ANALYSIS OF BETA CAROTENE & PROXIMATE COMPOSITION OF CARROT (*DAUCUS CAROTA*) FORTIFIED BREAD

Santo Shamol Das

Roll No: 0116/01

Registration No: 0419

Session: January-June/2017

A thesis submitted in the partial fulfillment of the requirements for the degree of Master of Science in Food Chemistry and Quality Assurance

Department of Applied Chemistry and Chemical Technology

Faculty of Food Science and Technology

Chattogram Veterinary and Animal Sciences University

Khulshi, Chattogram-4225, Bangladesh.

June 2019

Authorization

I hereby declare that I am the sole author of the thesis. I also authorize the Chattogram Veterinary and Animal Sciences University (CVASU) to lend this thesis to other institutions or individuals for the purpose of scholarly research. I further authorize the CVASU to reproduce the thesis by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

I, the undersigned, and author of this work, declare that the electronic copy of this thesis provided to the CVASU Library, is an accurate copy of the print thesis submitted, within the limits of the technology available.

Santo Shamol Das
June 2019

ANALYSIS OF BETA CAROTENE & PROXIMATE COMPOSITION OF CARROT (*DAUCUS CAROTA*) FORTIFIED BREAD

Santo Shamol Das

Roll No: 0116/01

Registration No: 0419

Session: January-June/2017

This is to certify that we have examined the above Master's thesis and have found that is complete and satisfactory in all respects, and that all revisions required by the thesis examination committee have been made.

(Mr. Md. Fahad Bin Quader)

Supervisor

(Mr. Md. Fahad Bin Quader)

Chairman of the Examination Committee

Department of Applied Chemistry and Chemical Technology

Faculty of Food Science and Technology

Chattogram Veterinary and Animal Sciences University

Khulshi, Chattogram-4225, Bangladesh.

June 2019

Acknowledgements

All praises are due to the "**Almighty God"** for blessing me with the strength, aptitude and patience and enabled me to pursue higher education and to complete the thesis for the degree of Masters of Science (MS) in Food Chemistry and Quality Assurance under the Departmentof Applied Chemistry and Chemical Technology, Chattogram Veterinary and Animal Sciences University, Chattogram, Bangladesh.

I have immense pleasure to express my deep sense of gratitude and indebtedness to my major advisor and research supervisor **Mr. Fahad Bin Quader** (Assisstant professor and Head, Department of Applied Chemistry and Chemical Technology, Chattogram Veterinary and Animal Sciences University, Chattogram, Bangladesh) for his guidance and moral support. His constant support, patience, valuable suggestions, useful criticism, constant encouragement and inspiration enabled me to overcome all hardship throughout this research and in preparation of the thesis.

I am highly grateful to **Mr. Mohammad Mozibul Haque (Jewel)** sir (Lecturer, depertment. of applied Food Science & Nutrition, Chattogram Veterinary and Animal Sciences University, Chattogram) for his worthy inspiration and generous help in carrying out of the research work.

I am also grateful to my friend **Farhana Sultana** (MS fellow, DepartmentFood processing and Engineering) for her scholastic support for my research work.

I would like to express my gratitude and cordial thanks to **Research and Extension** of Chattogram Veterinary and Animal Sciences University, Bangladesh for the financial help supplies during the study period.

I would like to express cordial thanks to my loving friends and well-wishers for their cooperation, cheerfulness and inspiration during the course of this study. I also expresses my heartfelt respects and thanks to my beloved parents and brothers for their understanding, inspirations, moral support, kindness and blessings, forbearance and endless love to complete this study.

The author

June 2019

Contents

List of Abbreviation

Abbreviation	Elaboration
%	Percentage
Abs.S	The absorbance of the standard
Abs.T	The absorbance of the Test Sample
B	Blank
S	Standard
T	Test
°C	Degree Celsius
°F	Degree Fahrenheit
ANOVA	Analysis of vaiance
conc	Concentration
CVASU	Chattogram Veterinary and Animal Sciences University
DF	Dilution factor
G	Gram
g/kg	Gram per kilogram
H/h	Hour
NaOH	Sodium hydroxide
HCl	Hydrochloric acid
UNICEF	United Nation International Children's Fund

Mg	Miligram
Min	Minute
Mm	Milimeter
mol/l	Mol per litre
Ng	Nano gram
nm	Nanometer
ppm	Parts-per-million
SD	Standard deviation
Temp	Temperature
UV-Vis	Ultraviolet-visible
w/w	Weight by weight
T_0	Control sample
T_1	Bread with 5% carrot powder
T_2	Bread with 10% carrot powder
WB	White bread
CP	Carrot Powder

List of Figures

List of Tables

Abstract

Carrot is one of the important root vegetables rich in bioactive compounds like carotenoids and dietary fibers with appreciable levels of several other functional components having significant health- promoting properties. Incorporation of carrot powder with refined flour in bread increase the several nutrients; vitamins, especially vitamin A (-carotene), fiber and minerals. The objectives of incorporation of carrot powder with refined flour is to make low cost food and consumed by large no of people and also easily available and have many health benefits. In present study, a systematic approach was followed to develop and standardize the process for the preparation of carrot fortified bread as product by cabinet drying method in different percentage. The proximate analysis, beta carotene value and sensory evaluation of the bread sample were determined. Crude fiber, moisture and fat content of the bread progressively increased with the addition of carrot powder were 10% carrot fortified bread having the highest values as 2.3%, 28.20%, 10.30% respectively and control bread having lowest values as 0.30%, 27.60%, and 8.90% respectively. Carbohydrate content decreased with carrot powder substitution. Control bread has highest value (49.1%) and 10% carrot fortified bread has the lowest value (46.5%) of carbohydrates. The sensory evaluation of the bread show crust, shape, internal texture, appearance and general acceptance significantly differed with in the samples. Aroma and taste of the bread samples were significantly different with the control bread. The beta carotene content is lower in 5% fortified bread than 10% fortified bread. The concentration of beta carotene is 3.002 mg in 5% fortified bread and 3.179 mg per 100 gram of 10% fortified bread respectively.

Keyword: Carrot, Bread, proximate composition, beta-carotene.

Chapter 1: Introduction

Carrot is one of the most nutritious and economical vegetable. It is becoming more popular due to its high carotene content which has anti-oxidative and anti-cancer property with abundant vitamins, dietary fiber and various minerals. B-carotene is converted into vitamin A in our body and plays key role in the maintenance of integrity of epithelial tissue and immune system. Carotenoid in carrot have inhibitory mutagenic activity thus lowers the risk of cancer also; they are potent anti-oxidants which helps to neutralize the effect of free radicals (Ibidapo Olubunmi Phebean *et al.*, 2017). Carrot has abundant calcium pectate content which reduces the risk of heart diseases, high blood pressure, and cholesterol (Adeleye A.S. *et al*, 2016). To extend carrot's utilization during off-season with maximum retention of b-carotene, oven-drying is a low-cost conventional method. It is also suitable for adopting by local companies as the demand for ready-to-use and quality food products has been increased in today's convenience-oriented market. Dehydrated foods extend the shelf life of food with reduced weight and bulk that further lowers transport and storage cost thus provides variety to the consumers. The prevalence and ever increasing incidence of protein energy malnutrition (PEM) among different age groups particularly children with an estimate of 400 million children being malnourished worldwide has been reported (Osthuizen, 2006; Agiriga and Iwe, 2009). This may be attributed to the ever increasing populace of the developing countries being fed predominantly on their staple food crops (maize, sorghum, cassava, etc) which have been reported to be poor sources of protein (Labadarious *et al.*, 2005) particularly in terms of amino acid balance but are rich sources of carbohydrate particularly starch. Protein deficiency is a major nutritional problem facing the world today, particularly the developing countries. High incidence of protein calorie malnutrition and nutritional diseases in developing countries particularly Nigeria has been reported (UNICEF, 2011).

Carrot is a major source of phytonutrients including phenolics (Babic *et al*, 1993), carotenoids (Block, 1994) and polyacetylenes (Hansen *et al*, 2003; Kidmose *et ai*, 2004). Due to appreciable level of variety of different compounds, carrots are considered a functional food with significant health promoting properties (Hager and Howard, 2006). Apart from being high in carotenoids, carrots are rich in dietary fibers (Bao and Chang,

1994b) which play an important role in human health (Anderson *et al,* 1994). High dietary fiber diets are associated with the prevention, reduction and treatment of some diseases such as diverticular and coronary heart diseases (Anderson *et al,* 1994; Gorinstein *et al.*, 2001; Villanueva-Suarez *et al,* 2003). Since, vitamin A deficiency is the leading cause of blindness amongst children in developing countries, slight dietary intervention with foods rich in pro-vitamin A such as carrots, could be one of the inexpensive solutions to overcome this problem (El-Arab *et al.,* 2002). Additionally, carotenoids owing to antioxidant activity are also beneficial in preventing major health problems such as cancer, coronary heart diseases and other diseases (Yeum and Russell, 2002). Carrots have also been designated as a significant source of calcium, potassium and phosphorus (Singh *et al.,* 2006). Due to changing life style and hectic schedule of the people various factors like environmental and dietary habits leads to an oxidative stress. Various *in vitro* studies have indicated that phytonutrients such as carotenoids and phenolics play a significant role in protecting biological systems from the effects of oxidative stress (Kalt, 2005).

In recent years, the consumption of carrot and its processed products has increased steadily due to their recognition as an important food having antioxidant and anticancer activities because of the presence of 13-carotene as a precursor of vitamin A (Dreosti, 1993; Speizer *et al.,* 1999). Being perishable in nature and seasonality, it is not possible to ensure availability of carrots throughout the year. Efforts have been made to extend the shelf-life of carrots by dehydration either in the form of cubes/dices or by fermenting, pickling, canning or cold storage (Mudahar and Jen., 1991). Therefore, to make carrot available throughout the year, dehydration of carrot shreds during the season could be one of the best alternatives. After juicing, 30-50% of carrot mass remains as pomace (Bao and Chang, 1994b) and up to 50% of the carotene present in the whole carrot lost with this pomace. Total carotene content of pomace may be up to 2g/kg dry matter, depending on processing conditions (Singh *et al.,* 2006). Carrot pomace contains 17% and 31-35% of the total a and 13-carotenes in the fresh unblanched and blanched carrots, respectively (Bao and Chang, 1994b). Hence, by-product of carrot after juicing (pomace) represent promising sources of compounds with bioactive properties that could be exploited in the development of food ingredients and dietary supplements (Moure *et al.,* 2001; Schieber *et*

al., 2001). Value addition in the waste also helps to curtail the price of main product thus a direct benefit to the producer, processor and consumer. Various attempts have been made at utilizing carrot pomace in bread, cake and the preparation of functional drinks (Schweiggeri, 2004) as well as in the preparation of high fiber biscuits (Kumari and Grewal, 2007).

