QUALITATIVE AND QUANTITATIVE EVALUATION OF BREAD, CAKE AND JAM PREPARED WITH THE ADDITION OF BANANA PEEL FLOUR

Afruza Akter

Roll no : 0118/22

Registration : 563

Session : January-June (2018-2019)

A thesis submitted in the partial fulfillment of the requirements for the degree of Master of Science in Applied Human Nutrition and Dietetics

Department of Applied Food Science and Nutrition

Faculty of Food Science and Technology

Chittagong Veterinary and Animal Sciences University

Chattrogram-4225, Bangladesh

June 2019

QUALITATIVE AND QUANTITATIVE EVALUATION OF BREAD, CAKE AND JAM PREPARED WITH THE ADDITION OF BANANA PEEL FLOUR

Afruza Akter

Roll no : 0118/22

Registration : 563

Session : January- June (2018-2019)

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

…..…………………………………… ……………………………………

(**Prof Dr. Jannatara Khatun)**

Supervisor

Professor

Department of Animal Science & Nutrition

(Mohammad Mozibul Haque)

Co-supervisor

Lecturer

Department of Applied Food Science & Nutrition

………………………………………..

(Asst. Prof Altaf Hossain)

(Chairman of the Examination committee)

Department of Applied Food Science and Nutrition

Faculty of Food Science and Technology

Chittagong Veterinary and Animal Sciences University

Khulsi, Chattragram-4225, Bangladesh

June 2019

Authorization

I hereby declare that I am the sole author of the thesis. I also authorize the Chittagong 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.

Afruza Akter

June 2019

Dedication

Every challenging work, needs self-efforts as well as guidance of elders especially those who were very close to our heart.

My humble afford I dedicate my MS research work to my sweet and loving

Family Members,

Whose affection, love, encouragement and prays of day and night make me able to get success and honor,

Along with all hard working and respected

Teachers

Acknowledgements

To commence with, I would like to express my gratitude to the **"Almighty Allah"** from my deepest sense of gratitude, whose blessing has enabled me to complete the thesis for the degree **of Masters of Science (MS)** in **Applied Human Nutrition and Dietetics** under Department of Applied Food Science and Nutrition, Chittagong Veterinary and Animal Sciences University, Chittagong, Bangladesh.

I express my sincere and deepest gratitude to supervisor, **Prof Dr. Jannatara Khatun**, Department of Animal Science and Nutrition, Chittagong Veterinary and Animal Sciences University for his effective steerage during my whole study period who ploughed through several preliminary versions of my text, making critical suggestions and posing challenging questions. Her expertise, invaluable guidance, constant encouragement, affectionate attitude, understanding patience and healthy criticism added considerably to my experience. Without her continual inspiration, it would have not been possible to complete this thesis.

At the same time, I also pay heartily gratitude to my co-supervisor **Mohammad Mozibul Haque,** Lecturer, department of Applied Food Science and Nutrition, Faculty of food Science and Technology, for his continual guidance, support and counseling during my study.

It's also great pleasure for me to express my heartfelt thanks and profound gratitude to my respectable teacher **Md. Altaf Hossain**, Head and Assistant Professor, Department of Applied Food Science and Nutrition, Faculty of food Science and Technology, for his valuable suggestions, inspiration and co-operations.

I owe my special thanks to the **director and the scientists** associated with this research work of Poultry Research and Training Center (PRTC) and Nutrition and Processing Laboratory, department of Fishing and Post-Harvest Technology, Faculty of Fisheries, CVASU for their constant inspiration and kind co-operation in performing the research activities precisely in those Laboratory.

I sincerely express my gratitude from the core of my heart to all the persons involved in the study.

I gratefully acknowledge the financial assistance in form of research fellow under the **National Science and Technology (NST)** fellowship program by **Minister of Science and Technology, Govt. of Bangladesh** and cordial thanks to **Research and Extension of Chittagong Veterinary and Animal Sciences University**, for their financial support.

Finally, I must express my very profound gratitude and cordial thanks to my loving friends and well-wishers for their cooperation, cheerfulness and inspiration during the course of the study. I grateful acknowledge thanks to my beloved parents for their understanding, inspirations, moral support, kindness and blessings, for bearance and endless love to complete my study.

The Author

June, 2019

Table of Contents

Table of Contents

List of Tables

List of Figures

List of Abbreviations	
Abbreviation	**Elaboration**
GDP	Gross Domestic Product
AOAC	Association of Official Analytical Chemists
%	Percentage
CVASU	Chittagong Veterinary and Animal Sciences University
°C	Degree Celsius
TVC	Total viable count
DPPH	2,2-diphenyl-1-picrylhydrazyl
mg	Milligram
ppm	Parts per million
GAE	Gallic acid equivalent
GBF	Green banana flour
QE	Quercetin equivalent
SD	Standard deviation
ANOVA	Analysis of variance
RDA	Recommended daily allowance
TIF	Total indigestible fraction
HI	Hydrolysis Index
TDF	Total Dietary Fiber
NA	Nutrient agar
SCV	Radical scavenging activity
MPN	Most Probable Number
WHO	World Health Organization
FAO	Food and Agriculture Organization

Abstract

The principle objective of this study was to develop functional bread, cake and jam with utilizing banana and peel increased antioxidant activity, ash and dietary fiber. Blends of banana with peel flour (BPF) at 10% and 15% were used in bread preparation and 15% were used for jam and cake preparation. The Proximate analysis, sensory evaluation and microbial analysis of bread, cake and jam samples were performed. The results of the whole wheat bread and formulated bread, cake samples showed that crude fiber and ash (%) had significant difference($p<0.05$). The moisture percentage is decreased in formulated products which improve the shelf life of the products. The crude protein, crude fat, crude fiber and ash content of the bread progressively increased with the addition BPF were 15% BPF bread having the highest value 11.38%, 6.92%, 3.41% and 3.01% respectively and control bread having 9.2%, 2.46%, 0.2% and 1.7% respectively. Carbohydrates content decreased with BPF substitution. The sensory evaluation indicated that the composite breads were not significantly different ($p<0.05$) from the whole wheat bread with respect to internal texture, taste, appearance and general acceptability, up to 15% BPF levels. The total viable counts (log CFU/ml) of cake ranged from 3.1 to 17.5 at day 1 to 15. The total viable counts (log CFU/ml) of BPF bread ranged from 2.5 to 11.5 and 2.1 to 17.7 at day 1 to 15 respectively. The total viable counts (log CFU/ml) of jam ranged from 3.2 to 18.2 at day 1 to 15. To evaluate physiochemical and antioxidants property even after heat treatment. Antioxidant activities of jam, bread and cake utilizing banana with its peel were compared through 1,1-diphenyl-2-picrylhydrazyl (DPPH). The phenolics, flavonoids and antioxidant activities of bread, cake jam were correlated positively with the amount of BPF added to the products. The developed products appear to be an additional benefit for human health and can be appropriate parts in diet plan.

Keywords: Proximate analysis, banana peel, antioxidants activity,

Phenolic, DPPH, flavonoids

Chapter 1: Introduction

Bangladesh is an agricultural country. Most people depend on agriculture directly or indirectly. Agriculture has a great contribution to the Gross Domestic Product (GDP) of the country. About 14.75% of GDP is derived from agriculture in the year 2015-16 (BBS, 2016). Banana is one of the most important commercial tropical fruits traded around the country. Banana is a type of fruit from herbaceous plants of the genus *Musa*. Banana grow in a wide range of environments and have varied human uses, ranging from the edible bananas and plantains of the tropics to cold-hardy fiber and ornamental plants. Bananas come in a variety of sizes and colors when ripened, including yellow, purple and red. Banana occupies an important position among the fruits of the country not only for its highest production among the fruits but also for its increasing popularity to many farmers as an economic crop and to many people as a nutritious fruit.

Banana and plantain, constitute the fourth most important staple food commodity of the world, after rice, wheat and maize (Islam et al., 2016). In Asian and Pacific regions, banana has great socio-economic significance. The name "banana" comes from an Arabic word meaning "finger" (Banana Link, 2016). Bangladesh ranks 14th among the top 20 banana producing countries in the world. Bangladesh produces nearly 1.00 million tons of bananas annually (Hossain, 2014). It is also a nutritious fruit crop in the world and grown in many tropical areas where they are used both as a staple food and dietary supplements. Each year about 35,000 children become blind due to lack of Vitamin-A. The common deficient nutrients of Bangladesh are Vitamin-A and Vitamin-C, riboflavin, folic acid etc. Banana provides those nutrients. Banana is one of the high-calorie fruits and 100 grams of its flesh carries 90 calories. Besides, it contains a good amount of health benefiting fiber, anti-oxidants, minerals, and vitamins (Nutrition, 2017). In Bangladesh, banana is the only fruit crop, which is available throughout the year and consumption rate is also higher than any other fruits.

Major Districts of cultivated Banana are Narsingdi, Gazipur, Rangpur, Bogra, Nator, Pabna, Noakhali, Faridpur, Khulna in our country. There are a number of banana cultivars in Bangladesh.

