folin- Ciocalteau reagent was added to each test tubes and kept in dark for 30 minutes. Readings were taken at 660 nm. Standard graph was plotted and amount of protein was calculated as mg/g or 100 g of sample.

5.3.4 FAT CONTENT:

PROCEDURE

Fat content was determined by Soxhlet extraction method. Dried samples (2g) were extracted with Petroleum ether in Soxhlet extraction apparatus for 6-8 hours in pre weighed round bottom flask. The extract containing fat and petroleum ether was evaporated over boiling water bath and dried in an oven at low temperature and weighed. The differences in the weight of the round bottom flask represented the ether extract (fat content) present in the sample(AOAC 2000).

Calculations:

Weight of sample = W (g)

Weight of empty round bottom flask = W_1 (g)

Weight of empty round bottom flask + Fat content = W_2 (g)

$$\text{Fat content (\%)} = \frac{\text{Amount of ether extract} \times 100}{\text{Weight of sample (g)}}$$

(OR)

$$\text{Fat content (\%)} = \frac{(W_2 - W_1) \times 100}{W}$$

5.3.5 CRUDE FIBRE

Moisture and fat free sample (2g) were digested with 200ml of 1.25 per cent H_2SO_4 by gentle boiling for half an hour. The contents were filtered and the residue was washed several times with hot distilled water till it became free from acid. Acid free residue was then transferred to the same flask to which 200ml of 1.25 per cent NaOH was added. The contents were digested again for half an hour, filtered it and residue was again washed with hot distilled till it became alkali free. The residue was dried in an oven overnight at 100ºC and weighed and then placed in muffle furnace at 600ºC (±50ºC) for 4 hours. The loss in weight after ignition the sample represented the fibre in the sample(AOAC 2000).

CALCULATION

Weight of sample	=	W (g)
Weight of empty crucible	=	W_1 (g)
Weight of empty crucible + sample before ignition	=	W_2 (g)
Weight of empty crucible + sample after ignition	=	W_3 (g)

$$\text{Fibre content (\%)} = \frac{(W2 - W1) - (W3 - W1)\ \text{x}\ 100}{W}$$

5.3.6 POTASSIUM

Potassium in solution was determined by Flame photometric method.

PROCEDURE

An aliquote of ash solution was diluted so that it contain less than 150 ppm potassium. Sufficient HCl was added so that the concentration of the acid is same as that in the standard solution. The diluted extract was atomised in a calibrated flame photometer with the wavelength dial set at 768 nm and transmittance set at 100% for the top standard solution of potassium. From the standard cuve note the concentration (Ranganna 1995).

CALCULATION

Potassium mg/100g = ppm found from standard curve x volume made up x dilution x 100 / Wt of sample x 1000

5.3.7 SODIUM

An aliquote of ash solution was diluted so that it contain less than 10 ppm of sodium. Sufficient HCl was added so that the concentration of the acid is same as that in the standard solution. The diluted extract was atomised in a calibrated flame photometer with the wavelength dial set at 589 nm and transmittance set at 100% for the top standard solution of sodium. From the standard cuve note the concentration (Ranganna 1995).

CALCULATION

Sodium mg/100g = ppm found from standard curve x volume made up x dilution x 100 / Wt of sample x 1000

5.4 FUNCTIONAL PROPERTIES

5.4.1 TOTAL ANTHOCYANIN

10 g of sample was blended with 10 ml of ethanol HCL in a blender at full speed and the mixture is transferred to a 50-ml volumetric flask using approximately 5 ml of ethanolic HCl for washing the blender jar and were stored overnight in a refrigerator at 4° C. The mixture was filtered through Whatman No. 1 using a Buchner funnel. The volumetric flask and the residue on the filter paper were washed repeatedly with ethanolic HCl until approximately 45 ml of extract is collected. The extract were transferred to a 50 ml volumetric flask and made to volume. For the spectrophotometric measurement, 25 ml was filtered through a fine pororsity, sintered glass funnel. A small aliquot of filterate was diluted with ethanolic HCl and stored in dark for 2 hours and measurement of color was taken at 533nm(Ranganna 1995).

CALCULATION

$$\text{Total OD per 100 g of black carrot} = \frac{\text{Absorbance at 535nm X Volume made up X Total volume X 100}}{\text{Weight of sample x 1000}}$$

$$\text{Total anthocyanin content (mg /100 g of black carrot)} = \frac{\text{Total OD /100g}}{98.2}$$

5.4.2 TOTAL FLAVONOIDS

The sample was extracted using 80% methanol in a pestle mortar, 0.5 ml of each extract (1.10 g/ml) in methanol was separately mixed with 1.5 ml of methanol solution, 0.1 ml of 10% aluminium chloride, 0.1 ml of potassium acetate and 2.8 ml of distilled water. It remained at room temperature for 30 minutes and absorbance of the mixture was measured at 415 nm with UV- visible spectrophotometer. The standard curve was prepared by using quercitin solutions at different concentration of 12.5 to 100 µg/ml in methanol, the concentration of flavonoids in the test samples was calculated from the caliberation plot and expressed as mg quercitin equivalent g of sample.

5.4.3 ANTIOXIDANT ACTIVITY

Antioxidant activity (Free radical scavenging activity) was measured as per the method of. A 1g of sample was extracted with 5 ml of 70% methanol. The mixture was then centrifuged at 1000 rpm for 15 minutes and the supernatant was collected. DPPH (2, 2-diphenyl-1-picrylhydrazyl) was used as a source of free radical. A quantity of 3.9 mL of $6x10^{-5}$ mol/L DPPH in methanol was put into a test tube with 0.1 mL of sample extract and the decrease in absorbance was measured at 515 nm for 30 min or until the absorbance become steady. Methanol was used as a blank (Brand-Williams *et al*.,1995).