Bread may be a described as a fermented confectionary product produced mainly from wheat flour, water, yeast and salt by a series of process involving mixing, kneading, proofing, shaping and baking *(Dewettinck et al., 2008)*. Recently, consumer's awareness of the need to eat high quality and healthy foods-known as functional foods which contain ingredients that provide additional health benefits beyond the basic nutritional requirements is increasing *(Ndife and Abbo, 2009)*. Therefore, the trend is to produce specially breads made from whole grain flour and other functional ingredients known as health breads or functional foods *(Dewettinck et al., 2008).* Bread can be enriched with dietary fiber (DF) from various sources, namely carrot powder *(Zlatica et al., 2012)*, Addition of DF to bakery products increases DF intake, decreases the caloric density of wheat rolls and prolongs freshness due to its capacity to retain water and thus reduces economic losses *(Elleuch et al., 2011, Kohajdova et al., 2011)*. Incorporation of fiber into wheat flour interacts directly with structural elements of the three dimension gluten networks and disrupts the starch gluten matrix, and finally affects the rheological behavior of blended dough during mixing, fermentation, and baking. However, the addition of these fibers sometime causes a negative effect on the final bread quality. The most notable change is the reduction of loaf volume *(Lai et al., 1989),* and poor sensory characteristics *(Mis et al., 2012)*. Nutritional quality of food supplements based on carrot powder and grits have been reported to be good source of β-carotene, fiber and many essential micronutrients and functional ingredients *(Singh and Kulshrestha, 2008).* The presence of high concentrations of carotenoids, especially β-carotene in carrot roots makes them to inhibit free radical scavengers, anti-mutagenic and immune-enhancers. Carrot is also an excellent source of calcium pectate; an extraordinary pectin fiber that has the cholesterol lowering properties. It has a property to reduce the risk of high blood pressure, stroke, heart disease and some type of cancer *(Bakhru, 1993)*. Carrot being

perishable and seasonal, it is not possible to readily make it available throughout the year. Dehydration of carrot during the main growing season is one of the important alternatives of preservation to further develop value added products throughout the year *(Krishan et al., 2012).*

Objectives of the Study:

The objectives of this study were to:

- Develop a carrot powder as a convenience product.
- Identify an acceptable process for dehydration and grinding from raw ingredient to finished product.
- Develop a new bread rich in beta carotene and other beneficial vitamin and minerals of carrot powder.
- Compare the newly developed bread with regular bread.
- Evaluate the beta carotene content after bake.

Chapter 2: Review of literature:

Carrot is one of the important root vegetable utilized for the preparation of many nutritionally rich products. It is a good source of useful bioactive compounds like carotenoids and dietary fiber. Due to appreciable levels of variety of different compounds, carrots are considered to be a functional food having significant health-promoting properties. Carrots are perhaps best known for their beta-carotene content. (The nutrient beta-carotene was actually named after the carrot!) While they can be an outstanding source of this phytonutrient, carrots actually contain a fascinating combination of phytonutrients, including other carotenoids (especially alpha-carotene and lutein); hydroxycinnamic acids (including caffeic, coumaric, ferulic); anthocyanins (in the case of purple and red carrots); and polyacetylenes (especially falcarinol and falcarindiol). Carrots are an excellent source of vitamin A (in the form of carotenoids). In addition, they are a very good source of biotin, vitamin K, dietary fiber, molybdenum, potassium, vitamin B6 and vitamin C. They are a good source of manganese, vitamin B3, vitamin B1, panthothenic acid, phosphorus, folate, copper, vitamin E and vitamin B2.

The present investigation was based on the preparation and storage of value added products from carrot like powder. Since, carrot commercially being utilized for the preparation of various products; therefore, an effort was made to utilize it to make use of its nutritional components. There is not much work done on drying and utilization of dried carrot pomace for the development of convenience products in Bangladesh and whatever literature is available in Bangladesh and abroad on various aspects of utilization of carrot has been reviewed under different heads:

1. Carrot production
2. Chemical characteristics of carrot
3. Effect of pre-treatments on the quality attributes of processed products
4. Dehydration process
5. Suitability of carrot for the preparation of various processed products
6. Dehydration and rehydration ratio
7. Equilibrium relative humidity (ERH)
8. Packaging
9. Effect of storage on quality of processed products

1. **Carrot production:** Carrot is one of the nutritious vegetables grown throughout the world. Commercial cultivation of carrot is successful in most of the regions. About 60% of carrot production of the world occurred in Asia alone. Carrot *(Daucus carota* L.) is one of the popular root vegetables grown throughout the world and is considered to be an important source of dietary carotenoids in Western countries including the United States of America (Block, 1994; Torronen *et al.*, 1996). China is the major carrot producing country in the world (FAQ, 2008). The area under carrot in India has been reported to be 22,538 hectares with an annual production of 4.14 lakh tones (Thamburaj and Singh, 2005). In India, Uttar Pradesh, Assam, Kamataka, Andhra Pradesh, Punjab and Haryana are major carrot producing states.

2. **Chemical Composition:**

a) **Moisture:** The moisture content of fresh carrot varies between 86.0 and 92.4%. (Howard *et al.,* 1962; Gill and Kataria, 1974; Gopalan *et al.,* 1991).

b) **Total soluble solids (TSS):** Gill and Kataria (1974) studied biochemical composition of Asiatic and European cultivars of carrot *(Daucus carota* L.) and found that their TSS varies from 12.0 to 16.1 and 14.3 to 15.6°Brix, respectively. Sharma (1990) has reported total soluble solids in black and red carrot as 10.7°Brix and 9.06°Brix, respectively. The total soluble solids in 30 varieties of carrot studied by Anand (2001) have been found to varying from 6.57 to 8.69°Brix. In Asiatic carrot, a total souble solid of 8°Brix has been reported by Sharma (2004).

c) **Titrable Acidity:** Luh and Woodroof (1982) have reported the titratable acidity of whole carrot to be 0.15 per cent while Wilson (1987) observed that the citric acid in carrot is only 0.02 per cent. Sharma (1990) observed that the titratable acidity in black and red carrot is 0.042 and 0.085 per cent, respectively. Sharma (2004) also reported 0.10% lactic acid in the carrot. Sagar *et al.* (2004) studied the physico chemical constituents of fresh carrot varieties, 'Pusa Kesar', 'Pusa Meghali', 'Sel-14' and 'Sel-16' and observed the titratable acidity as 0.10, 0.10, 0.08 and 0.09 per cent, respectively.

d) **Sugars:** The edible portion of carrot contains about 10 per cent carbohydrates. The soluble carbohydrates in four carrot cultivars ranged from 6.6 to 7.7 g/ 100 g (Howard *et al,* 1962). Kaur *et al.* (1976) have reported 1.67-3.35% reducing sugars, 1.02-1.18% non-reducing sugar, and 2.71-4.53% total sugars in six cultivars of carrot. Simon and Lindsay (1983) have reported that the relative proportion of reducing sugars in four hybrid varieties of carrots ranged between 6 to 32% of the free sugars.

e) **Ascorbic Acid:** Carrots are generally not considered as a good source of ascorbic acid. Wilson (1987) has reported 6 mg/100 g of ascorbic acid content in carrot while a range of 3 to 7 mg/100 g ascorbic acid in whole carrot has been reported by Gopalan *et al.* (1991). Salunkhe *et al.* (1991) observed that the roots of carrot have 9 mg/100 g of ascorbic acid. Howard *et al.* (1999) noticed the initial concentration of ascorbic acid in freshly harvested carrot during the seasons of 1994 and 1995 as 4.3 and 3.9 mg/100 g, respectively. Srilakshmi (1999) has reported 3 mg/100 g of ascorbic acid in fresh carrot.

f) **Carotenoids:** Carrot roots are a rich source of carotenoids. The importance of carotenoids in food goes beyond their role as natural pigments because many biological actions in human system have increasingly been attributed to these compounds. Carotenoids are important micronutrients for human health (Castermiller and West, 1998). In recent years, the consumption of carrot and its related products has increased steadily due to the recognition of antioxidant and anticancer activities of B-carotene in carrots, which is also a precursor of vitamin A (Dreosti, 1993; Speizer et al., 1999). The total carotenoid content in the edible portion of carrot roots ranges from 6000 to 54,800 pg/100 g (Simon and Wolff, 1987). Besides carotenoids, thiamin, riboflavin, niacin, folic acid, and vitamin C are also present in appreciable amounts in carrot roots (Howard *et al.,* 1962; Bose and Som, 1986). In past decades, carotenoids such as B-carotene have created considerable attention because of their possible protective effect against some types of cancers (Bast *et al.,* 1996; Santo *et al,*

1996; Van Poppel, 1996). Carotenoids are the primary source of vitamin A for most of the people living in the developing countries (Boileau *et al,* 1999) .

g) **Phenolics:** Phenolics are ubiquitous plant components that are primarily derived from phenylalanine via the phenylpropanoid metabolism (Dixon and Paiva, 1995). Phenolics in carrots are present throughout the root, but are highly concentrated in the periderm tissue (Mercier *et al,* 1994). In carrots, the two major classes of phenolics are hydroxycinnamic acids and para-hydroxybenzoic acids (Babic *et al.,* 1993a). Ninfali and Bacchiocca (2003) have reported the total phenolic content of fresh and frozen carrot juice as 0.26 and 0.20 mg/g juice, respectively while this content in extracted wet pulp from fresh and frozen carrot was 0.14 and 0.10 mg/g, respectively.

h) **Dietary Fiber:** The crude fiber in carrot roots consist of 71.7, 13.0 and 15.2% cellulose, hemi-cellulose and lignin, respectively (Kochar and Sharma, 1992). Apart from being high in carotenoids, carrots are also high in dietary fibers. Bao and Chang (1994b) reported that the carrot pulp contains 37-48% total dietary fibers. Dietary fiber plays an important role in human health (Anderson *et ai,* 1994). High dietary fiber diets are associated with the prevention, reduction and treatment of some diseases such as diverticular and coronary heart diseases (Anderson *et al.,* 1994; Gorinstein *et al.,* 2001; Villanueva-Suarez *et al.,* 2003). Dietary fibers are not only desirable for their nutritional properties but also for their functional and technological properties and because of those they can also be used as food ingredients (Thebaudin *et al.,* 1997; Schieber *et al.,* 2001). Fruits and vegetables fibers have a greater effect on blood lipids and on carbohydrate metabolism when they are consumed in sufficient amounts (Berger and Venhaus, 1992; Truswell and Beynen, 1992). Kumari and Grewal (2007) studied the chemical composition of carrot pomace powder and suggested that it contains 55.8±1.67% total dietary fibers.Whereas, Tanska *et al.* (2007) reported that the total fiber c ontent in dried carrot pomace as 37.5±2.50 per cent. Crude fiber in raw carrot,

pomace and dried pomace has been reported to be 1.87, 15.89 and 18.35% respectively by Upadhyay *et al.* (2008).