.Banana fruit consists of two parts: peel and pulp. Peel, which is the main by-product of banana, is about 40% of total weight of the fruit. Until recently, banana peel had no useful applications and was dumped as waste, contributing massive amounts of organic materials to be managed. Since researchers have begun to focus on studying the composition of Banana peel several possible applications have emerged (Agama-Acevedo et al., 2016). Banana pulp (BP), which is the edible part of the fruit, has an abundant amount of nutrients. Studies conducted on BP have investigated different aspects ranging from its use as an ingredient for food enrichment to extraction and isolation of many health-beneficial components, such as different types of starch, cellulose and bioactive compounds (Singh et al., 2016). As stated by Kitts (1994), bioactive compounds are constituents with extra nutritional advantages that are naturally occurring in plants and foods in small amounts. They exert their beneficial biological effects by stimulating the probiotic growth and help in the prevention of cardiovascular disease and cancer (KrisEtherton et al., 2002). Phenolics, carotenoids, flavonoids, biogenic amines, phytosterols, and other phytochemicals can be found in BP and peel (Pereira and Maraschin, 2015). Due to the presence of these compounds, bananas have a higher antioxidant capacity than some berries, herbs and vegetables (Moongngarm et al., 2014).

Dietary fiber are indigestible carbohydrate polymers that are classified based on their water solubility into two types, soluble fibers (pectin and some hemicelluloses) and insoluble fibers (cellulose, lignin and resistant starch) (Alba et al., 2018). In general, it has been reported that Banana peel contains more DF than banana pulp (Garcia-Amezquita et al., 2018). Extracting pectin from the peels could increase their added value. In addition, banana with peel flour (BPF) has high amount of lignin, cellulose and hemicelluloses fractions which can be extracted as a formed complex substrate named lignocellulosic biomass which could be used to produce bioethanol (Happi Emaga et al., 2008).

The utilization of by-products of fruits, especially banana, has become a trend as of late and many studies are in progress to evaluate their effects on food properties (Kaur et al., 2014). As approximately one-third of banana is lost due to the public tendency to consume only ripened fruit, utilization of different parts of the banana at different ripening stages has also gained interest over the past years (Sheikh et al., 2017). This review discusses the health benefits of banana bioactive compounds and utilization of different parts of the banana and the flour produced to evaluated processing options and their influence on flour nutritional and functional properties.

Banana peel is a rich source of minerals, bioactive compounds and DF (Kusuma et al., 2018). Several studies reported the use of banana with peel flour (BPF) as a functional food source (Ramli et al., 2010). According to some reports, both pulp and peel have high antioxidant activity (Gonza ´lez-Montelongo et al., 2010). Given that BPF extract has been found to be non-toxic to human cells, more information has become available on using it as an inexpensive fruit by-product source of antioxidants (Segundo et al., 2017b). The amount of ash, protein, crude fiber and digestible starch of BPF was reported to be significantly higher than that of pulp, which makes the BPF more effective as a functional additive (Nasrin et al., 2015).

The amount of waste from fruit peels is expected to increase with the development and progression of industrial manufacturing processes that use bananas as either green or ripe. For example accurate banana peels possibly introduce new products for various industrial and household uses (Gunaseelan, 2004; Bori et al., 2007).

Fruits and vegetable flour is rich in fiber, protein and minerals and has a high water holding capacity (WHC) and oil holding capacity (OHC). Thus, it can be used in a new low-calorie and cost products (Ferreira et al., 2013).

Banana peels have various health benefits to excellent nutritional status, and it treats the intestinal lesion, diarrhea, dysentery, ulcerative colitis, nephritis, gout, cardiac disease, hypertension, and diabetes. (Emaga et al., 2008; Wachirasiri et al., 2008; Imam and Akter, 2011).

Banana peels are rich in phenolic compounds as they are a good source of antioxidants, which protect against heart disease and cancer (Someya et al., 2002). Banana peel wastes from industrial processes represent about 40% of fresh bananas (Anhwange et al., 2008).

These wastes pose an environmental problem for their generation of large quantities of organic waste. Researchers have shown that noodles flour from banana peels lowers glycemic index and reduces the duration of digestion due to the high content of resistant starch (Li et al., 2006; Ramli et al., 2009).

There was a general trend recently toward increasing the nutritional value of bakery products like bakery products strengthening fiber, as the bakery products are consumed widely in the international food markets (Kotsianis et al., 2002). Bread is a staple diet that is consumed daily, and its quality and sensory attributes are highly considered by consumers (Motrena et al., 2011).

The high dietary fiber content of BPF (Banana with peel flour) with high levels of bioactive compounds have enabled the production foodstuffs with remarkable functionalities. Moreover, discovering high nutrition value of BPF represents a low-cost by-product for industrial application. There are 3 flour products produced from BPF with different chemical composition. Due to the structure of BPF, bakery products such as cake, bread, jam have gained more attention than other food products. The introduction BPF in product development can offer new products with standardized nutrient composition for industrial and domestic uses. The advantages of banana with peel flour prepared from mature banana include high fiber, ash, carbohydrate content, which is suitable for incorporation into food products requiring fiber enriched and high energy content. This flour also improves the antioxidants activity, flavonoid and phenolic components in the formulated bread jam and cake products.

The specific objectives of the present study were as follows:

1. To prepare functional food products using Banana with peel flour.
2. To analyze quality characteristics of developed products.
3. To determine the proximate analysis, sensory evaluation, bioactive compounds determination and microbial analysis of formulated cake, bread, jam.

Chapter 2: Review of Literature

Bananas are rich in vitamin B6, manganese, vitamin C, fiber, potassium, biotin, and copper. They have the power to prevent high blood pressure and protect against atherosclerosis. As a very low-fat food, it can also help keep blood cholesterol levels at healthy safe balance.

Their high levels of tryptophan convert into serotonin and help people overcome depression. Their iron levels relieve anemia and have the power to counteract calcium loss and enable bone strengthening. They're also a natural antacid and can provide relief from acid reflux, heart burn, and can restore electrolytes lost after dehydration from diarrhea. (Cherian BM et al., 2008)

Banana peel is eaten in many parts of the world, though [it's] not very common in the West," Flores said. "It contains high amounts of vitamin B6 and B12, as well as magnesium and potassium. It also contains some fiber and protein." A peels also have various bioactive compounds like polyphenols, carotenoids and others." (Applied Biochemistry and Biotechnology, 2011)

In this chapter relevant literatures on banana and its peels health benefits as well as cake bread, jam fortification with different functional ingredients have been reviewed. The review findings of some publish and unpublished articles presented below:

2.1 Banana:

Banana pulp is a rich source of essential phytonutrients, including phenolic compounds and vitamins (B3, B6, B12, C and E). It also contains carotenoids, flavonoids, amine compounds and dietary fiber (DF). Dietary fibers are indigestible carbohydrate polymers that are classified based on their water solubility into two types, soluble fibers (pectin and some hemicelluloses) and insoluble fibers (cellulose, lignin and resistant starch) (Alba et al., 2018). In general, it has been reported that Bpe (Banana peel) contains more DF than BP (Garcia-Amezquita et al., 2018). Extracting pectin from the peels could increase their added value. In addition, BPe has high amount of lignin, cellulose and hemicelluloses fractions which can be extracted as a formed complex substrate named lignocellulosic biomass which could be used to produce bioethanol (Happi Emaga et al., 2008). The extracted pectin Bpe could be an alternative source for commercial pectin

(Khamsucharit et al., 2018).

2.2 Medicinal Importance of Banana and its Peel

2.2.1 Reduced risk of high blood pressure

Bananas are one of the best sources of potassium, an essential mineral for maintaining normal blood pressure and heart function. A medium-sized banana provides 350 mg of potassium. The effectiveness of potassium-rich foods in lowering blood pressure has been demonstrated by a number of studies. The US Food and Drug Administration (FDA) have allowed the banana industry to make official claims for the fruit's ability to reduce the risk of blood pressure and stroke. According to the FDA, "Diets containing foods that are good sources of potassium and low in sodium may reduce the risk of high blood pressure and stroke." In addition, potassium helps to body maintain normal body fluid and electrolyte balances in the cells. Scientists report that natural compounds in bananas act in a manner similar to antihypertensive drugs. The team studied six popular banana varieties and found that all had angiotensin-converting enzyme (ACE) inhibiting properties, though the ripened bananas had a stronger action than unripe ones. Researchers have reported that blood pressure fell by 10% in people who ate two bananas daily for a week.

2.2.2 Reduced Risk of Stroke

Scientists suggest that people with a low amount of potassium in their diet may have an increased risk of stroke. A study of 5,600 people aged over 65 found that those with the lowest intake of the potassium were 50% more likely to suffer a stroke (Edwards WP, 2007). High-potassium foods, like bananas and peels, may lower the risk of stroke, but researchers say that more studies are needed to confirm whether increasing potassium in the diet can prevent strokes.

2.2.3 Restore normal bowel Activity

Because the banana is rich in nondigestible fibers (including cellulose, hemicellulose, and alpha glucans) it can help restore normal bowel activity and help with both constipation and diarrhea. Bananas normalize the colon's function to absorb large amounts of water for regular bowel movements. Their usefulness is due to their richness in pectin, which is water-absorbent and this gives them a bulk producing ability. Bananas are an exceptionally rich source of fructo-oligosaccharide a compound called a prebiotic because it nourishes probiotic (friendly) bacteria in the colon. These beneficial bacteria produce vitamins and digestive enzymes that improve our ability to absorb nutrients, plus compounds that protect us against unfriendly microorganisms. When fructo-oligosaccharides are fermented by these friendly bacteria, not only do numbers of probiotic bacteria increase, but so does the body's ability to absorb calcium. For this reason, ingesting antibiotics harm these beneficial bacteria. Research published in Digestive Diseases and Sciences underscores just how much bananas can improve nutrient absorption.