CALCULATION

$$\text{Antioxidant activity (\%)} = \frac{A_{\circ} - A}{A_{\circ}}$$

Where, $A_{\circ}$ = Absorbance of DPPH as blank

A = Absorbance of sample

5.5 PHYSICAL PROPERTIES

5.5.1 BULK DENSITY

A known amount of samples was weighed into 50mls graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top 10 times from a height of 5cm. The volume of the sample was recorded (AOAC 2000).

$$\text{Bulk density (g/ml)} = \frac{\text{Weight of the sample}}{\text{Volume of the sample after tapping}}$$

5.5.2 WATER ABSORPTION CAPACITY

To 1g of the sample, 15ml of distilled water was added in a 25ml centrifuge tube and agitated on a vortex mixer for 2 minutes. It was then centrifuge at 4000rpm revolutions per minutes for 20minutes. The supernatant was decanted and discarded. The adhering drops of water were removed and the tube reweighed again (AOAC 2000).

$$\text{WAC} = \frac{\text{Weight of centrifuge tube + weight of sediment - weight of empty tube}}{\text{Weight of sample}}$$

6.5.3 OIL ABSORPTION CAPACITY

To 1g of the sample, 10ml of distilled water was added in a 25ml centrifuge tube and agitated on a vortex mixer for 2 minutes. It was then centrifuge at 4000 rpm revolutions per minutes for 20 minutes. The supernatant was decanted and discarded. The adhering drops of oil were removed and the tube reweighed again (AOAC 2000).

$$\text{OAC} = \frac{\text{Weight of centrifuge tube + weight of sediment - weight of empty tube}}{\text{Weight of sample}}$$

5.6 COOKING PROPERTIES OF NOODLES

5.6.1 COOKING TIME

10 gm of sample were cooked in 200 ml of boiling water in a 250 ml beaker. Samples were cooked until the disappearance of white core is there and this is judged by squeezing it between the two slides. The cooking time was noted (Yadav *et al.*,2014).

5.6.2 <u>COOKED WEIGHT</u>

10 gm of sample were soaked in 300 ml of distilled water for 5 min and then cooked in water bath for 5 min. The beaker was covered with aluminium foil to minimise the loss of water. The cooked sample were drained for about 2 min and rinsed with distilled water in a Buchner funnel and cooked weight was calculated by weighing wet mass of samples (Galvez and Resurreccion, 1992).

5.6.3 <u>GRUEL SOLID LOSS (g/100g)</u>

To determine gruel solid loss the sample was cooked first and then rinsed with water and drained. The water with some solid was collected in a pre-weighed petridish and was dried in oven for 12 hours at 110°C. The residue was weighed after cooling in dessicator to determine gruel solid loss. (Yadav *et al.*,2014)

5.6.4 <u>WATER UPTAKE PERCENTAGE (g/100g)</u>

For water uptake percentage, the difference in weight of cooked sample and uncooked sample was calculated and was expressed as the percentage of weight of uncooked sample. The cooked sample was rinsed with cold water and drained for 30 seconds and then weighed to determine the cooking gain. (Galvez and Resurreccion, 1992).

5.7 <u>SENSORY ANALYSIS</u>

Noodle samples were boiled in unsalted water and were cooked with red carrot, onion, cabbage and capsicum. The sensory tests of the noodles were performed with an evaluation panel of 5 members (3 females, 2 males; age ranges 20-40 years) familiar with noodle. Information on the nature of this evaluation was given to panelist beforehand. All noodle samples (control, with 5, 10, 15, and 20% black carrot powder) were evaluated in 1 session on 1 day. Panelists received 1 sample at a time with a 2 min break between samples. The panelist were asked to score the cooked noodle in terms of properties like color and appearance, taste, aroma, flavour, texture and overall acceptability using a 9-point hedonic scale with 9-like extremely, 5-neither like or dislike, 4-dislike slightly, and 1-dislike extremely (Aydin and Gocmen, 2011).

5.8 STATISTICAL ANALYSIS

The means and standard deviations were determined for all the compositional, physical, cooking and sensory qualities. The significant difference of mean values was assessed with one-way analysis of variance (ANOVA) followed by Duncan's test using SPSS software at a significance level of ($P < 0.05$).

CHAPTER-6

RESULT AND DISCUSSION

The present study "**Development of functional foods from underutilized vegetable crops"** was conducted in the department of Food Technology and Nutrition, School of Agriculture, Lovely Professional University, Phagwara, Punjab during the year 2014-2015. The results are discussed in the following subdivisions:-

a) Chemical Properties

b) Physical properties

c) Bioactive properties

d) Cooking properties

e) Sensory analysis

6.1 PROXIMATE COMPOSITION OF NOODLES

Proximate composition of noodles supplemented with black carrot powder are given in Table 6.1. The proximate properties of all noodle samples were significantly ($p<0.05$) different. The mean moisture content of noodles supplemented with black carrot powder ranged from 11.2 (80% WF and 20% BCP) to 12.6 (100 % WF and 0 % BCP) per cent. It was observed that moisture content decreased with the increase in black carrot powder addition. Similar results have been reported by Ekici *et al.,* 2014 in which they studied the effect of black carrot concentrate on some physicochemical, textural, bioactive, aroma and sensory properties of sucuk, a traditional Turkish dry fermented sausage. Contrary results has been reported by Kumar And Kumar 2011 in the development of vitamin and dietary fibre enriched carrot pomace and wheat flour based buns where they reported that moisture content of the buns increased with the increase in carrot pomace. The decrease in the moisture content can be due to drying of black carrot and weight loss as reported by Bozkurt and Bayram 2006.

The protein content ranged from 0.62 (80% WF and 20% BCP) to 1.23 (100 % WF and 0 % BCF) per cent. The protein content decreased as the amount of wheat flour decreased in the different treatments. Similar results were reported by Gayas *et al.,* 2012 in which they studied the physico-chemical and sensory characteristics of carrot pomace powder enriched defatted soyflour fortified biscuits. This may be due to lower content of black carrot as compared to wheat flour.

The ash content of all treatments differed significantly ($p<0.05$) and was higher as compared to control sample (100 % WF). The highest amount was observed in 10, 15 and 20 % samples. It may be due to appreciable amount of minerals present in roots and tubers (Yadav *et al.,* 2014).