3. Effect of Pre-treatments on Quality Attributes of Processed Products:

Pre-treatments are common in most of the drying processes in order to improve quality, storage stability, and process efficiency. The common pretreatments like peeling, blanching and sulphuring/sulphiting, though cause losses, yet they are essential steps before dehydration. Blanching helps to inactivate the enzymes while sulphuring/sulphiting helps to retard the oxidative reactions like enzymatic and non-enzymatic browning and thus results in better retention of carotenoids and ascorbic acid during storage.

a. **Blanching:** Blanching is a process of pre-heating the product by immersing in water or steam for few minutes. In water blanching, wide variation of temperature may be possible, which can cause a loss of soluble nutrients. Water soluble vitamins may be lost due to leaching, thermal destruction or enzymatic oxidation during water blanching. Time and temperature of blanching are the important factors for achieving optimum quality of the dried product (Jackson *et al.',* 1996). Blanching times are correlated with the flavor and sensory attributes of dried fruits and vegetables (Shamaila *et ai,* 1996). Magnon and Culpepper (1924) and Melinick *et al.* (1944) concluded that steam blanching is preferable to water blanching because of less leaching losses of soluble nutrients. Blanching is done to control the activity of enzymes but under and over blanching can cause poor quality and texture with a loss in free amino acids and sugars (Kaushal and Joshi, 1995). The effect of pre-treatments condition on the physico-chemical parameters of carrot juice and the effect of different blanching solutions and blanching times (1-5min) on the quality of carrot juice have been studied (Bin-Lim and Kyung-Jwe,1996; Sharma *etal.,* 2007).

Several studies have reported an increase in total carotenoids after steam blanching (Howard *et al.,* 1999; Sulaeman *et al.,* 2001; Puuponen-Pimia *et al.,* 2003). Blanching has also been reported to result in isomerization of carotenoids (Desobry *et al;* 1998). Ambadan and Jain (1971) found that blanching of carrots shreds in 5% sugar solution

prior to dehydration not only imparts an attractive color but improves the organoleptic and keeping quality of the product. The degradation of 13-carotene is reportedly associated with the development of off-flavors in dehydrated carrots and sweet potato flakes (Ayers *et al.,* 1964; Walter *et al.,* 1970). Lipoxygenase are the major enzymes involved in carotene degradation (Kalac and Kyzlink, 1980). The activities of these enzymes can be decreased by blanching (Reeve, 1943). A study on effects of blanching and pre-drying treatments on the stability of carotenoids and anthocyanins in papaya and pineapple revealed that with the blanching temperature and time increase both of these pigments decreased while in case of pre-drying treatments, pre-treatment with sodium meta-bisulphite prevented carotenoids oxidation while orthophosphoric acid showed no effect on their oxidation. Carotenoids are more protected in a system with higher moisture retained by glycerol and sugar (Sian and Ishak, 1991). Banga and Bawa (2002) reported that B-carotene content of both blanched and unblanched samples increased with increase in drying air temperature whereas, ascorbic acid content of samples decreased. Blanching before juicing gives carrot pulp products good color and improves the color quality of carrot juice products (Sims *et al,* 1993; Bao and Chang, 1994b).

In all carrot batches, the rate of carotenoids degradation was at a minimum within the water activity range of 0.31-0.54. Below and above this range the rate of carotenoids degradation increased significantly. Blanching results in higher initial carotenoids content in dehydrated carrots however, it lost significantly during storage (Lavelli *et al,* 2006). Effect of pre-treatments before drying *viz.*, blanching, sulphiting, freezing, starching, sucrose and sodium chloride dipping on 6-carotene content of carrots has been assessed by Baloch *et al.* (1977a) and have concluded that the loss of soluble solids by leaching during blanching results in increasing in carotenoids content and thereby help to reduce the non-enzymatic browning, but encourages the enzymes for carotenoids destruction. The effect of various operating conditions on the losses of total carotenoids and ascorbic acid on dehydro-freezing of dried carrots were studied by Androetti *et al.* (1980). Their studies indicated that the best blanching method is steam blanching for 3 min and ideal drying method is either vacuum drying or drying at 80°C before subjecting the material to freeze drying.

b. **Sulphuring/Sulphiting:** Sulphiting and blanching can also be used together for pre-treatment of materials to be dried. Sulphiting ruptures and collapses cells, resulting in a smaller cell volume and hardness of the dried samples (Molyes, 1981). Treatment of sulphur dioxide in the drying of carrots (blanched and unblanched) reduces the losses of carotenoids (Baloch *et al.,* 1987). Mohamed and Hussein (1994) observed that carrot treated with sodium meta-bisulphite before drying resulted in twice as good retention of carotenoids than with no meta-bisulphite. Zhao and Chang (1995) showed that 2.5% sulphite concentration led to better retention of carotenoids in carrots. Arya *et al.* (1982) indicated that meta-bisulphite reduces the formation of browning compounds during dehydration and subsequent storage. Encapsulation of B-carotene with maltodextrin is another means to protect carotenoids from oxidation (Wagner and Warthesen, 1995; Desobry *et al.,* 1997).

4. Suitability Of Carrot And Its By-Product (Pomace) For The Preparation Of Various Processed Products:

Carrots are processed into products such as canned, dehydrated, juice, beverage, candy, preserve, intermediate moisture food and *gazrella* (Kalra *et al.,* 1987). Improvements in the color and quality of canned carrots by heat treatment and by the use of chemicals have been reported by several workers (Chiang *et al.,* 1971; Jelen and Chan, 1981; Edwards and Lee, 1986; Bourne, 1987). Thermal processing has been reported to increase the amount of carotenoids in products (De SA and Rodriguez-Amaya, 2004; Edwards and Lee, 1986). Pruthi *et al.* (1980) reported that carrots could be preserved in good conditions for 6 months at room temperature even in non-air tight containers using acidified brine with potassium meta-bisulfite. Carrot candy or preserve can be prepared by covering small whole carrots or slices of carrots with sugar or heavy sugar syrup so that total soluble solids content increases to 70-75°B (Beerh, 1984). Carrots have been processed to obtain intermediate moisture foods containing about 55% moisture (Jayaraman and Dasgupta, 1978; Sethi and Anand, 1982). The extraction, canning and storage of carrot juice have been described by Stephens *et al.* (1976), Grewal and Jain (1982) and Bawa and Saini (1987). Carrot beverages have been prepared by mixing carrot juice with other fruit

juices or skim milk (Saldana *et al.,* 1976). Carrot juice has been reported to contain high amount of A and B-carotene (Munsch and Simard, 1983; Heinonen, 1990; Chen *et al.,* 1995; Chen *et al.,* 1996). Carrot juice is also reported to have its use with other fruit juices in blended form (Stoll *et al.,* 2001). Carrot juice and blends with other juices are among the most popular non-alcoholic beverages in Germany. Yield and quality of carrot juice extracted by pressing varies with the pretreatment condition such as pH, temperature and time (Sharma *et al.,* 2006). JChan *et al.* (1988) have reported the quality aspects of carotene enriched beverages.

Fermented products production and consumption is growing continuously due to its therapeutic properties besides it high nutritive value (Karagul *et al.,* 2004). The health promoting properties of live lactic acid bacteria in yoghurt include protection against gastrointestinal upsets, enhanced digestion of lactose by mal-digesters, decreased risk of cancer, lower blood cholesterol, improved immune response and help the body assimilate protein, calcium and iron (Perdigeon *et al,* 1998). Carrot juice is also used in yoghurt industry (Schieber *et al,* 2002 and Simova *et al,* 2004). Blending of yoghurt with carrot juice would produce a nutritionally rich food (Ikken *et al,* 1998 and Raum, 2003). Carrot yoghurt has been prepared by blending milk with carrot juice at 5, 10, 15 and 20% before fermentation (Salwa *et al,* 2004). Processing and preservation of numerous sweet products from carrots have also been reported (Sampathu *et al.,* 1981; Beerh *et al,* 1984; Kalra *et al,* 1987). Carrot *halwa* is one of the popular sweet dishes of northern India. It is prepared by cooking shredded carrots with sugar and moderately frying in hydrogenated oil with grated dehydrated milk called *khoa* (Sampathu *et al,* 1981). A *kheer* mix is another sweet product which is formulated based on dehydrated carrot, skim milk powder, sugar and other ingredients (Manjunatha *et al,* 2003). Dehydrated carrot products *viz.,* carrot chops, carrot shreds and powder have been reported to be utilized for preparation of different recipes like carrot curry, carrot *halwa* and biscuits (Suman and Kumari, 2002).

5. Dehydration And Rehydration Ratio:

Adequate rehydration is essential in order to have satisfactory rating quality. Suman and Kumari (2002) reported that the rehydration of carrot shreds was faster as compared to carrot chops. The shreds had a maximum rehydration ratio (10.1) in 6 h, while the rehydration ratio of chops was (8.1) in 8 h. The lower rehydration ratio of carrot chops was due to the polysaccharide (com starch) gel absorbed on the cell walls causing changes in the texture and rehydration. Banga and Bawa (2002) reported that the blanched samples of carrot rehydrated better as compared to unblanched ones, with a maximum rehydration ratio of 9.57 for the sample dehydrated at 60°C. It may be attributed to the increased permeability as a result of blanching. In case of unblanched samples maximum rehydration ratio of 7.52 was obtained for the sample dehydrated at 70°C. The dehydration ratio was maximum (21.4) for the sample dehydrated at 50°C in case of blanched samples while the unblanched ones had maximum dehydration ratio (16.9) for 70°C dehydrated samples. Ponting *et al.* (1966) studied rehydration of osmotically treated and dried apple fruit chips and observed that in treated slices the rehydration was slightly less than the untreated sample, though their texture was better than control samples.

6. Equilibrium Relative Humidity (ERH):

Packaging requirements and storage characteristics of dehydrated foods are determined by ERH of the product. Hygroscopicity is one of the most important parameters of dehydrated foods and is influenced by the original moisture content of the product itself Labuza *et al.* (1970) reported that water exerts a strong influence on the rates of chemical deterioration in foods especially for lipid oxidation and non-oxidation and non-enzymatic browning. Optimum relative humidity for the storage of raw mango powder has been reported to be 40-43 per cent (Dabhade and Khedkar, 1980). Mould growth however, appeared when the powders were kept beyond 90% relative humidity. Alkesh (2001) studied the sorption behavior of dehydrated apple rings and apple powder and found optimum ERH to be 57 and 54%, respectively. At higher relative humidity i.e. above 54-57%) the dried apple products have tendency to absorb moisture and become moldy. The moisture sorption isotherm studies carried

out by Singh (2001) revealed that the un-osmosed dehydrated carrot shreds are more hydroscopic as compared to the osmosed dehydrated sample and require a lower relative humidity for safe storage. Sharma *et al.* (2000) studied the storage conditions of osmotically dehydrated apple and observed critical point (CP) at 79.60 per cent relative humidity with 30.30 per cent equilibrium moisture content (EMC) while optimum equilibrium relative humidity (ERH) was 52.00 per cent at 18.56 percent equilibrium moisture content. Subramanian *et al.* (1976) reported that addition of cane sugar (sucrose) to the fruit powders reduce their hygroscopicity and increase their water activity. Similarly, Kumar *et* a. (1991) also reported that pulverization of juice powder with cane sugar was found helpful in increasing water activity and improving quality and storage stability of dried products.