2.2.4 Protection from ulcers & Heartburn remedy

Bananas have long been recognized for their antacid effects that protect against stomach ulcers and ulcer damage. A flavonoid in the banana, leucocyanidin, has been found to significantly increase the thickness of the mucous membrane layer of the stomach. Since bananas help to neutralize acidity, they are also a great way to get rid of heartburn. In an animal study, a simple mixture of banana and milk significantly suppressed acid secretion.

2.2.5 Protection against neurodegenerative diseases (Alzheimer's disease)

Researchers at Cornell University investigated the effects of apple, banana, and orange extracts on neuron cells and found that the phenolic phytochemicals of the fruits prevented neurotoxicity on the cells. Among the three fruits, apples contained the highest content of protective antioxidants, followed by bananas then oranges (Olaoye et al.,2006).). These results suggest that fresh apples, banana, and orange in our daily diet along with other fruits may protect neuron cells against oxidative stress-induced neurotoxicity and may play an important role in reducing the risk of neurodegenerative disorders such as Alzheimer's disease.

2.2.6 Cholesterol-lowering effect

Animal studies have shown that banana has the potential to lower cholesterol. It was suggested that the dietary fiber component in banana pulp was responsible for its cholesterol-lowering effect. The amount of dietary fiber in banana is relatively constant during banana ripening.

2.2.7 Kidney Health

Bananas promote an overall improvement of the functional efficiency of kidneys. Benefits to the kidneys are again due to the high potassium content of bananas. A normal intake of potassium suppresses calcium excretion in the urine and minimizes the risk of kidney stones. The results of the Swedish population based prospective study (13.4 years) of 61,000 women aged 40-76, show that women eating more than 75 servings of fruits and vegetables per month (which translates into 2.5 per day) cut their risk of kidney cancer 40% (Pokorny et al., 2000). Among the fruits, bananas were especially protective. Women eating bananas four to six times a week halved their risk of developing the disease compared to those who did not eat this fruit.

2.2.8 Energy Booster

Bananas contain three natural sugars - sucrose, fructose and glucose combined with fiber. Potassium is also essential for helping muscles to contract properly during exercise and reduces cramping up. A banana gives an instant, sustained and substantial boost of energy. Research has proven that just two bananas provide enough energy for a strenuous 90-minute workout.

2.2.9 Immunity Booster

Bananas contain 25 percent of the recommended daily allowance (RDA) for vitamin B6, necessary for producing antibodies and red blood cells as well as aiding in the metabolism of fat. In addition, vitamin B6 serves as an immunity booster. So, this fruit strengthens our armor against infectious diseases. With each average sized banana, if one ingests about 15% of the RDA for vitamin C, one of the strongest antioxidants.

2.3 Health Benefits of Eating Bananas

2.3.1 Heart health

Bananas are good for our heart. They are packed with potassium, a mineral electrolyte that keeps electricity flowing throughout our body, which is required to keep our heart beating. Bananas' high potassium and low sodium content may also help protect our cardiovascular system against high blood pressure, according to the FDA.

A 2017 animal study conducted by researchers at the Alabama found that the potassium in bananas is also linked to arterial effectiveness; the more potassium we have, the less likely our arteries are to harden. In the study, mice with lower-potassium diet had harder arteries than mice consuming a normal amount of potassium. Arterial stiffness in humans is linked to heart disease.

2.3.2 Digestion and weight loss

Bananas are high in fiber, which can help keep us regular. One banana can provide nearly 10 percent of our daily fiber requirement. Vitamin B6 can also help protect against Type 2 diabetes and aid in weight loss, according to Flores. In general, bananas are a great weight loss food because they taste sweet and are filling, which helps curb cravings.

Bananas are particularly high in resistant starch, a form of dietary fiber in which researchers have recently become interested. A 2017 review published in Nutrition Bulletin found that the resistant starch in bananas may support gut health and control blood sugar. Resistant starch increases the production of short chain fatty acids in the gut, which are necessary to gut health.

2.3.3 Vision

Carrots may get all the glory for helping your eyes, but bananas do their share as well. The fruits contain a small but significant amount of vitamin A, which is essential for protecting our eyes, maintaining normal vision and improving vision at night, according to the National Institutes of Health. Vitamin A contains compounds that preserve the membranes around our eyes and are an element in the proteins that bring light to our corneas. Like other fruits, bananas can help prevent macular degeneration, an incurable condition, which blurs central vision.

2.3.4 Bones

Bananas may not be overflowing with calcium, but they are still helpful in keeping bones strong. Bananas contain an abundance of fructo-oligosaccharides (Journal of Physiology and Biochemistry, 2009) . These are nondigestive carbohydrates that encourage digestive-friendly probiotics and enhance the body's ability to absorb calcium.

2.3.5 Cancer

Some evidence suggests that moderate consumption of bananas may be protective against kidney cancer. A 2005 Swedish study found that women who ate more than 75 servings of fruits and vegetables cut their risk of kidney cancer by 40 percent, and that bananas were especially effective. Women eating four to six bananas a week halved their risk of developing kidney cancer.

Bananas may be helpful in preventing kidney cancer because of their high levels of antioxidant phenolic compounds.

2.3.6 Health effects of banana bioactive compounds

Carotenoids are natural antioxidants which contribute to the stability of foods during storage. Previous studies documented the existence of various carotenoids in banana fruit (Davey et al., 2006). Although some suggested that the cultivars genotype specifies the quantity of carotenoids, they mostly concurred that the amount of trans-alpha and trans-beta carotene comprised the majority of pro-vitamin A compounds (Yan et al., 2016). Another significant carotenoid reported was lutein, which exhibited antioxidant properties and an inhibitory effect on the age-related macular degeneration. Interestingly, it has been identified that green banana peel (GBPe) has substantially higher carotenoids than the pulp (Davey et al., 2006). Phytochemicals, especially phenolic acids, are the main bioactive compounds known for exerting health benefits. Unexpectedly, the percentage of phenolic compounds have been reported to be greater in peel than in pulp (Kanazawa and Sakakibara, 2000). Similarly, it was demonstrated that the quantity of gallocatechins in peel was five times greater than pulp. With regard to presented results, BPe extract was found to inhibit lipid oxidation better than pulp extract (Someya et al., 2002). Recently, it has been shown that gallocatechol extracted from GBPe was effective in the healing of surgical wounds in rats (Von Atzingen et al., 2015). Correspondingly, a unique flavonoid named leucocyanidin was found in aqueous extract of unripe plantain pulp, which is now known to be effective in the treatment of gastric diseases (Lewis et al., 1999). Biogenic amines play a key role in the prevention of depression. Catecholamines, dopamine, norepinephrine (noradrenaline) and epinephrine (adrenaline) are the bestknown examples of these bioactive compounds which regulate hormones in glycogen metabolism (Gonza ´lezMontelongo et al., 2010). Results of dopamine levels in different ripening stages of banana revealed an inverse relation between its concentration and fruit's maturity, noting that BPe contained more dopamine than pulp.

2.4 Health benefits of phenolics

A flavonoid, leucocyanidin, has been identified as a predominant component of aqueous extract of unripe banana pulp that showed significant anti-ulcerogenic activity (Lewis et al., 1999). Thus, many flavonoids, especially leucocyanidin analogues, may offer immense therapeutic potential in the treatment of gastric disease conditions. The structure–activity relationship of flavonoids indicates that their antioxidant capacity, scavenging free radicals, and chelating action are related to the presence of functional groups in their nuclear structure (Heim et al., 2002). They also attributed most of the health benefits from the consumption of flavonoids to their antioxidant and chelating properties. Because of these properties, flavonoids are also shown to exhibit antimutagenic and antitumoral activities (Rice-Evans et al., 1996). The flavonoids can also inhibit many enzymes, such as oxygenases (prostaglandin synthase), required in the synthesis of eicosanoids. Thus, the flavonoids inhibit hyaluronidase activity and help in maintaining the proteoglycans of connective tissues. This would prevent the spread of bacterial or tumour metastases (Havsteen, 2002). As the flavonoids get preferentially oxidized, they are reported to prevent the oxidation of body's natural water-soluble antioxidants like ascorbic acid. Generally, after the consumption of banana fruit, the peel ends up as a feed for the animals only. The disposal of peel (pomace) and other by-products from banana-processing industry causes a serious environmental problem

(Zhang *et al.*, 2005). Banana peel is reported to be rich in many high-value health-promoting antioxidant phytochemicals, such as anthocyanins, delphinidin, and cyanidins (Seymour, 1993). In a recent study, Rebello et al. (2014) have also shown the banana peel extract to be a rich source of total phenolics (29 mg/g as GAE), which are responsible for the very high antioxidant activity. They also determined various other antioxidant compounds, namely, highly polymerized PR delphinidins (~3952 mg/kg), flavanol glycosides (mainly 3-rutinosides and predominantly quercetin-based compounds, ~129 mg/kg), B-type procyanidin dimers, and monomeric flavan-3-ols (~126 mg/kg).