Noodle samples supplemented with black carrot powder at all levels had significantly ($p<0.05$) higher crude fibre contents compared with control sample. The crude fibre content ranged from 1.6 (100 % WF and 0 % BCP) to 2.6 (80% WF and 20% BCP) per cent. Similar results has been reported by Gayas *et al.,* 2012 in which they studied the physico-chemical and sensory characteristics of carrot pomace powder enriched defatted soyflour fortified biscuits. The different level of black carrot powder increased the total crude fiber content significantly in biscuit samples may be due to higher content of these nutrients in black carrot powder.

The fat content ranged from 0.42 (100 % WF and 0 % BCP) to 6.9 (80% WF and 20% BCP) per cent. Ash and Crude fibre were highest in 20% sample which can attributed to rich mineral and crude fibre content of black carrot. Carbohydrate content was calculated by the difference so the variation in the carbohydrate content may be credited to the differences in the contents of other constituents.

Table 6.1- Proximate composition of blends

% BCP	Moisture (%)	Ash (%)	Protein (g/100 gm)	Crude fibre (%)	Fat (%)	Carbohydrate (%)
0%	12.6± 0.2[a]	1.4±0.3[a]	1.23±0.012[a]	1.6± 0.14[a]	0.42±0.03[a]	82.8± 0.176[a]
5%	12.13± 0.30[b]	1.5± 0.5[b]	1.09±0.014[b]	1.82± 0.8[b]	1±0.07[b]	82.38± 0.11[b]
10%	11.8± 0.2[c]	1.6±0.28[c]	0.89±0.007[c]	1.88± 0.7[c]	1.24±0.05[c]	82.52± 0.09[c]
15%	11.33± 0.30[d]	1.6± 0.76[d]	0.74±0.011[d]	1.98± 0.8[d]	1.44± 0.05[d]	82.94±0.04[d]
20%	11.2± 0.6[e]	2.3± 0.28[e]	0.68±0.015[e]	2.6± 0.12[e]	2.69± 0.02[e]	80.54±0.01[e]

Each value is expressed as Mean±S.D (n=3); values followed by same letter in the different column are not significantly different at $p\leq0.05$.

6.1.1 MINERAL COMPOSITION

Table 6.2 shows the potassium content in blend, raw and cooked noodles. There were significant differences (p<0.05) in the mineral composition of the blends, raw noodles and cooked noodles. Potassium content ranged from 118.33 mg/100 gm (80 % WF and 20 % BCP) to 190 (100 % WF and 0 % BCP) in blends, 86 mg/100 gm (80 % WF and 20 % BCP) to 146.66 (100 % WF and 0 % BCP) in raw noodles and from 31.33 mg/100gm (80 % WF and 20 % BCP) to 67.66 (100 % WF and 0 % BCP). The loss was observed during cooking and the loss per cent was calculated. The loss percent observed was more in raw and cooked noodles as compared with blend and raw noodles (shown in table 7.2). Addition of black carrot powder increased the potassium content of the noodles. Similar results has been reported by Aydin and Gocmen 2011 in which they had studied the cooking quality and sensorial properties of noodle supplemented with oat flour and Oyewade, 2014 in his project on effect of carrot pomace on mineral composition functional and sensory properties of water yam and pigeon pea flour blends.

Table 6.1- Potassium content in blends, raw and cooked noodles

% BCP	Blends (mg/100gm)	Raw noodles (mg/100gm)	Cooked noodles (mg/100gm)	% Decrease (blend v/s raw noodles)	% loss (raw v/s cooked noodles)
0%	190± 5.56^{a}	146.66± 2.08^{a}	67.66± 2.08^{a}	22.81	53.86
5%	169± 7.93^{b}	131.33±3.05^{b}	65±3^{b}	22.28	50.50
10%	152.66± 5.03^{c}	104.66± 6.50^{c}	54.33±3.51^{c}	31.44	48.08
15%	132.66±3.78^{d}	95.66± 5.13^{d}	44.33± 2.30^{d}	27.89	53.65
20%	118.33± 6.65^{d}	86± 2^{d}	31.33± 7.02^{e}	27.32	63.56

Each value is expressed as Mean±S.D (n=3); values followed by same letter in the different column are not significantly different at p≤0.05.

The results of Sodium content in blend, raw and cooked noodles have been reported in Table 6.3. Sodium content ranged from 35 (100 % WF and 0 % BCP) to 55.33 mg/100 gm (80 % WF and 20 % BCP) in blends, 21.33 (100 % WF and 0 % BCP) to 40 mg/100 gm (80 % WF and 20 % BCP) in raw noodles and from 10.33 (100 % WF and 0 % BCP) to 35.33 mg/100gm (80 % WF and 20 % BCP) in cooked noodle. The result obtained showed there was increased sodium content as the amount of black carrot powder incorporation was increased and the potassium content decreased as the amount of BCP increased. This shows the higher content of minerals like sodium in black carrot. Minerals helps in the transportation of nutrients across cell membrane, and also helps in the regulation of body tissue growth (Tucker KL 2009).

Table 6.2 Sodium content in blends, Raw and cooked noodles

% BCP	Blends (mg/100gm)	Dry noodles (mg/100gm)	Cooked noodles (mg/100gm)	% decrease (blend v/s raw noodles)	% loss (raw v/s cooked noodles)
0%	35± 3[a]	21.33± 1.15[a]	10.33± 1.154[a]	4.6	51.57
5%	40± 1.73[a]	25.33±2.30[b]	15.66± 2.08[b]	3.9	38.17
10%	44.66± 0.57[b]	31.66± 0.57[c]	27.33± 1.15[c]	3.1	13.67
15%	48.33±0.57[c]	34.66± 0.57[d]	28.33± 0.57[d]	2.8	18.26
20%	55.33± 3.05[d]	40± 1.73[e]	35.33± 1.15[e]	27.7	11.67

Each value is expressed as mean±S.D (n=3); values followed by same letter in the different column are not significantly different at p≤0.05.