7. Packaging: Packaging plays an important role in enhancing the shelf-life of processed products. The selection of suitable package to store a particular food depends upon the temperature and relative humidity during storage. Polyethylene is permeable to gases and moisture during storage of dried foods thus, deteriorates the quality whereas, tin, glass and aluminum foils are considered to be good packaging material (Mahadeviah, 1999). Mehta *et al.* (1974) reported the use of 200 gauge polyethylene bags for the storage of dried apricot with a very little change in quality up to one year. The effect of different packaging materials (polyethylene, paper bags, silver color polyethylene and black color polyethylene and amber color bottles) on the ascorbic acid content of dried apricot during storage period of one year has been reported by Wahid *et al.* (1989). They observed that the amber color bottles and black color polyethylene were at par in retaining the maximum ascorbic acid content of 4.8 mg/100 g after one year from an initial value of 12.6 mg/100 g. The storage of garlic powder over a period of 3 month in various packages showed significant changes in browning, carbohydrate, protein, flavor and vitamin C. However, the loss of nutrients was less in case of aluminum foil laminates and brown glass bottles because of their barrier properties (Ambrose and Sreenarayanan, 1998). Different packaging materials were studied for safe storage of dehydrated apple rings by Sharma *et al.* (2000) and they observed that quality significantly deteriorated in polyethylene and glass

packages during storage up to 6 month at ambient temperature (13-36°C) however, a minimum change in chemical composition and sensory attributes was observed in vacuum sealed laminated pouches. Sagar and Khurdiya (1999) have also reported that aluminum laminated pouches are better for packaging and storage of dehydrated ripe mango slices up to 6 month with respects of color, flavor, texture and overall acceptability over to other packaging materials. However, Sagar *et al.* (1999) observed that nitrogen packed material with aluminum laminated polyethylene (260 gauge) were most suitable than low density polyethylene bags of 200 and 400 gauge as well as different mode of packs such as air pack and vacuum pack in terms of retaining good color of dehydrated mango slices. Khurdiya and Roy (1974) observation on packaging of guava powder in polyethylene pouches revealed that retention of ascorbic acid and SO_2 during storage was proportional to gauge thickness. However, 200 gauge polyethylene coupled with aluminum foil was found to be the best for ascorbic acid retention (15%), SO2 retention (9.3%) and less gain in moisture (3.1%)) in six months. Dabhade and Khedkar (1980) observed rapid rise in moisture uptake in dried mango powder packed in paper bags than in polyethylene bags during 6 month of storage at room temperature. Thus, the variation in moisture uptake was attributed to the difference in water vapor transmission rates of different packaging materials.

8. Effects Of Storage On Quality Of Processed Products:

Chemical evaluation of dehydrated carrots for B-carotene content (chopped, shredded and powdered) has revealed that the powder retained the most B-carotene during 3 month storage (Suman and Kumari, 2002). Carotenoids in carrots are relatively stable during long term frozen storage (Howard *et al.,* 1999; Kidmose and Martens, 1999; Puuponen-Pimia *et al.,* 2003). Many processed vegetables are reported to have higher levels of carotenoids than that of fresh one during refrigerated storage (Gross, 1991; Kidmose *et al,* 2004). Carotenoid content of minimally processed carrots do not decrease during storage however, these products are degraded by microbial spoilage and accelerated metabolic activity (Lavelli *et al.,* 2006). The reducing sugars and acidity of carrot pickle have been found to increase significantly, 84.5 to 86.5 mg/g

and 1.57 to 2.61%, respectively after 4 month of storage (Chawla *et al*, 2005). On the other hand, Chawla *et al.* (2005) reported the retention of B-carotene up to the level of 31.71% at the end of 4 month of storage. They further observed that storage significantly reduced the fi-carotene content of carrot pickle as the content was found to reduce from 3.69 mg/100 g in fresh pickle to 1.17 mg/100 g at the end of 4 month of storage. Similarly, ascorbic acid content has also been reported to be reduced from 5.76 mg/100 g to 3.96 mg/100 g after 4 month of storage which is to the tune of 31.25 per cent.

Studies during storage of dried carotenoids powder extracted from carrot waste revealed that isomerization of carotenoids occurs readily under high storage temperature (45°C) or extended exposure to light (Chen and Tang, 1998). Pigments of spray dried carrot pulp waste proved to be prone to degradation during storage depending on storage time and temperature (Singh *et al.* 2006). Low temperature (7"C) helps in retaining higher level of total carotenoids and beta carotene in ready-to-eat dehydrated carrot shreds (Sagar, 2009). The stability of carotenoids during storage of mango pulp has been investigated by Sudhakar and Maini (1994) and found that higher concentration of sulphur dioxide helps in better retention of carotenoids. They further observed that packing of pulp in

Chapter 3: Materials and Methods

3.1 Materials:

Fresh, ripe, good quality carrots were purchased from local markets in Chattogram City, Bangladesh, then washed, peeled and cut into small cubes and blanched prior of dehydration. Blanching was done by putting small cubes of carrot into hot water for five minute to inactivate polyphenol oxidase enzyme. After five minute small cubes were dipped into ice water. All chemicals were obtained from Applied Chemistry and Chemical Technology Laboratory, Chattogram Veterinary and Animal Sciences University (CVASU) unless otherwise stated.

3.2 Carrot Powder:

Carrot powder was the result from fresh, ripe tomatoes which have been dried in Cabinet Drier at Food Processing and Engineering Laboratory (CVASU) and formed to powder. It was packaged in a plastic air tight bottle.

As carrot powder has moisture content at lower level, the stability of this powder will be very high about 4-6 months. No artificial color and preservatives were added, that’s why it is totally natural.

Carrot powder processing:

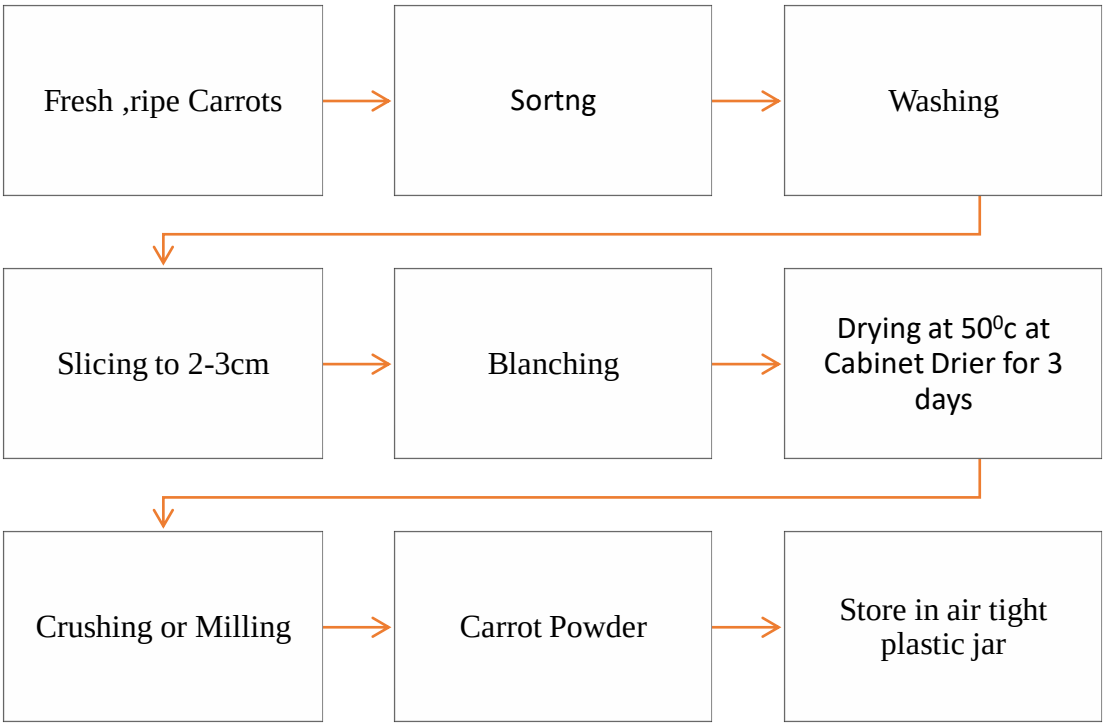


Figure 1: Carrot powder processing

3.3 Processing of Bread with Carrot Powder:

- **Ingredients:**
  - Flour
  - Fresh carrot powder
  - Instant Yeast
  - Sunflower Oil
  - Milk Vita milk
  - ACI salt
  - Fresh Sugar
  - Drinking Water

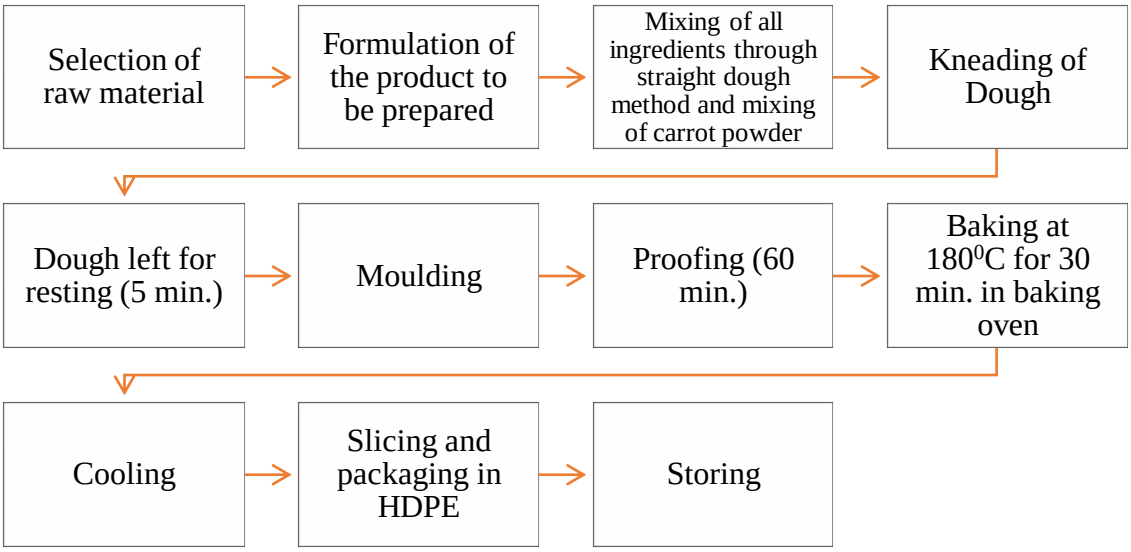


Figure 2 Manufacturing of carrot fortified bread

Table 1: Treatment Parameter for Bread

Treatment parameters			
Sr. No.	Treatments	Refined flour%	Carrot powder %
1.	WB	100	0
2.	T_1	95	5
3.	T_2	90	10

3.4 Proximate Analysis Of Carrot Powder, Control Bread and Bread Fortified With Carrot:

3.4.1 Determination of Crude Fiber

Principle:

The suitably weighed sample is successively treated with boiling sulfuric acid solution and sodium hydroxide solution. The residue is separated by filtration, washed, dried, weighed and then ashed. The loss in mass from ashing is called the crude fiber content.

Reagent Required:

- H_2SO_4
- NaOH

Apparatus Required:

1. Conical flasks
2. Reflux condenser
3. Desiccators
4. Hot air oven
5. What-man filter paper
6. Volumetric flasks
7. Analytical Balance.

Procedure:

1. 0.5 gm. sample was weighed and taken in volumetric flasks.
2. Then samples were boiled with 50ml 0.225 N H_2SO_4 for 30 minutes in a reflux condenser.
3. Insoluble residues were then filtered and collected.
4. The obtained residual substances were boiled subsequently with 0.313M Na0H for 30 minutes in a reflux condenser.
5. After that it was chronologically washed and filtered to get insoluble residue.
6. The residue obtained was then dried for 2hrs at 103±2°C in oven.
7. The weight of dried residue with filter paper and blank filter paper was taken.
8. Then the both filter paper were ashed in a muffle furnace at 550±25°C for 5 hrs.