2.5 Banana flour applications

The high dietary fiber content of Green banana peel flour (GBPF) and high levels of mentioned bioactive compounds have enabled the production of BF foodstuffs with remarkable functionalities. Moreover, discovering high nutrition value of BPeF represents a low-cost by-product for industrial application. As discussed earlier, depending on the ripening stage, there are four flour products produced from banana with different chemical composition. Due to the structure of BF, cereal based products have gained more attention than other food products. The main starch-based foods targeted for enrichment with BF products are as follows.

2.5.1 Bread

In a study by Juarez-Garcia et al. (2006), GBF was obtained from a Mexican species (Musa paradisiacal L.) to develop a high gluten bread using 37% GBF in the formulation. Chemical composition analysis showed an increase in ash, protein, TDF and starch percentage of banana bread compared to wheat bread. Even though RS was decreased from 17.5% in flour to 6.7% in banana bread, it was significantly higher than the control sample. The authors also reported a significant decrease in predicted Glycemic Index (pGI) and Hydrolysis Index (HI) of the final product; a result that was in accordance with a higher value of total indigestible fraction (TIF), the main ingredients unavailable for digestion in the small intestine. However, rheological and sensory properties and shelf life of banana bread were not determined. In another study, with more attention to the sensory characteristics, GBF substitution with wheat flour resulted in lower sensory scores in 20%

enriched-samples (Gomes et al., 2016). Moreover, darker color, higher hardness and lower specific volume compared to control sample indicated negative effects of this enrichment. While TDF and ash content increased significantly in 20% substitution, the significant technological defects (Gomes et al., 2016). In a study on gluten-added bread, substitution of 25% of ready freeze-dried banana powder (maturity level was not mentioned) with wheat flour resulted in increased volume and viscosity of leavened bread (Mohamed et al., 2010). Banana bread was darker than the control due to excess sugar in the BF that caused the Maillard Reaction to occur between reducing sugars and proteins. Regarding the evaluation of shelf life, while bread staling (firmness) increased in higher BF concentration regardless of storage temperature (25 C, 4 C and - 20 C), the stiffness of the control was higher than BF bread (Mohamed et al., 2010). By comparing storage temperature, it was stated that bread stored at - 20 C up to 7 days, experienced lower firmness compared to other samples (Mohamed et al., 2010). Similar findings reported by (Ho et al., 2013) who prepared a steam bread with 30% GBPF wheat flour substitution. In terms of mineral evaluation, the percentage of Mg, K, Na and Ca were higher than the control, and yielded consequently higher ash content. Increased TDF and RS were also reported to a level of 9% and 5%, respectively. However, the adverse impact of GBPF and added gluten caused an increase in hardness and adhesiveness in the produced bread. The cohesiveness, elasticity and chewiness of bread supplemented with 30% GBPF were decreased due to the lack of consistency in gluten structure. With reference to higher specific volume in banana bread samples containing 8% gluten, researchers explained that GBPF could affect the gluten network and attenuate the gas holding capability of the dough, which leads to low elasticity and expansion in leavened bread.

2.5.2 Cake

Due to its high sugar content, utilization of BF in confectionaries has been heightened by the food industry, specifically cereal-based ones. The growth of pathogens in a cake premix made with 60% GBPF instead of wheat flour over 4 months of storage was investigated. Despite a high sugar concentration, the pre-mixture remained significantly unaltered in pH and pathogenic growth, fungus or yeasts (Borges et al., 2010). In another study, foaming stability and overall acceptability increased in the presence of 10% BPF.

Also, with increased content of BPF to 20% of the formulation, higher hardness was reported, although chewiness and adhesiveness were not significantly different amongst samples. The reason behind this phenomenon was the lower amount of moisture content in banana cakes (Park et al., 2010). With the aim of increasing DF and RS in layer and sponge cakes, GBPF was added at different particle sizes; ranging from 80 lm (fine) to 200 lm (coarse) in diameter. Researchers showed that the fine flour comprised 40% RS compared to 25% RS in the coarse flour. This fact specified higher RS content (about 3%) in 30% replacement samples with fine flours in both layer and sponge cakes. However, the percentage of TDF, protein, ash, lipid, phenolic compounds and amylose was higher in the coarse flour. In terms of technological properties, sponge cakes were noticeably worsened with the presence of banana flours (lower specific volume, inferior sensory characteristics and higher hardness), which was diminished at the 15% ratio; except for cohesiveness that showed a dramatic decrease in all samples compared to the control. The authors accounted for different gelatinization and retrogradation behavior of banana starch compared to wheat starch for textural changes and decreased sensory scores in banana cakes. Still, samples made by fine particle sizes of GBPF showed better nutritional properties without negatively affecting textural attributes (Segundo et al., 2017a). The same results were reported in a similar study by selection of YBPF in 40% substitution with sugar. Both sponge and layer cakes depicted enhancement in DF, polyphenols and antioxidant capacity values. In concurrence with their previous work, increased hardness and decreased volume led to the decline of the acceptability of cakes by panelists, especially in 40% banana cakes. Considering the correlation between volume and hardness was more significant in sponge than in layer cakes, the maturity of banana was not correlated to improvements of textural properties (Segundo et al., 2017b).

2.6 Conclusion

Banana with peel flour and its benefits, functional properties of banana pulp and peel. Its fiber, ash, protein quality along with other beneficial ingredient, cereal products and its health benefits, bread, cake, jam preparation and fortification with high fiber BPF. The benefits on overall nutritional quality and antioxidants, phenolic, flavonoid contents importance have been discussed and assessed the justification to perform the current study.

Chapter 3: Materials and Methods

3.1 Introduction

This chapter describes the materials and methods used in the process of data collection as well as appropriate formulae for data analysis and presentation.

3.1.1 Sources of ingredients of Cake, Bread, Jam:

For the preparation of experimental cake, jam, bread, banana (sagor kola) was purchased from Lalkhan Bazar Market, Wheat flour (local) was purchased from Wireless Jawtola market, Chattogram City, whereas “Saf-instant” instant dry yeast, sun flower oil, dano skim milk powder, fresh refined sugar, ACI refined salt, CHINIGO Natural sugar substitute, all purposes flour, egg, baking powder, citric acid were individually purchased from the Basket supermarket in Chattogram city, Bangladesh.

3.2. Processing of Banana into Powder form

The mature Bananas (*Musa* species) were washed in tap water then again washed by distilled water. After that the unwanted parts were removed and sliced the banana with peel into small pieces, (5kg) were dipped in 5 liters of water containing 15 grams of citric acid, 20 grams white vinegar. The fruits were removed from the dip solution and dried in a cabinet dryer at 50℃ for 48 hours. The dried banana chips were passed through a blender to obtain banana with peel flour (BPF). Then powder was transferred to a glass bottle and stored at – 18 ℃ in refrigerator.

Figure 3.1: Raw material used in the study.

3.2.1 Blend formation and Bread making

Three bread samples were prepared of which one sample was considered as control and others were considered as banana with peel flour (BPF) treated sample. The ratio of whole wheat flour and banana with peel flour in different samples were as follows: 100:0 (control sample), 90:10 and 85:15 (treated samples).

The three blend formulations were baked using straight dough method (Edwards, 2007). The same baking formula was followed for all bread samples (Olaoye et al., 2006): 56% whole wheat flour or the blend of whole wheat flour treated with banana with peel flour, 36% water, 3.4% sugar, 1.6% vegetable oil, 1% skim milk powder, 1% salt and 1% yeast. All ingredients were then mixed by hand for 20 minutes to get appropriate well mixed dough. The dough was then fermented in a bowl covered with sterile and wet clean muslin cloth for 1 hour at 29℃. The fermented dough was raised twice to its initial volume by air trapping during this period. Then the raised dough was punched to remove air and scaled to 350gm dough pieces. This weighed dough was molds to its final shape in bread making dice and proofed in a manually prepared proofing cabinet for an hour at 30℃ with maintaining 85% relative humidity. Final proofed dough was baked at 220℃ for 30 minutes.

Figure 3.2: Final product after baking. (Bread)

3.2.2 Preparation of Cake

Two cakes were prepared, one control and other was formulated with Banana with peel flour (BPF). Cake were prepared by replacing wheat flour with different levels of Banana with peel flour in the basic formulation of cake as per the methods of Rajchel et al. (1975). All purposes flour, banana with peel flour and other ingredients for each cake were weighed accurately, and the sugar and shortening were mixed in a mixing machine for 20 minutes to produce a cream. In later stages, oil, egg and other ingredients and, finally, the flour was mixed using a mixer at low speed for 10 minutes to ensure even distribution of the components. The bowl was scrapped and batter was mixed for an additional two minutes at medium speed. Portion of batter, weighing 150 g, was scaled into pre-greased cake pan. All cakes were baked in convection oven for 30 minutes at 140°C.