6.2 PHYSICAL PROPERTIES OF BLACK CARROT NOODLES

The physial properties of flours play important role in the manufacturing of products. The black carrot powder (BCP) and whole wheat flour (WF) were analyzed for their physical properties. Table 7.4 shows the various physical properties of flours. Bulk density indicates the relative amount of packaging material required and high bulk density is a good physical attribute for determining the mixing quality of a particulate matter (Mishra *et al.*, 2012). The bulk density ranged from 0.656 (80 % WF and 20 % BCP) to 0.661(100 % WF and 0 % BCP) g/cm^3. Bulk density of blends and dry noodles were compared and were found to be high in raw noodles shown in Table 7.5. It was observed that bulk density decreases as concentration of black carrot increased in the noodles. Similar result has been reported by Baljeet *et al.,* 2010 in their studies on functional properties and incorporation of buckwheat flour for biscuit making and contrary result has been reported by Kumar and Kumar 2012 in their study of development of vitamin and dietary fibre enriched carrot pomace and wheat flour based buns where they reported bulk density increased as the amount of carrot pomace increased in the flours. Similar findings has also been reported by Morsey *et al.*, 2015 in which they studied the physico chemical properties, antioxidant activity, phytochemicals and sensory evaluation of rice-based extrudates containing dried corchorus olitorius l. Leaves in which they reported that bulk density increased with Jew Mellow leaves addition. This may be due to high protein and fibre content which increased the density of the product.

The water absorption capacity (WAC) expresses the ability of a product to associate with water under conditions where water is a limiting factor. The WAC ranged from 191(100 % WF and 0% BCP) to 267.33 (80 % WF and 20 % BCP) per cent. It was observed noodle supplemented with 20 % BCP has the highest WAC as compared to control sample and dry noodles has lower WAC as compared to blends (Table 7.6) and it can be seen that the WAC increased in the increase in BCP but significant difference ($p \leq 0.05$) was observed at 10 % and 15 %. Similar result has been reported by Yadav *et al.*, 2014 in their study on suitability of wheat flour blends with sweet potato, colocasia and water chestnut flours for noodle making.

Oil absorption capacity (OAC) is important as it improves the mouth feel and retains flavour. Oil absorption capacity of black carrot noodles ranged from 201 to 203 %(table 7.4). And the highest per cent was observed in noodles supplemented with 10 % BCP. OAC of blend and raw noodles were compared and result showed that it was high in blends as compared to dry noodles (Table 7.8).

Table 6.4- Physical properties of Blends

% BCP	Bulk density (g/cm^3)	Water absorption capacity (%)	Oil absorption Capacity (%)
0%	0.661 ± 0.004^{a}	191 ± 6.24^{a}	201 ± 4^{a}
5%	0.650 ± 0.004^{a}	206 ± 7.54^{a}	199 ± 7.81^{a}
10%	0.658 ± 0.006^{a}	226 ± 7.93^{b}	203 ± 1.73^{a}
15%	0.663 ± 0.005^{a}	254 ± 2^{c}	198 ± 2^{a}
20%	0.656 ± 0.005^{a}	267.33 ± 4.16^{c}	201.33 ± 1.154^{a}

Each value is expressed as mean±S.D (n=3); values followed by same letter in the different column are not significantly different at $p\leq0.05$.

Table 6.5- Comparison between bulk density of blends and dry noodles

% BCP	Bulk density of blends (g/cm^3)	Bulk density of raw noodles (g/cm^3)
0%	0.661±0.004	0.976± 0.005
5%	0.650± 0.004	0.961± 0.009
10%	0.658± 0.006	0.973± 0.010
15%	0.663± 0.005	0.967± 0.005
20%	0.656± 0.005	0.964± 0.005

Each value is expressed as mean±S.D (n=3); values followed by same letter in the different column are not significantly different at $p \leq 0.05$.

Table 6.6- Comparison between water absorption capacity of blends and dry noodles

% BCP	WAC of blends	WAC of noodles
0%	191± 6.24	194± 4.93
5%	206± 7.54	193.66± 3.21
10%	226± 7.93	187± 3.60
15%	254± 2	201.33± 3.21
20%	267.33± 4.16	205.66± 5.68

Each value is expressed as mean±S.D (n=3); values followed by same letter in the different column are not significantly different at $p \leq 0.05$.

WAC= Water absorption capacity

Table 6.8- Comparison between oil absorption capacities of blends and dry noodles

% BCP	Oil absorption capacity of blends (%)	Oil absorption capacity of raw noodles (%)
0%	201± 4	190± 7.211
5%	199± 7.81	186.33± 5.68
10%	203± 1.73	183.33± 4.04
15%	198± 2	183.66± 3.51
20%	201.33± 1.154	188.66± 5.68

Each value is expressed as mean±S.D (n=3); values followed by same letter in the different column are not significantly different at $p \leq 0.05$.