9. After ashing the mass of loss of the sample was recorded.

Calculation:

$$\textbf{Crude fiber Content}\% = \frac{\text{weight of ash}}{\text{Weight of sample taken}} \times 100$$

3.4.2 Determination of Moisture Percentage

Principle:

Moisture Content is important parameter of foods. If food product absorbs moisture from environment its moisture content increases and allow the microorganisms to grow. The measure of moisture content during thermo-gravimetric analysis defines moisture as the loss of mass of a substance when heated, by the process of water vaporization. The substance difference is continually calculated and recorded by a precision balance. Sample substance mass is measured before and after the drying process for final moisture determination on percentage basis.

Materials Required:

- Crucible
- Micro-Oven
- Spoons.

Procedure:

a. Weight out previously dried crucible and about (5-10) g of sample was taken in it.

b. Then the sample in crucible was kept in a hot air oven.

c. After 4hrs the 1st reading was taken.

d. Then the process was repeated 3 times at 1hr interval.

e. Then the final reading was taken and moisture content determined.

Calculation:

$$\textbf{Moisture Content}\% = \frac{\text{Weight of crucible with sample} - \text{weight of empty crucible}}{\text{Weight of sample taken}} \times 100$$

3.4.3 Determination of Ash Percentage

Principle:

Ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of oxidizing agent, which provide a measure of the total amount of minerals within a food.

Materials:

- Crucible
- Micro-Oven
- Spoons.

Working Procedure:

1. Taken certain amount of sample in crucible
2. Placed in oven at 105°C to remove moisture.
3. After removal of moisture placed the crucible with sample in muffle furnace at 550°C for 6hours.
4. Taken the weight of Ash

Calculation:

$$\textbf{Ash Content}\% = \frac{\text{Weight of crucible with ash} - \text{weight of empty crucible}}{\text{Weight of sample taken}} \times 100$$

3.4.4 Determination of Fat Percentage

Principle:

Soxhlet apparatus is one of the most commonly used methods for determination of total fat. This is because it is fairly simple to use and officially recognized method. My processed food products may contain small amount of fat.

Materials and Reagents:

- Filter paper
- Rota vapor
- Reflux Condenser. etc.
- N- Hexane.

Working Procedure:

i. Sample taken in filter paper
ii. Placed in soxhlet apparatus with n hexane in Round
iii. Bottom Flux for fat extraction
iv. Transferred it with n hexane in rota vapor for separation of fat
v. The fat was then collected
vi. Heated into Final weight was taken.

Calculation:

$$\textbf{Fat}\% = \frac{\text{Weight of flaskwith fat} - \text{weight of empty flask}}{\text{Weight of sample taken}} \times 100$$

3.4.5 Determination of Protein Percentage

Principle:

A food is digested with a strong acid so that it releases nitrogen which can be determined by a suitable titration technique. The amount of protein present is then calculated from the nitrogen concentration of the food. The same basic approach is

still used today, although a number of improvements have been made to speed up the process and to obtain more accurate measurements.

Materials:

1. Beaker.
2. Glass crucible.
3. Nylon cloths.
4. Sintered Glass Crucible.
5. Desiccators.

Reagents:

- 0.3% NaOH
- 5% Acetic Acid
- 95% Alcohol
- Acetone.

Procedure:

1. About 5gm of finely ground/paste food sample was dispersed in 150ml of 0.3% NaOH solution at pH of about 11.6 in a 250ml beaker.
2. The content of beaker was heated at 50°C on a water bath for 2 hours with occasional stirring.
3. The solids were then separated from dispersion medium by filtration through a nylon cloth and then by centrifugation.
4. Proteins were precipitated by gradual addition of 5% acetic acid at the isoelectric point from the alkali extract.
5. The protein thus precipitated out was then filtered through sintered glass crucible, washed several times with 95% alcohol and finally with acetone.

6. The washed proteins were dried in the desiccators at room temperature.

Calculation:

Weight of Protein: Weight of dried filter paper with residue – weight of empty filter paper

$$\textbf{Protein Percentage} = \frac{\text{Weight of Protein}}{\text{Weight of sample taken}} \times 100$$

3.4.6 Carbohydrate by Difference:

Total carbohydrate was calculated by subtracting the moisture, ash, protein and fat content from 100. I.e.-100 - (Moisture +ash + protein + fat). Carbohydrates are important in foods as a major source of energy to human physiological processes.

Calculation:

Carbohydrate content % = 100 - (Moisture +ash + protein + fat)

3.5 Determination of Beta carotene:

5 g of sample was dissolved in acetone and ground till the whole color is extracted, extract was transferred into a separating funnel and contained petroleum ether. Colored portion was separated, collected. The content of β-carotene in the petroleum-ether extract was determined spectrophotometric ally; the absorbency was measured at the wavelength of 450 mm using the spectrophotometer. The concentration of carotenes expressed as β-carotene (g/100 ml) was calculated using the response factors as follows:

$$\beta - carotene = \frac{A \times V \times D}{E^{1\%} 1cm \times W} \quad \text{(g/100ml)}$$

Where, $E^{1\%} 1cm$ =coefficient of absorbency (2592 for petroleum ether),

A – Absorbency,

D – Dilution,

w – Weight of sample (g),

V – Volume (ml)

3.6 Sensory Evaluation:

Sensory evaluation was conducted on freshly baked samples (control and treated) by 15 untrained panelists of the fourth year and the first year students of the faculty of Food Science And Technology, Chattagram Veterinary And Animal Sciences University, Khulsi, Chattagram. The sensory evaluation attributes were crust, aroma, internal texture, taste, appearance and general acceptability. Each sensory attribute of the bread samples was assessed by panelists according to 9-point Hedonic Scale (1=neither like or neither dislike; 2=dislike very much; 3=dislike moderately; 4=dislike slightly; 5=neither like nor dislike; 6=like slightly; 7=like moderately; 8=like very much; 9like extremely) (Ranganna, 1991)

3.7 Statistical Evaluation:

Data collected in this study was analyzed by one way (Tukey's Multiple Comparison Test) using Microsoft excel 2007 and SPSS (Statistical Package for the Social Sciences) version 16.0. A significant difference was considered at the level of $p<0.05$.

Chapter 4: Result

4.1 Gross Chemical Composition:

Chemical composition of wheat flour (72 % extraction) and carrot powder (CP) is presented in figure 1. The results indicate that wheat flour (72 % extraction) and carrot powder (CP) were significantly different in terms of crude protein, total carbohydrates, fat, ash, and crude fiber.

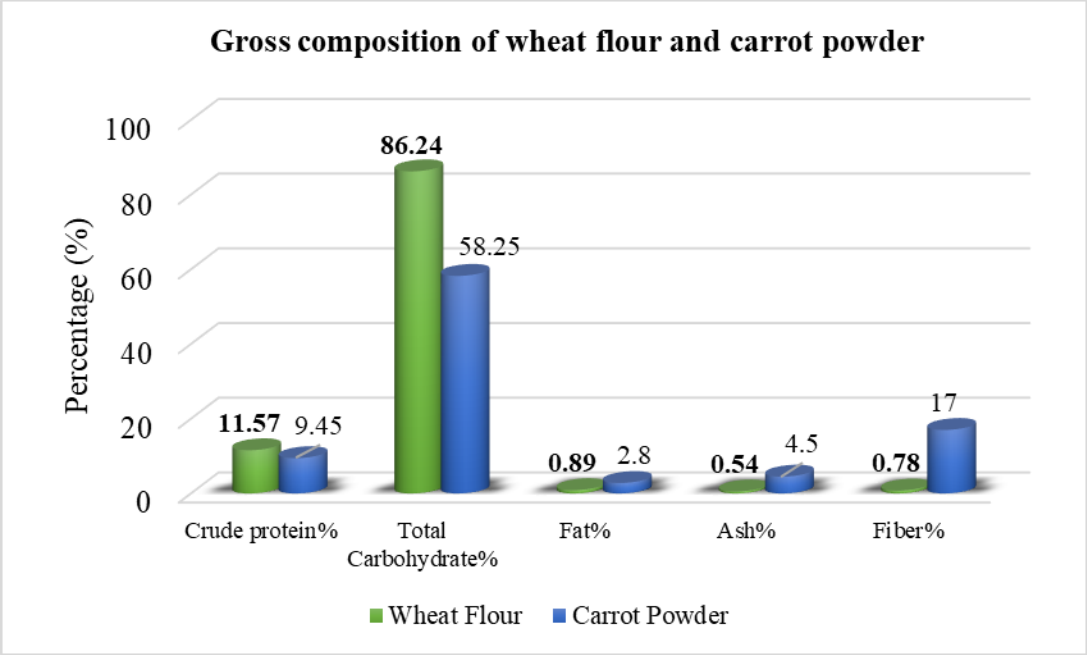


Figure 3: Gross chemical composition of wheat flour and dry carrot powder (On dry weight basis)

4.2 Proximate Compositions of whole wheat bread and carrot powder treated bread

One way ANOVA (Analysis of variance) test (Table 2) was performed to see the overall mean difference of samples for proximate compositions. Tukey's multiple comparison test was performed to make sure for which samples were the most significant for proximate compositions. It was observed that all pairwise comparisons were significantly different from one another regarding to fat and carbohydrates. Regarding to moisture, it was observed that Carrot powder (CP), was significantly different from bread treated with 5% carrot powder (T_1), bread treated with 10% carrot powder (T_2) and whole wheat bread (WB). There was no significant difference between bread treated with 5% carrot

powder (T_1) and bread treated with 10% carrot powder (T_2); bread treated with 5% carrot powder (T_1) and whole wheat bread (WB); bread treated with 10% carrot powder (T_2) and whole wheat bread (WB); and vice-versa. Regarding to ash, the result observed that all pairwise days combination were significant except bread treated with 5% carrot powder (T_1) and bread treated with 10% carrot powder (T_2). Regarding to fiber and protein, it was observed that Carrot powder (CP), was significantly different from bread treated with 5% carrot powder (T_1), bread treated with 10% carrot powder (T_2) and whole wheat bread (WB). There was no significant difference between bread treated with 5% carrot powder (T_1) and bread treated with 10% carrot powder (T_2); bread treated with 5% carrot powder (T_1) and whole wheat bread (WB); and vice-versa.