Figure 3.3: Process flow of Cake preparation

3.2.3 Preparation of Banana with peel flour Jam

The jam formulation of 50gm of stevia leaf Extract powder and 1gm of citric acid and banana with peel powder (BPP) 30gm. Distilled water 60ml was added to the BPP in a water bath for 10 minutes to extract pectin. Sugar previously dissolved in boiling water with citric acid was added to the BPP dispersion (pectin extract) after 20 minutes of heating at 121°C.The dispersion was then again heated approximately 30 min at 80°C.In order to obtain a desirable gel consistency, the end point was judged as the point at which the total soluble solids of the viscous dispersion reached 72°Bx, as determined by the hand refractometer. The dispersion was then poured into a mold and cooled for 48hr at room temperature to produce a jam. Then the jam was Stored at -18°C for further analysis.

3.3 Proximate Analysis:

Proximate analysis, such as moisture, protein, fat, fiber and ash contents were determined according to the Association of Official Analytical Chemists' method (AOAC, 2012). The carbohydrate content was determined by subtracting the other food value i.e. protein, fat, moisture, ash and fiber. A total of 6 samples (raw and developed) were used for this analysis. Triplicate analysis of each sample was conducted.

3.3.1 Moisture Content Determination

Moisture content was determined using the procedure as follows: 2 g of the milled sample was weighed using an analytical balance, placed in a crucible and dried in a thermostatically controlled oven at 105℃ for 5 h. The sample was removed and placed in a desiccator and cooled to room temperature. The sample and crucible were weighed repeatedly until a constant weight was obtained. Loss in weight of the sample was reported as moisture content.

% Moisture content = (Loss in weight/ Weight of sample) *100

Figure 3.4: Moisture Analysis using hot air oven.

3.3.2 Crude Protein determination:

The crude protein was determined by kjeldahl method. 0.3g sample was weighted into digestion tube. Potassium sulfate 72gm and Copper sulfate 8gm a mixture was prepared. 4gm of this mixture was added to the digestion tube. About 5ml of concentrated H_2SO_4 were added into the digestion tube. Digestion was carried out at 320°C for 30minutes. Sample was cooled down before addition of 25ml of distilled water and 25 ml of 40% NaOH. About 10ml 4% boric acid with 3 drops of green bromocresol indicator was prepared as receiving solution in conical flask. Cooled tube and receiving solution was placed into the distillation unit. After that, 25ml 40% NaOH was filled automatically into the tube and the distillation process was conducted for 4 minutes. The receiving solution turned to green color after the distillation process. The receiving solution was titrated with 0.2N HCL until it turned to grey color. The percentage of crude protein was calculated by formula.

Percentage of protein= Percentage of nitrogen * 6.25

$$\text{Percentage of nitrogen} = \frac{(T-B) * N * 14.007 * 100}{\text{Weight of sample in mg}}$$

T= Volume of titration of sample.

B= Volume of titration for Blank.

N= Normality of HCL (0.2)

Figure 3.5: Crude protein determination.

3.3.3 Crude Fat Determination

The following procedure was used for the determination of crude fat. About 2gm samples were transferred into a thimble and was set to the chamber. About 70 ml diethyl ether was weighed into an extraction beaker. Then Decocting 20 minutes, rinsing for 20 mints and evaporation was done in the chamber and finally calculated the fat % present in the sample.

% of Crude Fat = (Weight of fat/Weight of sample) * 100

Figure 3.5: Crude Fat analysis.

3.3.4 Crude Fiber Estimation

Accurately 2gm sample was weighed and transferred into a beaker. About 125ml of 1.25% sulfuric acid solutions, 3-4 drops of n-octanol (antifoam agent) was added to the beaker. Then it was boiled 30 minutes at exactly constant volume. After that the sample was washed three times to make it acid free. After draining the last wash 125ml 1.25% sodium hydroxide and 3-5 drops antifoam was added. Again boiled 30 minutes at exactly constant volume. It was then filtered and washed the residue as above. Second wash was performed with 1% HCL solution to make it acid free. Finally, the residue was dried in hot air oven at 105℃ up to constant weight. The residue was cooled in desiccator and weighed. Then burned up to no smoke and ignited in the muffle furnace up to white ash (550-600℃, 3-4 hr). Weighed the ash and deducted the value to get fiber weight.

% crude fiber $=(W-W_1)/W_2 *100$

Where, W= weight of crucible, crude fiber and ash,

W_1= weight of crucible and ash,

W_2= weight of sample

Figure 3.6: Fiber Determination Process.

3.3.5 Estimation of Ash

The ash fraction contains all the mineral elements jumbled together. This method performs oxidization of all organic matter by incineration and determines the weight of remaining ash. However, high temperature may cause volatilization of certain elements particularly K, Na, Cl and P and many cause the mineral matter melted and fused. Firstly, the crucible was Cleaned and dried in hot air oven. Then it was Cooled in desiccators and weighed. After that accurately 2-5 gm of samples in crucible were placed and Burned the samples with crucible up to no smoke. The samples then cooled and transferred to muffle furnace. The samples were at 550-600°C for 6-8 hours until white ash. Again, Allowed the furnace to cool at 150°C and transferred it to the desiccator. The samples were cooled and weighed while it is mile warm.

Calculation

Calculation of the ash percentage as follows:

% Ash = (W-W1)/W2 *100

Where, W = Weight of crucible and ash, W1 = Weight of crucible, W2 = Weight of sample

3.4 Sensory Analysis

The symmetry and the characteristics of crust and crumb of the cakes supplemented with banana with peel powder were evaluated and recorded. Cakes, bread and jam were evaluated organoleptically for color, flavor, texture, crust, crumb, aroma and overall acceptability. A 1-7-point hedonic rating test was also performed to assess the degree of acceptability of cakes, bread and jam containing banana with peel powder. A set of 20 panelists was selected from teacher, students of the faculty of Food Science and Technology, Chittagong Veterinary and Animal Sciences University, Bangladesh and briefed on procedure before evaluation. One slice from each lot of cake, bread, 1 spoon of jam was presented to 20 panelists. The taste panelists were asked to rate the sample for color, flavor, texture and overall acceptability on a 1- 7-point scale, where 1 = dislike very much; 2=much disliked; 3= disliked; 4= liked or did not like; 5 =liked; 6 = liked a lot; 7= very much liked.

Figure 3.8: Plate for sensory evaluation.

3.5 Microbiological Analysis

Determination of total bacterial count

Nutrient agar media was used to determinate the total bacterial count. NA plates were dried and labeled for appropriate dilutions to be used for dilution and spread plate method. Plates were inoculated and incubated at 37 °C for 18-24 hours. Total number of bacteria cfu/ml of sample was calculated and recorded for interpretation of the result.

For determining the microbial load in bread, cake and jam samples, the total viable count (TVC) and *E Coli* count were determined with spread plat method. The total plat count agar and MaConkey agar respectively used to indicate the TVC and *E. coli* for the formulated samples. 1gm of each sample were diluted in 10-folds in sterile normal saline water (.85% Nacl) and properly diluted up10^{-1} to 10^{-6} decimal in normal saline water. 100microlitre from each dilution of each sample were spread on selected media by spread plate method with sterile glass spreader. Plates were incubated overnight at 37°C and visible colonies were counted and represented as CFU/g or CFU/ml in log scale. Cell counts (CFU/ml) were derived from the average of 3 independent experiments.

Figure 3.9: **TVC and *E coli* count plat.**

3.6. Antioxidant activity

3.6.1. Preparation of DPPH solution (100 µm)

At first 4 mg of DPPH was dissolved in 100 ml of methanol (95%) in a dark condition.

3.6.2. Preparation of standard ascorbic acid solution

10 mg of ascorbic acid was dissolved in 10 ml of distilled water. So, the concentration of the solution became 1mg/ml. This is called stock solution. Then serial dilution was performed in order to prepare different concentrated solution (2 ppm, 4 ppm, 8 ppm, 16 ppm, and 32 ppm).

3.9: Sample preparation for antioxidants activity determination.

3.6.3. Procedure

About 4 ml of DPPH solution was added to 1 ml of sample extracts or standards at different concentration. The mixture was shaken vigorously and allowed to stand at room temperature in the dark for 30 min. Then the absorbance of the solution was measured at 517 nm using a UV-Vis spectrophotometer (COmpany) against blank. Control sample was prepared containing the same volume without any extract and reference ascorbic acid. Methanol was used as blank. IC50 was calculated from % inhibition. Scavenging of the DPPH free radical was measured using the
following equation:

% inhibition = {(A0 – A1)/(A0)} ×100

A0 = absorbance of DPPH alone

A1 sample = absorbance of DPPH along with different concentrations of extracts.

3.6.4 Determination of Total Phenol Content

3.6.1.1. Preparation of standard gallic acid solution

About 10 mg of gallic acid was dissolved into 10 ml of distilled water. So the concentration of the solution was 1mg/ml. This is called stock solution. Then serial dilution was performed in order to prepare different concentrated solution (2 ppm, 4 ppm, 8 ppm, 16 ppm, 32 ppm).