OAC= Oil absorption capacity

6.3 Bioactive properties

6.3.1 Anthocyanin Content

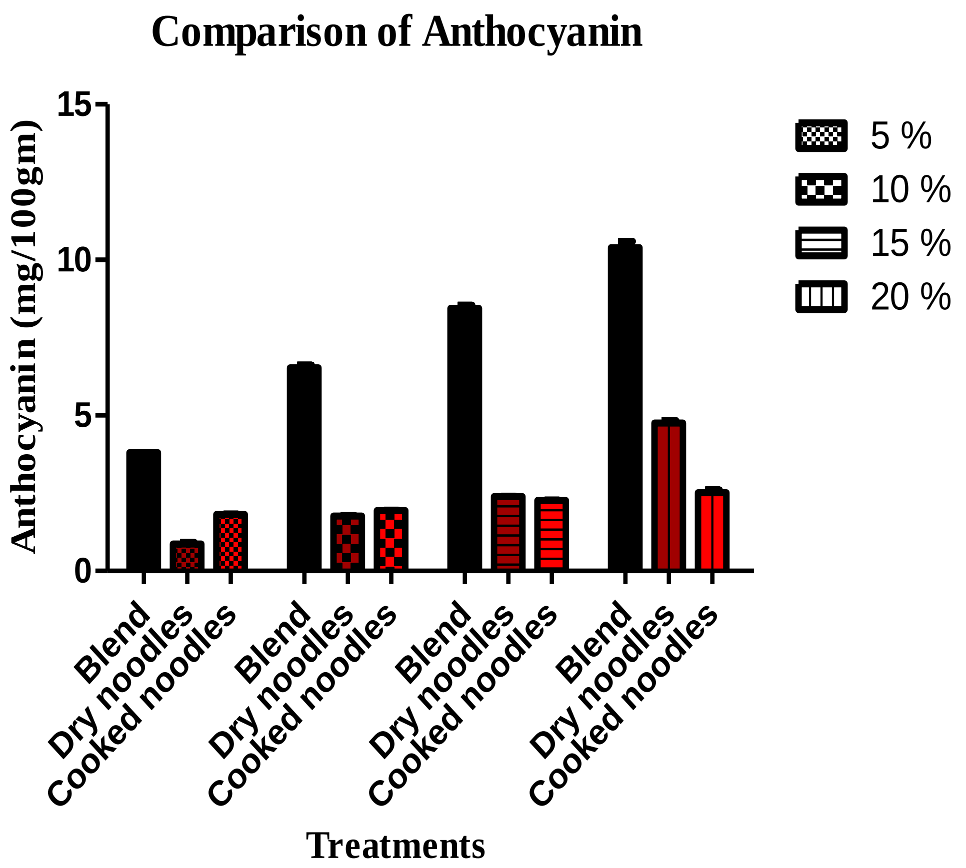
Anthocyanin are responsible for the color diversity in carrot. Black carrot has been reported as a good source of anthocyanin (Kamerer *et al.*, 2003). The anthocyanin content observed was ranged from 3.80 (100 % WF and 0 % BCF) to 10.39 (80 % WF and 20 % BCF)mg/100 gm (80 % WF and 20 % BCF) in blends, 1.81 (100 % WF and 0 % BCF) to 4.75 (80 % WF and 20 % BCF) in raw noodles and 0.8 (100 % WF and 0 % BCF) to 2.15 (80 % WF and 20 % BCF) in cooked noodles (Table 6.9). Percent decrease in blend v/s raw noodles and per cent loss in raw versus cooked noodles were also observed as shown in graph 6.1. Similar results has been reported by Hady *et al.*, 2014 in their study of color stability of strawberry jam fortified by purple carrot puree where they reported total anthocyanin content increased gradually by increased amount of black carrot addition. Effect of temperature, solid content and pH on the stability of black carrot anthocyanins were reported by Kirca *et al.*,2007 where they stated that degradation of anthocyanin increased with heating. The decrease in the raw noodles may be due to effect of heat on the anthocyanin content and cooking loss in cooked noodles can be due leaching of anthocyanin as it is a water soluble pigment. So, higher stability of anthocyanin in black carrot may be attributed to the presence of much higher amounts of acylated anthocyanins. This result could be explained by the fact that polyphenols such as anthocyanin are more prone to this feature than other compound.

Table 6.9- Anthocyanin content in blends, raw and cooked noodles

% BCP	Blends (mg/100gm)	Dry noodles (mg/100gm)	Cooked noodles (mg/100gm)	% decrease (blend v/s raw noodles)	% loss (raw v/s cooked noodles)
5%	3.805±0.007[a]	1.815± 0.021[a]	1.766± 0.022[a]	52.29	2.6
10%	6.535± 0.119[b]	1.945± 0.021[b]	0.946± 0.0749[b]	70.23	51.3
15%	8.445± 0.148[c]	2.396± 0.004[c]	2.265± 0.021[c]	71.62	54.67
20%	10.395± 0.275[d]	4.758± 0.111[d]	2.15± 0.134[d]	54.22	54.81

Each value is expressed as mean±S.D (n=3); values followed by same letter in the different column are not significantly different at $p \leq 0.05$

Graph 6.1- Comparison of anthocyanin content



6.3.2 Total flavonoid content

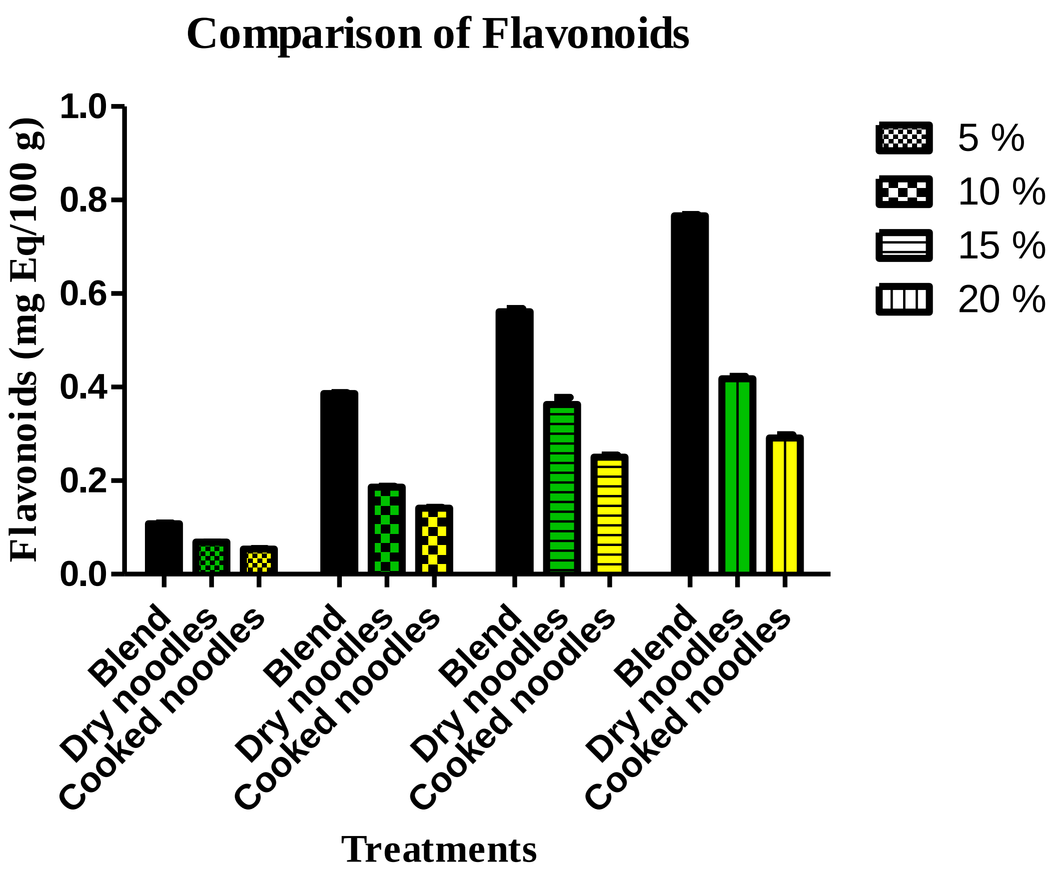
Flavonoids are important bioactive compounds which shows pharmacological and biochemical effects including anti- inflammation, anti-oxidation, antitumor effects, antimicrobial activities and anti- allergic effects (Koley *et al.*, 2013). The flavonoid content ranged from 3.833 (100 % WF and 0 % BCF) to 47.766 (80 % WF and 20 % BCF) in blends, 1.23 (100 % WF and 0 % BCP) to 24.5 (80 % WF and 20 % BCP) in dry noodles and 0.233(100 % WF and 0 % BCP) to 16.1 (80 % WF and 20 % BCP) in cooked noodles shown in table 6.10 and per cent decrease in blend v/s raw noodles and per cent loss in raw versus cooked noodles were also observed as shown in graph 6.2 . Similar results has been reported by Koley *et al.*, 2013 in their study of evaluation of bioactive properties of Indian carrot (*Daucus carota* L.) in which they reported that black carrot are rich source of flavonoids.