Table 2: Proximate composition (%) of Carrot powder (CP), bread treated with 5% carrot powder (T_1), bread treated with 10% carrot powder (T_2) and whole wheat bread (WB)

Proximate composition (%)						
Sample ID	Moisture (Mean±SD	Ash (Mean±SD	Fat (Mean±SD	Fibre (Mean±SD	Protein (Mean±SD)	Carbohydrate (Mean±SD)
CP	8 ± 1^{a}	4.5 ± 0.2^{a}	2.8 ± 0.1^{a}	17 ± 1^{a}	9.45 ± 0.02^{a}	58.25 ± 0.04^{a}
T_1	28.5 ± 0.01^{b}	1.4 ± 0.02^{b}	9.8 ± 0.1^{b}	1.6 ± 0.1^{bc}	11.4 ± 0.1^{bc}	47.3 ± 0.2^{b}
T_2	28.2 ± 0.03^{b}	1.6 ± 0.01^{b}	10.3 ± 0.2^{c}	2.3 ± 0.1^{b}	11.1 ± 0.01^{b}	46.5 ± 0.01^{c}
WB	27.6 ± 0.02^{b}	2.6 ± 0.01^{c}	8.9 ± 0.1^{d}	0.3 ± 0.2^{c}	11.5 ± 0.2^{c}	49.1 ± 0.02^{d}
F-test	1212**	593.842**	2078**	696.28**	217.574**	8369**

** Significant at P <0.01; Values followed by different superscript letters denote a significant difference; comparison done across the columns.

Results are means ± standard deviation of triplicates (n=3)

4.3 Beta-carotene content (mg/100g) of Carrot powder (CP), bread treated with 5% carrot powder (T_1) and bread treated with 10% carrot powder (T_2)

One way ANOVA (Analysis of variance) test was performed to see the overall mean difference of beta-carotenes (Table 3). Tukey's multiple comparison test was performed to make sure for which beta-carotenes were the most significant for samples. It was observed that all pairwise comparisons were significantly different from one another regarding to beta-carotene.

Table 3: Beta-carotene content (mg/100g) of Carrot powder (CP), bread treated with 5% carrot powder (T_1) and bread treated with 10% carrot powder (T_2)

Beta carotene (mg/100g)	
Sample ID	(Mean±SD)
CP	24.653±0.003[a]
T_1 (5%)	3.002±0.001[b]
T_2 (10%)	3.179±0.005[c]
F-test	39850000000**

** Significant at P <0.01; Values followed by different superscript letters denote a significant difference; comparison done across the columns.

Results are means ± standard deviation of triplicates (n=3)

4.4 Sensory evaluation:

The mean score for crust, aroma, appearance, taste, internal texture and overall acceptability of the breads (bread treated with 5% carrot powder (T_1), bread treated with 10% carrot powder (T_2) and whole wheat bread (WB)) were evaluated and the mean score of their responses are represented in Table. It was observed that the mean scores of hedonic scales were significantly different for aroma, appearance and taste separately for samples. The mean score of crust, internal texture and general acceptance were not significantly different and the multiple Tukey's Multiple Comparison Test (TMCT) at ($p<0.05$) was performed to show the pairwise significant difference of flavor, texture and taste of different categories. It was observed that regarding to aroma, there were no significant difference between whole wheat bread (WB) and bread treated with 5% carrot powder (T_1) as well as bread treated with 5% carrot powder (T_1) and bread treated with 10% carrot powder (T_2) but whole wheat bread (WB) and bread treated with 10% carrot powder (T_2) were significantly different. Regarding appearance, whole wheat bread (WB) and bread treated with 10% carrot powder (T_2) were not significantly different but whole wheat bread (WB) and bread treated with 5% carrot powder (T_1) and bread treated with 5% carrot powder (T_1) and bread treated with 10% carrot powder (T_2) were significantly

different. Regarding to taste for different category of breads, whole wheat bread (WB) is significantly different from bread treated with 5% carrot powder (T_1) and bread treated with 10% carrot powder (T_2) but there was no significant difference between bread treated with 5% carrot powder (T_1) and bread treated with 10% carrot powder (T_2)

Table 4: Sensory Evaluation of Breads

Sl. No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Mean Score±SD	F test
Crust	WB	9	9	9	8	8	7	9	9	8	8	7	8	8	8	8	8.2 ± 0.68	0.757^{NS}
	T_1	8	8	9	9	8	7	8	8	7	7	8	7	6	9	8	7.8 ±0.86	
	T_2	9	7	9	4	7	8	8	9	9	9	8	3	8	9	8	7.7 ±1.84	
Aroma	WB	9	9	8	9	8	7	8	8	8	8	8	9	6	8	8	8.07 ± 0.8^{a}	4.22*
	T_1	8	9	9	8	8	8	8	7	7	6	7	6	6	8	8	7.7 ± 0.9^{ab}	
	T_2	4	6	6	4	7	8	9	8	9	7	6	1	7	9	7	6.6 ± 2.2^{b}	
Appearance	WB	9	6	7	8	7	7	9	7	9	9	6	7	8	9	8	7.7 ± 1.1^{a}	10.07**
	T_1	7	9	9	9	8	7	8	7	7	6	8	8	8	7	7	7^{b}	
	T_2	8	8	9	8	8	8	9	8	9	7	8	8	8	8	8	8.1 ± 0.52^{a}	
Taste	WB	4	8	6	6	7	8	8	6	8	7	5	7	8	7	4	6.6 ± 1.4^{a}	15.20**
	T_1	8	9	9	9	9	8	8	8	7	8	7	8	7	9	8	8.1 ± 0.74^{b}	
	T_2	9	9	9	9	9	8	9	8	9	7	8	9	8	8	8	8.5 ± 0.64^{b}	
Internal texture	WB	8	9	7	9	8	7	8	8	8	8	6	8	8	8	8	7.9±0.74	2.47^{NS}
	T_1	8	7	7	9	8	8	9	8	8	7	6	6	7	8	7	7.5±0.92	
	T_2	9	9	9	9	8	8	8	9	9	8	8	5	8	9	8	8.3±1.03	
General Acceptance	WB	9	9	8	8	8	7	9	8	8	8	8	8	8	8	8	8.1±0.52	2.67^{NS}
	T_1	8	9	9	9	8	7	8	8	7	7	6	6	7	8	7	7.6±0.99	
	T_2	5	9	7	9	7	8	9	8	8	8	6	4	8	7	5	7.2±1.57	

Here, WB= 100% wheat flour, T_1=bread treated with 5% carrot powder & T_2=bread treated with 10% carrot powder.

Chapter 5: Discussion

5.1 Gross Chemical Composition:

Chemical composition of wheat flour (72 % extraction) and carrot powder (CP) is presented in figure 1. The results indicate that crude protein, total carbohydrates, fat, ash, and crude fiber of 72 % ext. wheat flour were: 11.57, 86.24, 0.89, 0.54 and 0.78 %, respectively. These data are in the same line with those obtained by Doweidar, (2002). Regarding to the same table, the crude protein, total carbohydrates, fat, ash, crude and fiber of dry carrot were 9.2, 65.26, 2.9, 6.83 and 7.16% respectively.

5.2 Proximate Compositions of whole wheat bread and carrot powder treated bread:

Proximate composition is presented in Table...

Moisture contents, ashes, fats, fibers, proteins and carbohydrates for CP, T_1, T_2 and WB were (8 ±1%, 28.5±0.01%, 28.2±0.03%, 27.6±0.02% 4.5±0.2%, 1.4±0.02%, 1.6±0.01%, 2.6±0.01%); (2.8±0.1%, 9.8±0.1%, 10.3±0.2%, 8.9±0.1%; 17±1%, 1.6±0.1%, 2.3±0.1%, 0.3±0.2%); (9.45±0.02%, 11.4±0.1%, 11.1±0.01%, 11.5±0.2%; 58.25±0.04%, 47.3±0.2%, 46.5±0.01% and 49.1±0.02%) respectively.

The moisture, ash, fat, crude fiber and proteins for bread without carrot pomace powder, bread with 2.5% carrot pomace powder, bread with 5% carrot pomace powder, bread with 7% carrot pomace powder, bread with 10% carrot pomace powder were (38.81%, 37.36%, 37.01%, 33.43%, 32.06%; 0.97%, 1.24%, 1.53%, 1.68%, 1.89%; 2.06%, 1.97%, 1.94%, 1.90%, 1.86%); (0.47%, 0.94%, 1.48%, 1.87% 2.42%; 9.98%, 9.2%, 8.89%, 8.38% and 8.16%) observed initially by Pandey et al., 2016 during the evaluation of effect of storage period on the bread quality fortified with carrot pomace powder maximum parameter of which are higher than the results presented in Table...which occurred may due to the type of heat treatment, preparation and formulation of dough etc.

Tiwari and Sarkar (2018) found the Moisture content to be 87.02% in fresh carrot which decreased until constant weight reached during drying, dried carrot powder contain 4.2% moisture. In powder and flour, moisture higher than 14% will affect

storage quality as mould growth, bacteria infestation and agglomeration could occur (Roongruangsri W & Bronlund J.E, 2016). Fiber content in fresh carrot was 8.2 which increased on drying to 13.0 g/100g attributed to concentration due to moisture removal. The similar results were reported by M.S.Alam et al., (2013) and Adeleye A.S.et al., (2016). Carbohydrate, ash and energy content were in range of 9.4mg/100g, 7.0mg/100g and 57Kcal respectively on dry basis. Dried carrot powder was found to contain reduced carbohydrate (8.7g/100g), ash (6.1g/100g) and energy 49 kcal/100gm respectively.

(Gopalan et al., 1991) have reported the chemical constituents of carrot as moisture (86%), protein (0.9%), fat (0.2%), carbohydrate (10.6%), crude fiber (1.2%), total ash (1.1%), whereas, the values reported by (Holland et al., 1991) for most of these parameters are different i.e. moisture (88.8%), protein (0.7%), fat (0.5%), carbohydrate (6%), total sugars (5.6%), crude fiber (2.4%).

(Kumari and Grewal 2007) have studied that carrot pomace on dry weight basis contains $2.5 \pm 0.15\%$ moisture, $5.5 \pm 0.10\%$ ash, $1.3 \pm 0.01\%$ fat, $0.7 \pm 0.04\%$ protein, $20.9 \pm 0.15\%$ crude fiber, $55.8 \pm 1.67\%$ total dietary fiber, $71.6 \pm 0.23\%$ total carbohydrate and 301 ± 0.09 kcal/100 g energy.

5.3 Beta-carotene content (mg/100g) of Carrot powder (CP), bread treated with 5% carrot powder (T_1) and bread treated with 10% carrot powder (T_2):

Beta-carotene content of carrot powder (CP), bread treated with 5% carrot powder (T_1) and bread treated with 10% carrot powder (T_2) presented in Table… which were 24.653±0.003 mg/100g, 3.002±0.001 mg/100g and 3.179±0.005 mg/100g. This results revealed the increase in beta-carotene content with the increase of the percentage of carrot powder in bread. This makes them suitable to be used as an ingredient in the production of beta-carotene rich supplementary foods or as functional foods. Also, they could serve as an easiest mean of tackling vitamin A deficiency.

Tiwari and Sarkar (2018) found dried carrot powder was analyzed and found to contain 31.72 (mg/100g) of beta-carotene which was higher than the result for carrot

powder obtained from the Table... This variation may be due to the type of drying process, drying time, cultivar, climatic conditions etc.

5.4 Sensory evaluation:

Sensory characteristics of the developed products (T_1 and T_2) and the commercial bread (WB) showed that the overall acceptability of the samples got the hedonic scale like very much. The results indicate that the formulated breads are equally acceptable since it got the same hedonic scale of that commercial sample WB (Table). However, no significant difference in terms of crust and crumb (internal texture) of the formulated products with the commercial products, which indicates positive sign for the developed product.