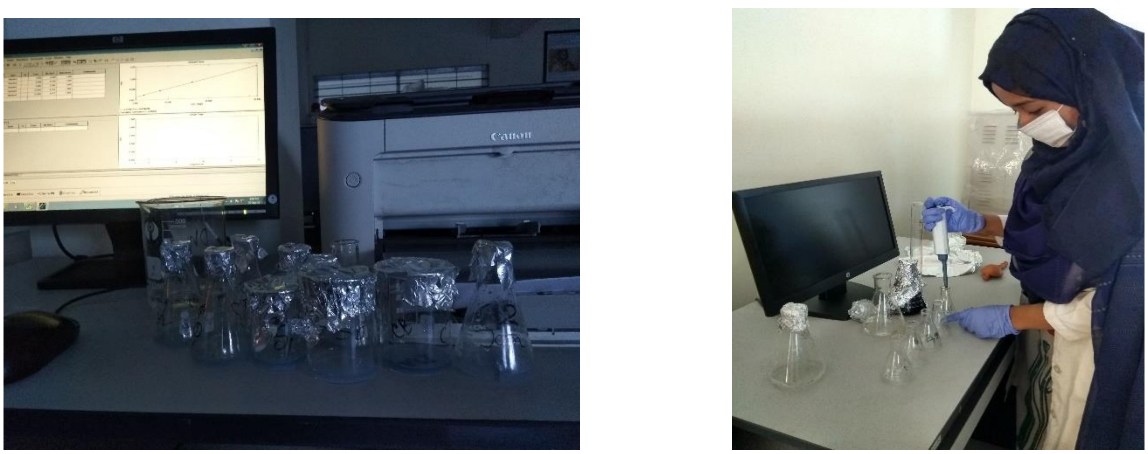


Figure 3.10: samples preparation and UV-visible spectrography analysis of flavonoid and phenolic compounds.

3.6.1.2. Procedure

The total phenol content of sample extracts was evaluated by the Folin-ciocalteu method as described by (Wojdyło et al., 2007). About 1ml of sample extracts or standard at different concentrations were mixed with 2 ml of Folin–Ciocalteu reagent (10times diluted), and incubated at room temperature for 3 min. After that, 10 ml of 20% sodium carbonate was added to the mixture and left for incubation at room temperature for an hour. The absorbance of the mixture was measured at 765 nm with a Shimadzu UV–VIS-2600 spectrophotometer against a blank solution. The blank solution contained all the reagent mixture without extract or standard sample. Gallic acid standard curve was used to quantify total phenolic contents and the results were expressed as mg of gallic acid equivalent (GAE) per gram of dried weight. All determinations were performed in triplicate (n = 3).

3.6.2. Total flavonoid content determination

Flavonoid content in samples was measured by aluminum chloride colorimetric method.

3.6.2.1. Preparation of 1M potassium acetate solution

0.9815 g of potassium acetate was dissolved in 10 ml water.

3.10.2. Preparation of 10% $AlCl_3$ solution

1gm $AlCL_3$ was dissolved in 10ml water.

3.6.2.3. Preparation of standard quercetin solution

About 10 mg of quercetin was dissolved into 10 ml of distilled water. So the concentration of the solution was 1mg/ml. This is called stock solution. Then serial dilution was performed in order to prepare different concentrated solution (6 ppm, 12ppm, 24ppm, 48ppm, 96ppm).

3.6.2.4. Procedure

About 1ml of sample or standard at different concentration solution was taken in a test tube. After that, 0.2 ml of 10% aluminum chloride, 0.2ml of 1 M potassium acetate, and 8.6ml of distilled water were added. The reaction mixture was then incubated at room temperature for 30min to complete the reaction. The absorbance of the mixture was measured at 420 nm. Quercetin was used to make the calibration curve. The calculation of total flavonoids content in the extracts was carried out in triplicate and the results were averaged. The final result was expressed as mg of quercetin equivalent (QE) per gram of dried weight. All determinations were performed in triplicate (n = 3).

3.7. Statistical Analysis:

All results presented in the paper are expressed as mean and standard deviation (±SD) from three experiments (n=3). Difference in mean values between the groups were analyzed by a one-way analysis of variance (ANOVA) with post-hoc Tukey HSD test and all tests were considered statistically significant at $p<0.05$.

Chapter 4: Results

4.1. Proximate composition

The results of proximate analysis on the Banana with peel flour and whole wheat bread samples are presented in table 4.1. The results showed that banana with peel flour treated bread contained significantly better proximate composition in two formulated bread (90:10, 85:15), compared to control bread with original and the developed recipe showed no significant difference ($p>0.05$) in the fiber content (Table 4.1). However, there were significant differences ($p<0.05$) in the moisture, fat, ash and carbohydrate contents of the samples (Table 4.2).

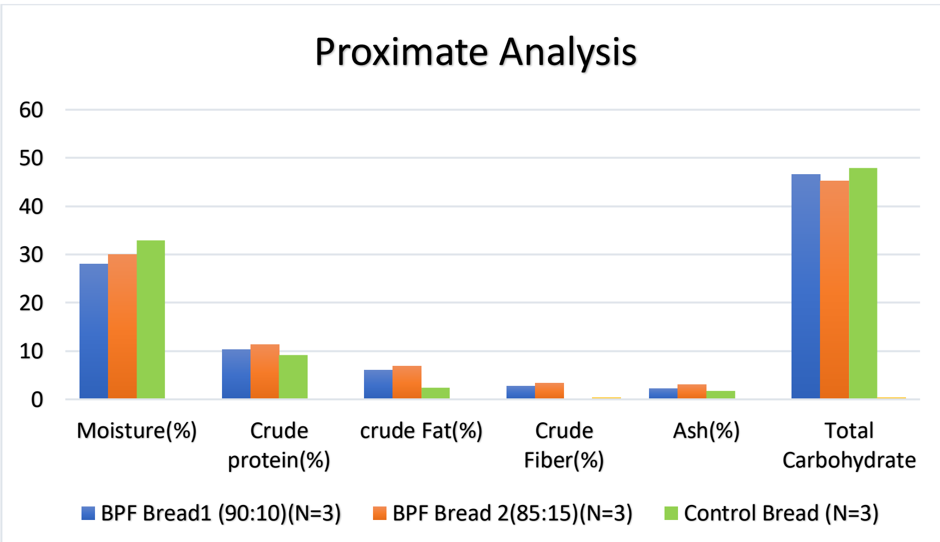


Figure 4.1. Comparison of proximate data between BPF formulated Bread and Control Bread

The mean moisture content of developed bread-1 (23%) and bread-2 (30%) is lower than the control bread (33%).

Developed bread had higher fat bread-1 (6.09%) and in bread-2 (6.92%), Ash contents with values of 2.25% and 3.01% as against 1.70% and 1.7% for control bread respectively. The Protein percentage are close to the formulated bread and the control bread.

Table 4.1 Chemical composition of Bread (Formulated and Control)

Parameters	BPF Bread (90:10)(N=3)	BPF Bread (85:15)(N=3)	Control Bread (N=3)	P(1-ANOVA)
Moisture(%)	28±1.5[a]	30±1.00[b]	33±1.00[c]	<0.001
Crude protein(%)	10.36±1.00[a]	11.38±1.00[a]	9.2±1.00[a]	0.095
crude Fat(%)	6.09±1.00[a]	6.92±1.00[a]	2.466±.57[c]	0.002
Crude Fiber(%)	2.78±1.00[b]	3.41±1.001[b]	0.2±.10[a]	0.04
Ash(%)	2.25±1.00[a]	3.01±1.00[a]	1.7±1.00[a]	0.007
Total Carbohydrate	46.633±2.02[ab]	47.29±1.76[bc]	45.966±4.60[bc]	0.35

A=Formulated Bread with Banana with peel flour (BPF)90:10.

B= Formulated Bread with Banana with peel flour (BPF) 85:15.

C= Controlled Bread with no BPF flour.

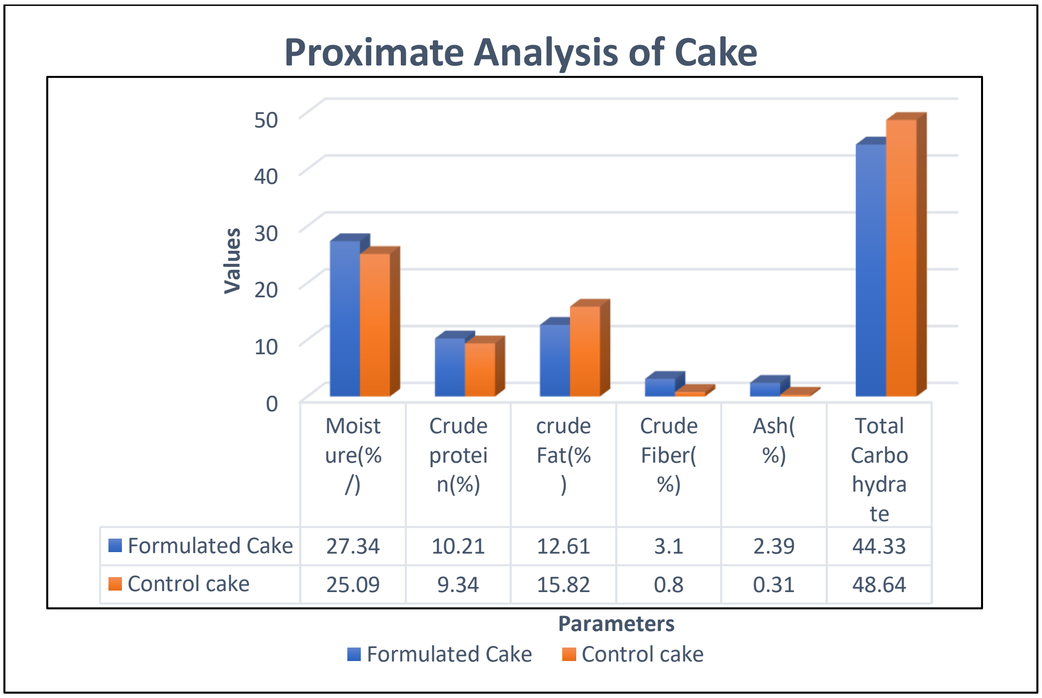


Figure 4.2. Comparative bar diagram representation of banana with peel flour (BPF) Cake and Control Cake

It was observed that protein and fat content decreased with increasing levels of substitution while ash and crude fiber contents increased. There was significant difference ($p<0.05$) in crude fat, crude fiber and ash contents between BPF formulated cake and the control cake. Banana peel flour contained higher amount of fiber (13.20%) and ash (5.68%) which attributed to higher amount of ash and fiber in the formulated cake compare to the control cake.