Table 6.10- Flavonoid content in blend, raw and cooked noodles

% BCP	Blends (mg QE/100 gm)	Dry noodles (mg QE/100 gm)	Cooked noodles (mg QE/100 gm)	% decrease (blend v/s dry noodles)	% Loss (raw v/s cooked noodles)
5%	3.833±0.235[a]	1.23± 0.047[a]	0.233± 0.141[a]	67.91	22.65
10%	22.433± 0.141[b]	9.066± 0.188[b]	6.1± 0.141[b]	59.58	32.71
15%	34.1± 0.612[c]	20.833± 1.461[c]	13.36± 0.424[c]	38.90	35.87
20%	47.766± 0.235[d]	24.5± 0.518[d]	16.1± 0.612[d]	48.70	34.28

Each value is expressed as mean±S.D (n=3); values followed by same letter in the different column are not significantly different at p≤0.05.

Graph 6.2- Comparison of flavonoid content



6.3.3 Antioxidant activity

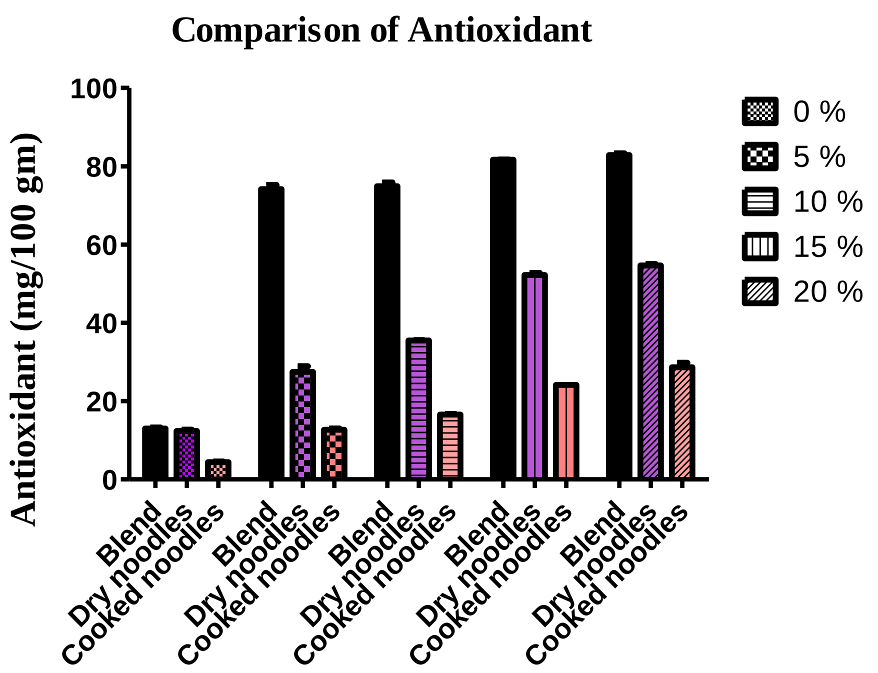
Total antioxidants are the one that quantifies the ability of complex biological sample to quench free radicals. The antioxidant activity observed ranged from 13 (100 % WF and 0 % BCP) to 82.5 (80 % WF and 20 % BCP) per cent in blends, 12.39 (100 % WF and 0 % BCP) to 54.655 (80 % WF and 20 % BCP) in dry noodles and 4.425 (100 % WF and 0 % BCP)to 28.66 (80 % WF and 20 % BCP) in cooked noodles a shown in table 6.10 and per cent decrease in blend v/s raw noodles and per cent loss in raw versus cooked noodles were also observed as shown in graph 6.3. Similar results has been reported by Ekici *et al.,* 2014 in which they studied the effect of black carrot concentrate on some physicochemical, textural, bioactive, aroma and sensory properties of sucuk, a traditional Turkish dry fermented sausage where the reported antioxidant activity increased with increased in the black carrot addition. Koley T.K *et al.,* studied the evaluation of bioactive properties of Indian carrot (Daucus carota L.): A chemometric approach where they reported that cultivarsof black carrot showed higher antioxidant activity. Contrary results has been reported by Khandare *et al.,* 2011 in their study of Black carrot (Daucus carota ssp. Sativus) juice: processing effect on antioxidant composition and color where they observed that there was 30 % increase in antioxidant activity of black carrot juice extracted with enzymes over straight pressed juice. It was observed that cooking caused a significant change in the flavonoid content in the black carrot noodle. Usually, thermal treatments shows destructive effect on the flavonoid compounds as they are highly unstable compounds (Ismail, Marjan and Foong, 2004 and Saika and Mahanta 2013). The observed result may be correlated with the high polyphenolic content of black carrot (Algarra *et al.*, 2014).