Chapter 6: Conclusion

It was hereby concluded that quality of prepared bread was enhanced by the addition of carrot powder. Rather the control sample was found to have deprived in its quality faster than the experimental samples. On comparing the data it is found that the carrot powder directly affects the quality of the final product which is evident after analyzing the data. Qualitatively the keeping quality of the experimental samples is enhanced as protein content loss percentage is less in the experimental samples. Also the added fiber retards the loss of fat which shows that fiber has good fat retention properties. The present study also suggested that the increased fibrous content in the experimental samples are certainly because of the variable amount of carrot powder which finally increases the mineral content of the final product while adding value to the prepared bread. The Carrot powder is rich in Beta carotene having antioxidant activity. This is a beneficial fact of carrot powder to be used as a source for fortifying agents rich in both beta carotene and antioxidant. In such way, it can be added an economic value. Thus this research work would help in creating a new field for fortification of food sector with reducing unemployment problem in Bangladesh.

Recommendations and future perspective

Recommendations for future research based on the findings of the development and evaluation of the bread fortified with carrot powder of the study include:

- Include the value analysis studies for developed carrot powder.
- Developing a product with value added ingredients, which may give some organoleptic changes.
- Formulation and evaluation of products based on HACCP procedures.
- Determining the shelf life period using food analysis and various types of packaging techniques.
- Developing the marketing plan for new product in to food service system.
- The beta carotene should be measured by different colorimetric method.
- The most important thing is that this study should be carried out in a room with controlled atmosphere in order to obtain more specific results.
- A microwave oven was used in this study. But it would have been better to use modern rotary gas oven to have better quality of bread.
- Improvement in mixing dough and maintaining humidity may develop the quality of bread. In current study bread quality was not so good due to hand mixing and humidity was not maintained properly during proofing time.

References

Abdellhaq El H and Labuza TP. 1987. Air drying characteristics of apricots. *Journal of Food Science,* 52(2): 342-345.

Adeleye, A.S, Oyerinde, A.S, Bratte, A. G. (2016).Comparison of Nutritional and Colour Properties of Fresh and Dried Carrot (Daucus carota L.) Slices and Carrot Pomace,*Journal of Multidisciplinary Engineering Science and Technology (JMEST)* ,3(8),366-370.

Adeola A. A, Ogunjemilusi M. A, Akanbi C. T (2012): Effects of carrot pomace on the chemical and sensory attributes of Ogi, a Nigerian fermented food. *Nigerian Journal of Nutritional Sciences Vol 33,No 2 Pp 25-30 ISSN 0189-0913*.

Agiriga AN, Iwe MO (2009). Proximate composition of cookies produced from cassava groundnut-corn starchblend. A Response Surface Analysis. *Nigerian Food Journal. 27 (1): pp 102-107.*

Ahmed J and Choudhary DR. 1995. Osmotic dehydration of papaya. *Indian Food* Packer, 49(4): 5-11.

Alkesh. 2001. Evaluation of some low chilling cultivars for dehydration and development of dehydrated fruit based products. M. Sc. Thesis. Dr YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh, India.

Babic I, Amiot MJ, Ngugen-The C and Aubert S. 1993. Changes in phenolic content in fresh, ready-to-use, shredded carrots during storage. *Journal of Food Science,* 58: 351-356.

Babic I., Amiot M. J., Ngugen-The C. and Aubert S. (1993). Changes in phenolic content in fresh, ready-to-use and shredded carrots during storage. *Journal of Food Science 58:351*.

Berger M and Venhaus A. 1992. Dietary fiber in the prevention and treatment of diabetes mellitus. In: Dietary Fiber- A Component of Food. Schweizer TF and Edwards CA. (eds). Springer, London, p.279-292.

Byers T and Perry G. 1992. Dietary carotenes. Vitamin C and Vitamin E as protective antioxidants in human cancers. *Annual Reviews of Nutrition*, 12:139-159.

Castenmiller JJM and West CE. 1998. Bioavailability and bioconversion of carotenoids. Annual Reviews of Nutrition, 18: 19-38.

Chiang JC, Singh B and Salunkhe DK. 1971. Effect of water quality on canned carrots, sweet cherries, and apricot. Journal of the American Society for Horticultural Science, 96(3): 353-356.

Dixon RA and Paiva NL. 1995. Stress-induced phenylpropanoid metabolism. Plant cell, 7: 1085-1097.

Dreosti IE. 1993. Vitamins A, C, E and beta-carotene as protective factors for some cancers. Asia Pacific Journal of Clinical Nutrition, 2(1): 5-21.

Edwards CG and Lee CY.1986. Measurements of pro-vitamin A carotenoids in fresh and canned carrots and green peas. Journal of Food Science, 51: 534-535.

El-Arab AE, Khalil F and Hussein L. 2002 Vitamin A deficiency among preschool children in a rural area of Egypt. International Journal of Food Science and Nutrition, 53: 465-414.

Elleuch M., Bedigian D., Roiseux O., Besbes S., Blecker Ch., Attia H., (2011). Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: A review. Food Chem. 124 (2), 411-421.

Eshtiaghi MN, Stute R and Knorr D. 1994. High pressure and fi-eezing pretreatments effects on drying, rehydration, texture and colour of green beans, carrots and potatoes. Journal of Food Science, 59: 1168-1170.

Faulks RM, Southon S (2001) Carotenoids, metabolism and disease. In: Handbook of Nutraceuticals and Functional Foods. CRC Press, Florida, p 9.

FELLOWS, F.J.1996. Blanching, and Dehydratíon.Ui Food Processing Technology Principles and Practices. pp. 201-208, 281.Woodhead Pub Us Uing Limited. Cambridge London.

Gill HS and Kataria AS. 1974. Some biochemical studies in European and Asiatic varieties of carrot (Daucus carota L.). Current Science, 43: 184.

Hager TJ, Howard LR (2006) Processing effects on carrot phytonutrients. Hortic Sci 41:74–79

Hansen SL, Purup S, Christensen LP (2003) Bioactivity of falcarinol and the influence of processing and storage on its content in carrots (Daucus carota L). Journal of the Science of Food and Agriculture 83:1010–1017.

Ikken Y, Cambero I, Marin M, Mariner A, Hars I and Morales P. 1998. Antimutagenic effect of fruit and vegetable aqueous extracts against Nnitrosamine evaluated by the Ames test. Journal of Agricultural and Food Chemistfy, 46: 5194-5200.

Jackson JC, Bourne MC and Barnard J. 1996. Optimization of blanching for crispness of banana chips using response surface methodology. Journal of Food Science, 61: 165-166.

Jayaraman KS and Dasgupta DR. 1978. Development and storage ability of intermediate moisture carrot. Journal of Food Science, **43(6):** 1880-1882.

Jayaraman KS, Dasgupta DK and Rao B. 1990. Effect of pre-treatment with salt and sucrose on the quality and stability of dehydrated cauliflower. International Journal of Food Science and Technology, 25: 47-60.

Kalra CL, Kulkami SG and Berry SK. 1987. The carrot: A popular root vegetable. Indian Food Packer, **41(6):** 48-52.

Kalt W. 2005. Effects of production and processing factor on major fruit and vegetable antioxidants. Journal of Food Science, 70: 11-19.

Karagul Y, Wilson C and White H. 2004. Formulation and processing of yoghurt. Journal of Dairy Science, 87: 543-550.

Kaur G, Jaiswal SP, Brar KS and Kumar JC. 1976. Physico-chemical characteristics of some important varieties of carrot. Indian Food Packer, 30(2): 5-8.

Kumari S, Grewal RB (2007). Nutritional evaluation and utilization of carrot pomace for preparation of high fiber biscuits. Journal of Food Science and Technology; 44:56-58.

Labadarious D, Steyn NP, Maunder E, Macintyre V, Gericke G, Swart R, Huskosson J, Dannhauser A, Varseter HH, Nesmuuni AE, Nel JK (2005).

The National Food Composition Survey (NFCS): South Africa, 1999. Public Health Nutrition. 8 (5): 533-543.

Labuza TP, Tannerbaum SR and Kaul M. 1970. Water content and stability of low moisture and intermediate moisture foods. Food Technology, 24(5): 35-40.

Lai, C. S., Hoseney, R. C., and Davis, A. B., (1989). Effects of wheat bran in bread making. Cereal Chemistry, 66, 217e219.

Lavelli V, Pagliarini E, Ambrosoli R, Minati JL and Zanoni B. 2006. Rate of carotenoid degradation in dehydrated carrots. Post-harvest Biology and Technology, 40: 34-40.

Luh BS and Woodroof JC.1982. Commercial Vegetables Processing, 4* edition. AVI Publishing Company, Westport.

M. S. Alam, K. Gupta, H. Khaira and M. Javed. (2013). Quality of Dried Carrot Pomace Powder as affected by Pre-treatments and Methods of Drying. Agricultural Engineering International: Cigr Journal,15(4), 236-243.

Moure A, Cruz JM, Franco D, Dominguez JM, Sineiro J, Dominguez H, Nunez MJ and Carlos PJC. 2001. Natural antioxidants from residual sources. Food Chemistry, 12: 145-171.

Mudhar GS and Jen JJ. 1991. Infilfrated biopolymer effect on quality of dehydrated carrots. Journal of Food Science, 56(4): 520-523.

Munsch MH and Simard RE. 1983. Relationships in colour and carotene content of carrot juices. Canadian Institute of Food Science and Technology, 16: 173-178.

Ndife, J. and Abbo, E., (2009). Functional Foods: Prospects and Challenges in Nigereia. J. Sci. Technol.,1(5) 1-6.

Negi PS and Roy SK. 2001. The effect of blanching on quality attributes of dehydrated carrots during long term storage. European Food Research and Technology, 111: 445-448.

Ninfali P and Bacchiocca M. 2003. Polyphenols and antioxidant capacity of vegetables under fresh and frozen conditions. Journal of Agricultural and Food Chemistyy, 51: 2222-2226.

Oosthuizen D, Napier C, Oldewage-Theron W (2006). The formulation and development of multi-mix for primary school children within an informal South-Africa. Nigerian Food Journal. 24 (1): 139.

Pruthi JS, Saxena AK and Mann JK. 1980. Studies on the determination of optimum conditions of preservation of fresh vegetables in acidified sulphited brine for subsequent use in hidian style curries. Indian Food Packer, 34(6): 9-16.

Puuponen-Pimia R, Hakkinen ST, Aami M, Suortti T, Lampi AM, Eurola M, Piironen V, Nuutila AM and Oksman-Caldentey KM. 2003. Blanching and long-term freezing affect various bioactive compounds of vegetables in different ways. Journal of the Science of Food and Agriculture, 83: 1389-1402.

Raum R. 2003. Microbiological quality of health food and organic foods. Netherland Milk and Dairy Journal, 14: 130-134.

Reeve RM. 1943. Microscopy of the oils and carotene bodies in dehydrated carrots. Food Research, 8: 137.

Roongruangsri, W. and Bronlund, J. E. (2016). Effect of air-drying temperature on physico-chemical, powder properties and sorption characteristics of pumpkin powders,International Food Research Journal 23(3), 962-972.

Sagar VR and Khurdiya DS. 1999. Studies on dehydration of Dashehari mango slices. Indian Food Packer, 53(1): 5-9.