Table 4. 2 Chemical composition of Control Cake and formulated cake

Parameters	Formulated Cake	Control Cake	P(1-ANOVA)
Moisture (%)	25.34±1.52[a]	27.09±1.00[a]	0.099
Crude protein (%)	10.21±1.00[a]	9.34±1.00[a]	0.347
crude Fat (%)	12.61±1.00[a]	15.82±1.00[c]	0.017
Crude Fiber (%)	3.10±1.00[a]	0.80±.10[b]	0.017
Ash (%)	2.39±1.00[a]	.31±1.00[c]	0.004
Total Carbohydrate	48.33±3.05[a]	44.64±1.00[a]	0.081

4.3. Formulated Jam

Banana with peel flour jam is especially prepared for the obese and diabetes patients, which content no extra sugar and artificial pectin. The control banana jam contained protein 5.95%, carbohydrate 57.69%, fat 0.967%, moisture 31.12%, ash 1.5%. where as the formulated jam moisture content 27.93%, protein 6.42%, crude fat .93%, crude fiber 8.85% and ash 2.53%.

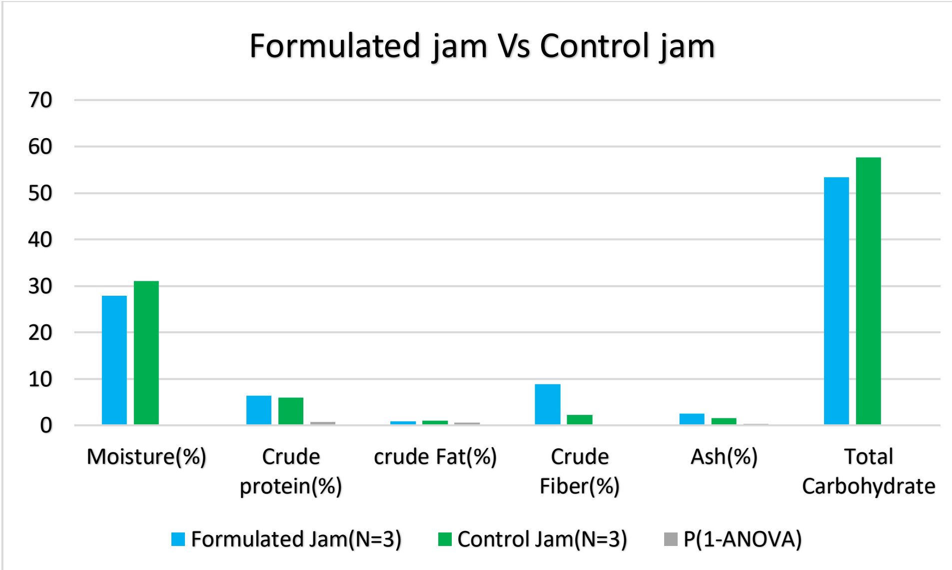


Figure 4.3 Proximate composition of Jam

There was a significant difference ($p<0.05$) crude fiber between formulated jam with BPF and the controlled banana jam.

Table 4.3 Chemical composition of jam

Parameters	**Formulated Jam**	**Control Jam**	**P(1-ANOVA)**
Moisture (%)	27.93 ± 1.00^{a}	31.12 ± 1.00^{b}	0.017
Crude protein (%)	6.4233 ± 1.00^{a}	5.95 ± 1.00^{a}	0.677
crude Fat (%)	$.93 \pm 1.00^{a}$	$.9667 \pm .0577^{a}$	0.612
Crude Fiber (%)	8.85 ± 1.00^{a}	2.25 ± 1.00^{c}	0.001
Ash (%)	2.53 ± 1.00^{a}	1.50 ± 1.00^{a}	0.276
Total Carbohydrate	53.40 ± 2.12^{a}	57.69 ± 1.08^{c}	0.029

Formulated Jam with Banana with peel flour (BPF). Controlled Jam without BPF flour.

4.2. Sensory Evaluation

The mean score of taste was significantly varied among bread, cake and jam and the post-hoc suggested the mean significant in case of all formulated products compared with the control product ($p<0.05$). There was significant difference in all attributes including crust, flavor, texture, taste, crumb, appearance and overall acceptability between the banana with peel flour using products and control products.

Table 4.4 Hedonic sensory score for cake samples

Parameters	A(N=3)	C(N=3)	P(1- ANOVA)
Color	5.40±.820[a]	6.35±.58[b]	<0.001
Taste	6.1±.788[a]	6.25±.71[a]	0.533
Flavor	6.10±.6407[a]	6.05±.759[a]	0.823
Texture	5.900±.718[a]	6.000±.794[a]	0.679
Appearance	5.700±.732[a]	6.300±.656[c]	0.01
Overall Acceptability	6.3500±.587[a]	6.400±.598[a]	0.791

*A=Formulated cake with BPF sample, C=Controlled cake sample,

Regarding the taste attribute, the formulated BPF bread1 and formulated BPF bread2 obtained the highest average. Crust and aroma of two bread samples had significantly difference($p<.05$). There was no significant difference between taste, shape appearance and internal texture in BP bread1 and BPF bread2. The BPF bread2 had the highest acceptance percentage found, obtaining the highest average of 5.35, a fact observed in all evaluated sensory attributes.

Table 4.5 Hedonic sensory score for bread samples

Parameters	Formulated bread1 90:10	Formulated Bread2 85:15	P(1-ANOVA)
Crust	4.550±.1.050[a]	3.750±.63867[b]	0.006
Aroma	4.900±1.29371[a]	4.050±.82558[a]	0.018
Taste	5.1053±1.2864	4.6316±.895	0.196
Shape	4.55±1.0500	4.55±.887	1
Appearance	4.9500±.998	4.8000±.5231	0.558
Internal texture	4.600±1.273	4.400±.8207	0.555
Overall Acceptability	5.100±.91191	5.3500±.5871	0.309

In case of texture attribute of BPF jam, texture obtained the highest range 4.56. Color, Taste, overall acceptability in medium range.

Table 4.6 Hedonic sensory score for jam samples

Parameters	Formulated jam (N=3)
Color	3.60±.1.3917
Taste	4.3000±1.29371
Texture	4.6500±.988
Overall Acceptability	4.500±.7608

4.3. Antioxidants Activity

4.3.1 Contents of total phenolics

Phenolic compounds are plant constituents that possess antioxidants and prevents the decomposition of hydroperoxides into free radicals (Pokorny et al., 2001)

The total phenolic contents in Banana with peel flour (BPF), BPF formulated bread-1, BPF formulated bread-2, BPF formulated cake, control cake and BPF jam are described in figure 4.7.

.

Table 4.7 Phenolic content for different samples

Parameters	BPF Bread1	BPF Bread2	BPF Cake	Control Cake	BPF Jam	BPF
sample solution (ug/ml)	1000	1000	1000	1000	1000	1000
weight of dry extract per ml m(gm	0.001	0.001	0.001	0.001	0.001	0.001
Absorbance	1.107	.994	0.865	0.598	0.891	1.221
Concentration mg/l	23.730	21.252	18.445	16.985	19.015	26.200
QE conc. C (ug/ml)	21.859	19.647	17.123	11.898	17.6320	24.090
QE conc. C (mg/ml)	0.021	0.0196	0.0171	0.0118	17.6320	0.024
TFC as GAE, A=(C*V)/m Mg/gm	21.86±1[a]	19.65±1.00[a]	17.12±2.97[a]	11.89±1.42[ab]	17.63±1.00[bc]	24.090±4.06[bc]
P value	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00

The gallic acid contents in Banana with peel powder (BPF), BPF formulated bread-1, BPF formulated bread-2, BPF formulated cake, control cake and BPF jam were 24.090mg/g, 21.859mg/g, 19.674 mg/g, 17.123mg/g, 11.898mg/g, 17.6320 mg/g respectively.