Table 6.11- Antioxidant activity in blends, raw and cooked noodles

% BCP	Blends (%)	Dry noodles (%)	Cooked noodles (%)	% decrease (blend v/s dry noodles)	% Loss (raw v/s cooked noodles)
0%	13± 0.33[a]	12.39±0.381[a]	4.425± 0.176[a]	4.69	64.28
5%	74.15± 1.527[b]	27.445± 2.04[b]	12.67± 0.480[b]	62.98	53.83
10%	74.915± 1.33[c]	35.47± 0.155[c]	16.55± 0.183[c]	52.65	64.27
15%	81.7± 0.056[d]	52.245± 0.700[d]	24.145± 0.007[d]	36.05	53.78
20%	82.85± 0.615[e]	54.655± 0.459[d]	28.66± 1.569[e]	34.03	47.56

Each value is expressed as mean±S.D (n=3); values followed by same letter in the different column are not significantly different at $p \leq 0.05$.

Graph 6.3 Comparison of Antioxidant activity



6.4 Cooking properties

Black carrot powder addition caused significant differences in gruel solid loss and water uptake per cent of noodle samples ($p<0.05$) (Table 6.11). Black carrot powder addition negatively affected the cooking quality of noodles. The noodle samples with black carrot powder addition had significantly higher cooking loss values as compared to those of the control sample (without BCP) ($p<0.05$). Cooked time observed was in range of 5.19 (100 % WF and 0 % BCP) to 5.09 (80 % WF and 20 % BCP) minutes.

Cooked weight ranged from 11.03 (100 % WF and 0 % BCP) to 16.28 (80 % WF and 20 % BCP) g.

Solid gruel loss indicates the degree of harm to noodles and their ability of structural maintenance during the cooking procedure (Yadav *et al.*, 2011). Gruel solid loss ranged from 0.15 (100 % WF and 0 % BCP) to 0.49 (80 % WF and 20 % BCP) g/100 g.

Water uptake percent reflects the degree of noodle hydration (Kober *et al.*, 2007) and its high value is undesirable. Water uptake percent ranged from 120 (100 % WF and 0

% BCP) to 225.6(80 % WF and 20 % BCP). The water absorption values of BCP supplemented noodles were significantly (p≤0.05) higher then the control noodle. The noodle containing 20 % of BCP exhibited the highest water absorption values among the sample tested. The differences in water uptake capacity among noodles of can be related to the different contents of amylopectin and amylose in wheat flour (Kober *et al.,* 2007). Similar results has been reported by Aydin and Gocmen 2011 in their study of cooking quality and sensorial properties of noodle supplemented with oat flour in which they had reported gruel solid loss and water uptake per cent increased as the amount of oat flour increased and Ma Ji *et al.*, 2013 in their study of cooking, textural, sensorial, and antioxidant properties of common and tartary buckwheat noodles in which they had reported higher cooking loss and water uptake per cent.

Table 6.12 Cooking properties of cooked noodles

% BCP	Cooking time (min)	Cooked weight (g)	Gruel solid loss(g/100 g)	Water uptake percentage (g/100g)
0%	5.19±0.056[a]	11.03± 0.014[a]	0.15± 0.098[a]	120.9± 0.707[a]
5%	4.875±0.601[a]	12.435± 0.176[b]	0.57± 0.155[a]	153.7± 3.535[b]
10%	5.25±0.070[a]	14.37±0.282[c]	0.515± 0.021[a]	202.1± 5.232[c]
15%	5.075±0.106[a]	16.28±0.311[c]	0.515± 0.021[a]	206± 3.676[c]
20%	5.095±0.077[a]	16.28±0.311[d]	0.49± 0.113[a]	225.6± 6.222[d]

Each value is expressed as mean±S.D (n=3); values followed by same letter in the different column are not significantly different at p≤0.05.

6.5 Sensory properties

The results, as presented in Table 6.13, showed that the acceptabilities of color and appearance, taste, aroma, flavour, texture and overall acceptability. Increasing addition levels of black carrot powder slightly decreased all sensorial scores. But all noodles prepared with black carrot powder were liked moderately and liked slightly by panelists. Among the noodle samples containing black carrot powder, the sample with 5 % and 10% black carrot powder received the highest sensory scores and scores of it were found statistically (p<0.05) similar. Especially, the usage of 5% black carrot powder in noodle formulation gave satisfactory results in terms of acceptability.

Table 6.13 Sensory characteristics of cooked noodles

SAMPLES	CA	TASTE	AROMA	FLAVOUR	TEXTURE	OA
CN_1	7.4±0.54^a	7.66±0.54^a	7.2±0.44^a	7.0±0^a	7.0±0.7^a	7.24±0.21
CN_2	6.8±0.44^b	6.8±0.44^a	6.64±0.41^a	6.0±0.7^b	6.4±1.1^b	5.92±0.34
CN_3	5.6±0.54^c	6.4±0.54^b	6.6±0.89^a	5.4±0.54^b	6.4±0.89^b	5.71±0.33
CN_4	4.8±0.44^c	5.7±0.67^c	6.0±0.35^b	5.0±0^c	5.6±0.54^b	5.15±0.38
CN_5	4.8±0.44^c	4.8±0.44^c	6.0±0^b	4.5±0.54^c	5.3±0.97^c	4.74±0.68

Each value is expressed as mean±S.D (n=3); values followed by same letter in the different column are not significantly different at $p \leq 0.05$.