Saldana G, Stephens ST and Lime BJ. 1976. Carrot beverage. Journal of Food Science, 41(5):1245.

Salunkhe DK, Bolin HR and Reddy NR. 1991. Storage, processing and nutritional quality of fruit and vegetables. Processed Fruits and Vegetables, 2nd edition. CRC Press Inc., Florida.

Salwa AA, Galal EA and Neimat AE. 2004. Carrot yoghurt: Sensory, chemical, microbiological properties and consumer acceptance. Pakistan Journal of Nutrition, 3(6): 322-330.

Sampathu SR, Chakraberty S, Kamal P, Bisht HC, Agrawal MP and Saha NK. 1981. Standardization and preservation of carrot halwa: An Indian sweet. Indian Food Packer, 41: 60-67.

Santo MS, Leka L, Fotouhi N, Meydani M, Hennekens GH, Meydani SN, Wu D and Gaziano JM. 1996. Natural killer cell activity in elderly men is enhanced by J3-carotene supplementation. American Journal of Clinical Nutrition, 64:772-777.

Schieber A, Marx M and Carle R. 2002. Simultaneous determination of carotenes, tocopherol in ATBC drinks by high-performance liquid chromatography. Food Chemistry, 76: 357-362.

Sharma HK, Kaur J, Sarkar BC, Singh C and Singh B. 2007. Effect of pretreatment conditions on physico-chemical parameters of carrot juice. International Journal of Food Science and Technology, 40: 35-39.

Sharma HK, Kaur J, Sarkar BC, Singh C, Singh B and Shitandi AA. 2006. Optimization of pre-treatment conditions of carrots to maximize juice recovery by response surface methodology. Journal of Engineering Science and Technology, 1(2): 158-165.

Sharma K, Karki S, Thakur NS, Attri S (2012): Chemical and processing of carrot- A review. Journal of Food Science and Technology Composition, Functional Properties India 49 pp22-32.

Suman M and Kumari K. 2002. A study on sensory evaluation, beta-carotene retention and shelf-life of dehydrated carrot products. Journal of Food Science and Technology, 39: 668-677.

Tiwari S and Sarkar N (2018). Development And Evaluation of Carotene Rich Carrot Powder, I J R B A T, Vol. VI (Special Issue 1): 123- 131.

Torronen R, Lehmusaho M, Hakkinen S, Hanninen O and Mykkanen H. 1996. Serum B-carotene response to supplementation with raw carrots, carrot juice or purified B-carotene in healthy non-smoking women. Nutrition Research, 16(4): 565-575.

Truswell AS and Beynen AC. 1992. Dietary fiber and plasma lipids: Potential for prevention and treatment of hyperlipidaemias. In: Dietary Fiber – A Component of Food. Schweizer TF and Edwards CA. (eds). Springer, London.

Upadhyay A, Sharma, HK and Sarkar BC. 2008. Characterization and dehydration kinetics of carrot pomace. Agricultural Engineering International: The CIGR e-Journal.

Van Poppel G. 1996. Review: Epidemiological evidence for B-carotene in prevention of cancer and cardiovascular disease. European Journal of Clinical Nutrition, 50: 557-561.

Villanueva-Suarez MJ, Redonda-Cuenca A, Rodriguez-Sevilla MD and Heras M. 2003. Characterization of non-starch polysaccharides content from different edible organs of some vegetables, determined by GC and HPLC: Comparative study. Journal of Agricultural and Food Chemistry, 51: 5950-5955.

Villanueva-Suarez MJ, Redonda-Cuenca A, Rodriguez-Sevilla MD, Heras M (2003) Characterization of non-starch polysaccharides Food Sci Technol (January–February 2012) 49(1):22–32

Wagner LA and Warthesen JJ. 1995. Stability of spray-dried encapsulated carrot carotenes. Journal of Food science, 60: 1048-1053.

Wahid M, Saltor A, Jan M and Khan I. 1989. Effect of combination methods on insect disinfection and quality of dry fruits. Journal of Food Processing and Preservation, 13(1): 79-83.

Walter WM Jr, Purcell AE, and Cobb WY. 1970. Fragmentation of beta-carotene in auto-oxidating dehydrated sweet potato flakes. Journal of Agricultural and Food Chemistry, 18: 881-884.

Wang TSC, Chen J and Hsiang W. 1985. Catalytic synthesis of humic acids containing various amino acids and dipeptides. Soil Science, 140: 3-10.

Wilson RBH. 1987. Composition of Australian fresh fruit and vegetables. Food Technology in Australia, 39(11): 523-526.

Yeum KJ and Russell RM. 2002. Carotenoid bioavailability and bioconversion Annual Review of Nutrition, 22: 483-504.

Zaman Z, Roche S, Fielden P, Frost PG, Nerilla DC and Cayley ACD. 1992. Plasma concentration of vitamin A and E and carotenoids in Alzheimer's disease. Age and Aging, 21: 91-96.

Zhao YP and Chang KC. 1995. Sulfite and starch affect colour and carotenoid of dehydrated carrots during storage. Journal of Food Science, 60: 324-326.

Zlatica, K., Jolana. K., and Michaela J., (2012). Influence of carrot pomace powder on the rheological characteristics of wheat flour dough and on wheat rolls quality. Acta Sci. Pol., Technol. Aliment. 11(4), 381-387.

Appendix A: Proximate Composition (%) of white and carrot fortified bread and carrot powder

Sample ID	Moisture	Ash	Fat	Fiber	Protein	Carbohydrate
WB	27.6	2.6	8.9	0.3	11.5	49.1
WB	27.58	2.59	8.8	0.1	11.3	49.08
WB	27.62	2.61	9.0	0.5	11.7	49.12
T_1	28.5	1.4	9.8	1.6	11.4	47.3
T_1	28.49	1.38	9.7	1.7	11.3	47.1
T_1	28.51	1.42	9.9	1.5	11.5	47.5
T_2	28.2	1.6	10.3	2.3	11.1	46.5
T_2	28.17	1.59	10.1	2.2	11.09	46.49
T_2	28.23	1.61	10.5	2.4	11.11	46.51
CP	8.0	4.5	2.8	17.0	9.45	58.25

Appendix B: Beta Carotene Content (mg/100g) of Carrot Fortified Bread and Carrot Powder:

Sample ID	Beta carotene (mg/100g)
T_1	3.179
T_1	3.174
T_1	3.184
T_2	3.002
T_2	3.003
T_2	3.001
CP	24.653
CP	24.65
CP	24.656

Appendix C: Hedonic Rating Test (Breads)

Name: **Date:**

Taste these samples and check how much you like or dislike it. Use the appropriate scale to show your attitude by checking at the point that best describe your feelings about the sample; please give a reason for this attitude. **An honest expression of your personal feeling will help us**. Score as follow-

Hedonic	**Samples**	**Attributes**																	
		Crust			**Aroma**			**Appearance**			**Taste**			**Internal texture**			**General Acceptance**		
		WB	T_1	T_2	WB	T_1	T_2	WB	T_1	T_2	WB	T_1	T_2	WB	T_1	T_2	WB	T_1	T_2
Like extremely																			
Like very much																			
Like moderately																			
Like slightly																			
Neither like nor dislike																			
Dislike slightly																			
Dislike moderately																			
Dislike very much																			
Dislike extremely																			

Here, WB= Whole wheat bread; T_1= Bread with 5% carrot powder & T_2= Bread with 10% carrot powder

Hedonic Scale Used:
Like extremely = 9, Like very much = 8, Like moderately = 7, Like slightly = 6, neither like nor dislike = 5, Dislike slightly = 4, Dislike moderately = 3, Dislike very much = 2, Dislike extremely = 1

Appendix D: Quality standard for bread

<table>
<tr><th colspan="3">Yeast Bread</th></tr>
<tr><th>Appearance</th><th>Texture</th><th>Flavor</th></tr>
<tr><td>Top
Golden brown, evenly brown and smooth. Crust 1/8’ thick</td><td>Gas Holes
Small to medium and evenly distributed</td><td rowspan="4">Sweet, slightly yeast aroma</td></tr>
<tr><td>Exterior
Sides pale brown Even “shredded”</td><td>Cell Walls
Thin</td></tr>
<tr><td rowspan="2">Interior
Creamy white or distinctive of ingredients.</td><td>Top
Crips and tender</td></tr>
<tr><td>Interior
Moist and resilient</td></tr>
</table>

Appendix E: Photo Gallery

Drying in cabinet drier

Dried Carrot powder

Mixing

Proofing

Baking

White bread

Carrot fortified bread

Protein determination
(titration)

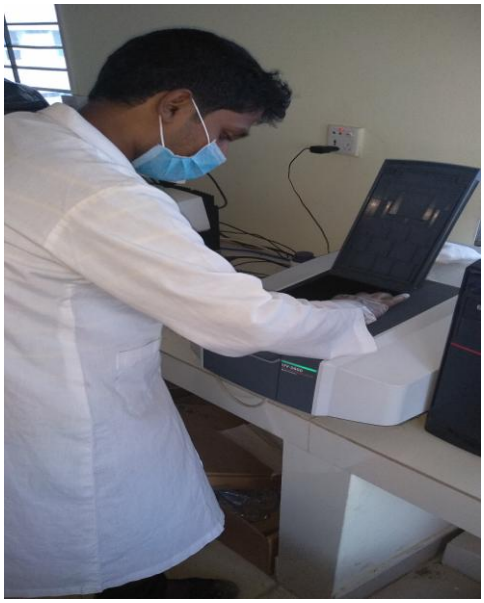
Ash determination

Moisture determination

Fat determination

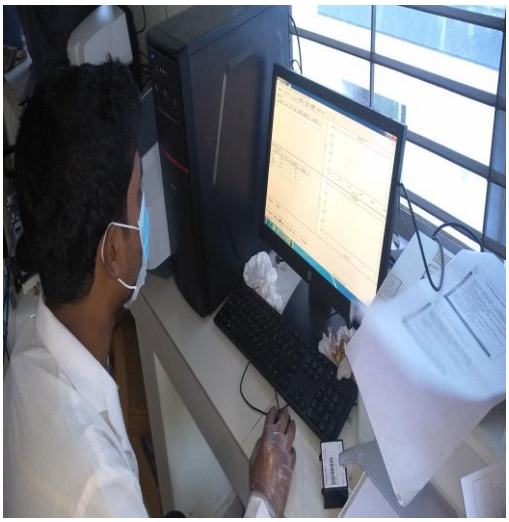
Crude fiber determination

Separation of beta carotene



Inserting sample UV Spectrophotometer

Adding sample in separatory funnel



Measuring of absorbance in UV Spectrophotometer

Brief bio-data of the student

Santo Shamol Das passed the Secondary School Certificate Examination in 2008 with GPA 5 followed by Higher Secondary Certificate Examination in 2010. He obtained his B.Sc (Hons.) in Food Science and Technology (BFST) from Faculty of Food Science and Technology, Chattogram Veterinary and Animal Sciences University (CVASU), Bangladesh with CGPA 3.19. Now he is a candidate for the degree of MS in Food Chemistry and Quality Assurance under the Department of Applied Chemistry and Chemical Technology, Faculty of Food Science and Technology, CVASU. He has immense interest to work on analytical chemistry in a food testing lab.