CN= Cooked noodles

CA= Colour and appearance

OA= Overall acceptability

CHAPTER-7

CONCLUSION

Black carrot is a underutilised vegetable in India which is a rich source of fibre and have good bioactive properties (antioxidant, anthocyanin and total flavonoids). The objective of this study was to use dry black carrot powder as an ingredient to make dry noodles of high nutritional quality. Noodle making machine was used to prepare noodles and then were dried at 50ºC. Noodles made from black carrot powder and whole wheat flour were investigated into compositional analysis, cooking, physical, bioactive (antioxidant, anthocyanin and total flavonoids) and sensorial properties. Five different treatments with different concentration of black carrot powder (0, 5, 10, 15 and 20%) were made including control (whole wheat flour). As black carrot powder level increased fat, ash, crude fibre and sodium contents of noodles increased. Decrease in the level of protein, moisture and potassium content was observed. Water and oil absorption capacity showed remarked increase.

Black carrot noodles were found to be good sources of anthocyanin (3.8 to 10.9 mg/100 g) and flavonoids (3.82-47.76 mg QE eq./100 g). Black carrot noodles also showed higher antioxidant capacity measured by DPPH radical scavenging (13-82.5%). Black carrot powder caused increases in gruel solid, cooked weigh and water uptake percentage. Noodle with 5% black carrot powder received the highest sensory scores in all noodle samples containing black carrot powder. Overall acceptability scores of control and in only the noodle with 5% black carrot powder were found statistically ($p<0.05$) similar. Especially, the usage of 5% black carrot powder in noodle formulation gave satisfactory results in terms of acceptability. Overall, black carrot noodles are good alternative food with high nutritional quality and have good nutraceutical properties.

CHAPTER- 8

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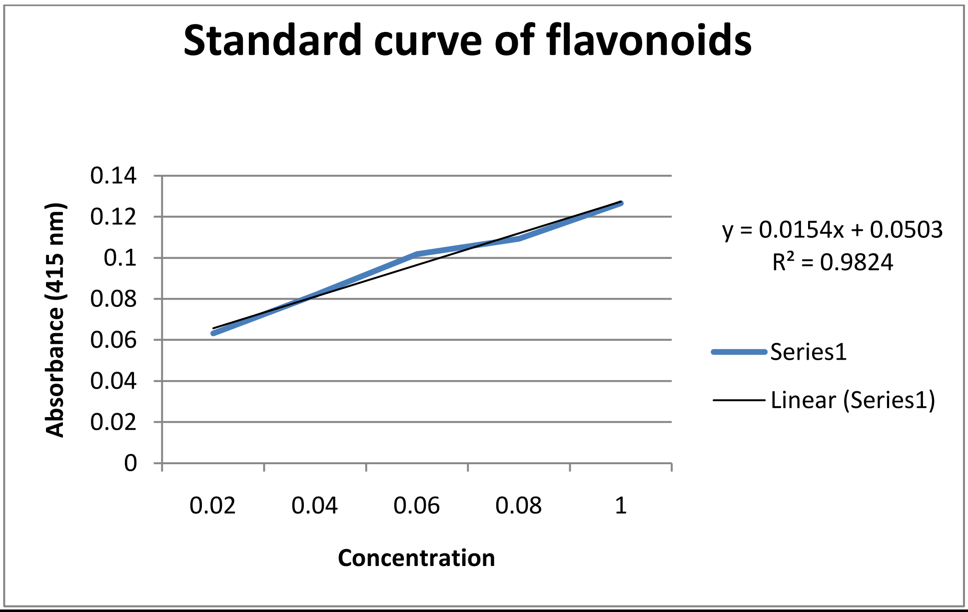
CHAPTER- 9

APPENDICES

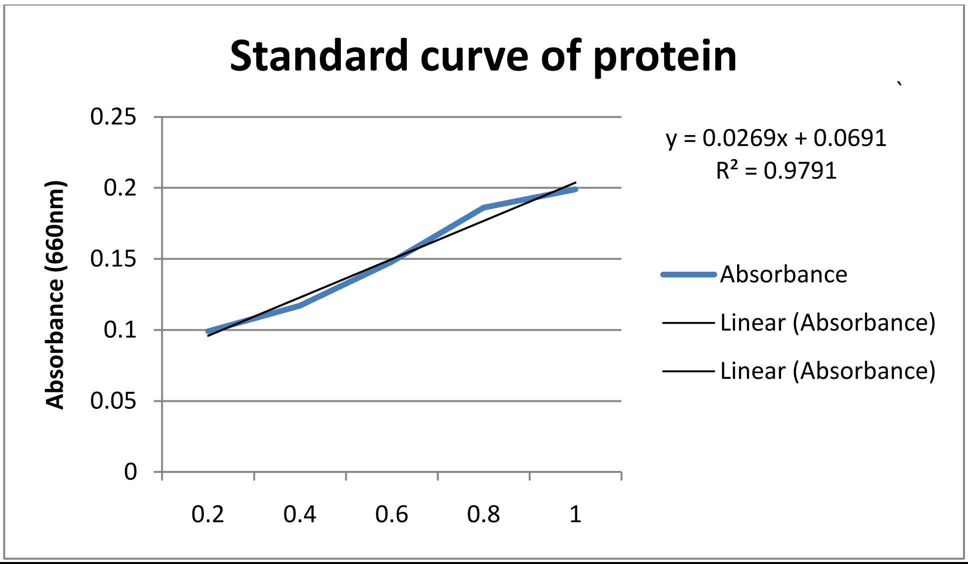
Appendix 1- Standard curve of Quercitin

S.no	Concentration	Absorbance
S_1	0.02	0.0632
S_2	0.04	0.0819
S_3	0.06	0.1018
S_4	0.08	0.1093
S_5	1	0.1265



Appendix 2-

Treatments	Concentration	Absorbance
S_1	0.2	0.009
S_2	0.4	0.117
S_3	0.6	0.148
S_4	0.8	0.186
S_5	1	0.199


Standard curve of protein
Absorbance (660nm)
0.25
0.2
0.15
0.1
0.05
0
0.2
0.4
0.6
0.8
1
y = 0.0269x + 0.0691
R² = 0.9791
Absorbance
Linear (Absorbance)
Linear (Absorbance)