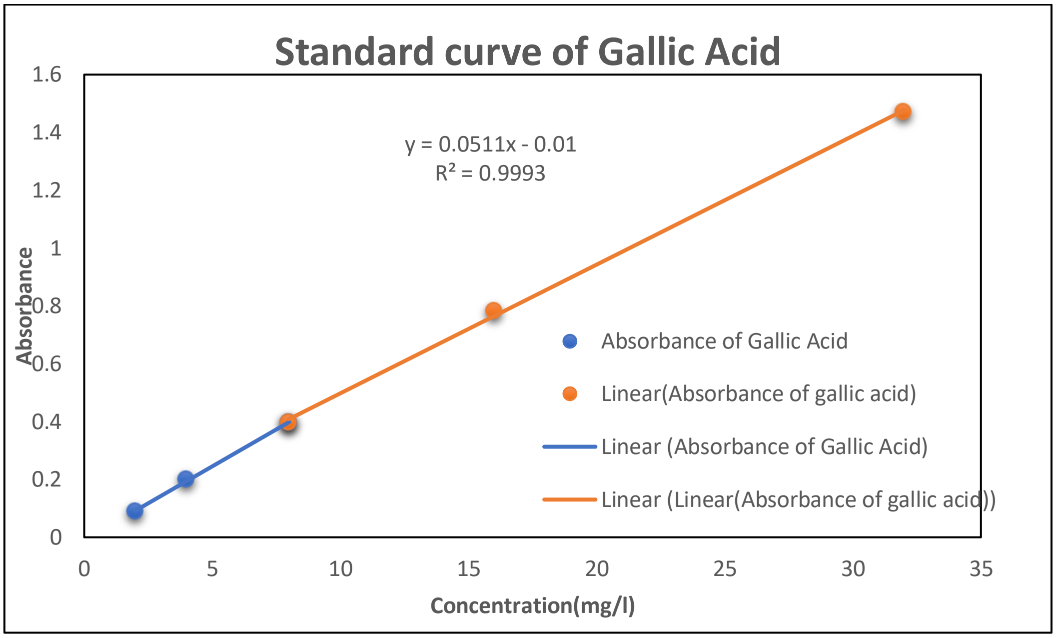


Figure 4.4: Standard curve of gallic acid.

4.3.2. Total Flavonoid Content

The total flavonoid contents were expressed as mg quercetin equivalent per gm. The total flavonoid contents in Banana with peel flour (BPF), BPF formulated bread-1, BPF formulated bread-2, BPF formulated cake, control cake and BPF jam are described in table 4. 8

Table 4.8 Flavonoid content for different samples

Parameters	BPF Bread1	BPF Bread2	BPF Cake	Control Cake	BPF Jam	BPF
sample solution (ug/ml)	1000	1000	1000	1000	1000	1000
weight of dry extract per ml m (gm)	0.001	0.001	0.001	0.001	0.001	0.001
Absorbance	0.02	0.023	0.005	0.009	0.009	0.034
Concentration mg/l	9.492	11.341	7.597	8.037	5.692	7.16
QE conc. C (ug/ml)	11.3461	11.7307	9.9423	9.3358	9.9358	13.14
QE conc. C (mg/ml)	0.01134	0.0117	0.00994	0.00933	0.00933	0.01314
TFC as QE, A=(C*V)/m Mg/gm	11.34 ± 1.00^{a}	11.73 ± 1.00^{a}	9.94 ± 1.00^{a}	9.33 ± 0.87^{bc}	9.93 ± 1.0^{bc}	13.14 ± 1.0^{b}
P value	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00

The contents in Banana with peel flour (BPF), BPF formulated bread-1, BPF formulated bread-2, BPF formulated cake, control cake and BPF jam were 13.141mg/g, 11.3461mg/g, 11.7307 mg/g, 9.94 mg/g, 9.3358mg/g, 9.9358 mg/g respectively.

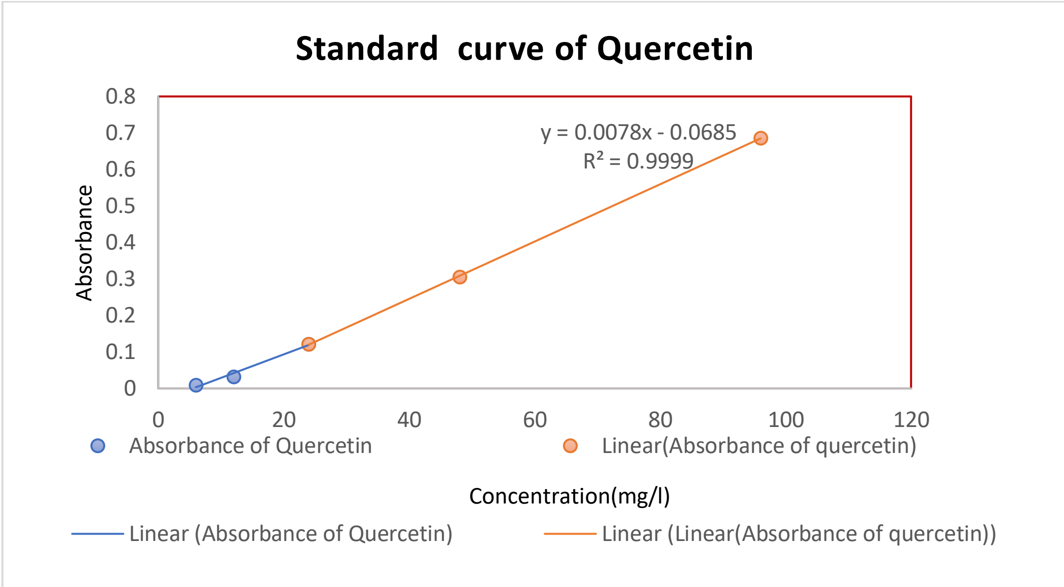


Figure 4.5: Standard curve of quercetin.

4.5. Antioxidants Activities of Products:

Results for the DPPH free radical scavenging activity of different formulated products using banana with peel flour (BPF) shown in figure 4.9.

Table 4. 9 IC_{50} Value for DPPH

Serial No	Concentration (ug/ml)	Absorbance	%SCV	Inhibition concentration (IC_{50})
1	2	0.74	28.77767084	
2	4	0.648	37.63233879	
3	8	0.471	54.66794995	9.22
4	16	0.316	69.58614052	
5	32	0.098	90.56785371	
Blank		1.039		

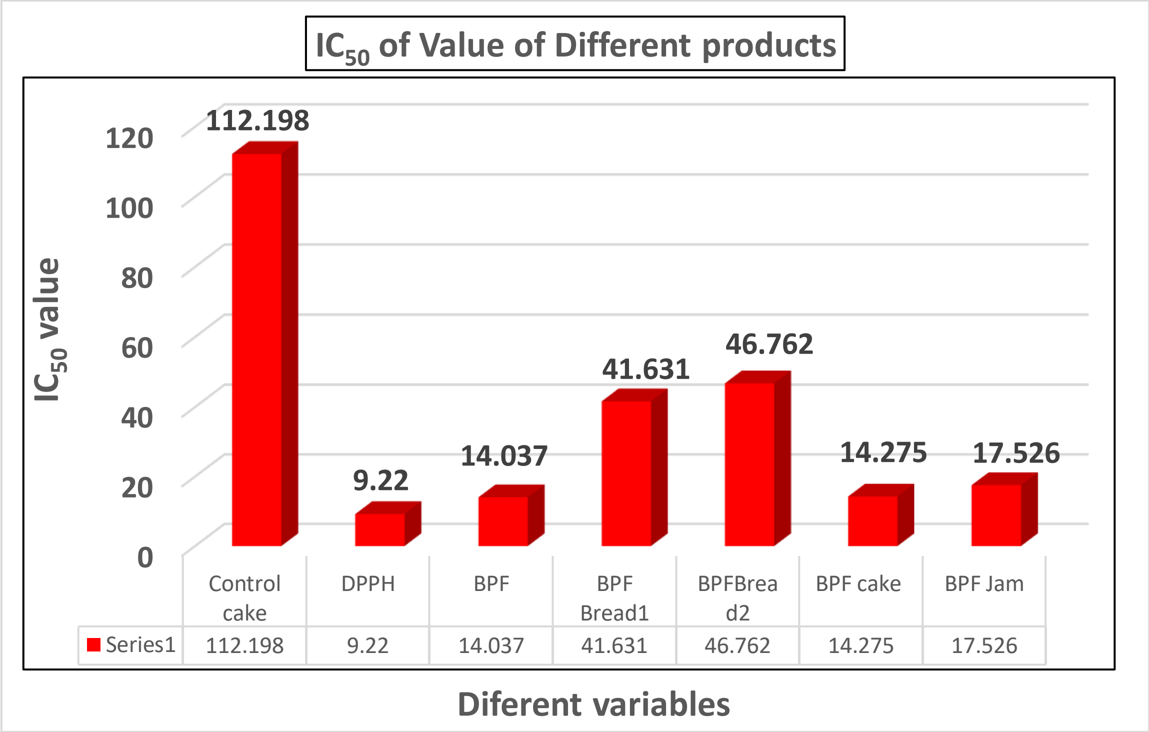


Figure 4.6 Bar diagram representation of IC_{50} for different products.

Note: Higher the IC_{50} lower the antioxidant activity**.**

All Formulated products including BPF Bread-1, BPF bread-2, formulated cake and the BPF jam showed a radical scavenging effect in DPPH assay. The half inhibition concentration (IC_{50}) value for ascorbic acid were 9.22 ug/ml. In contrast IC_{50} value for free radicals achieved by BPF bread1 41.632 ug/ml, BPF bread2 46.762ug/ml, BPF cake 14.275 ug/ml and BPF jam 17.526 ug/ml.

So in comparison with ascorbic acid all the formulated products possess antioxidants activity.

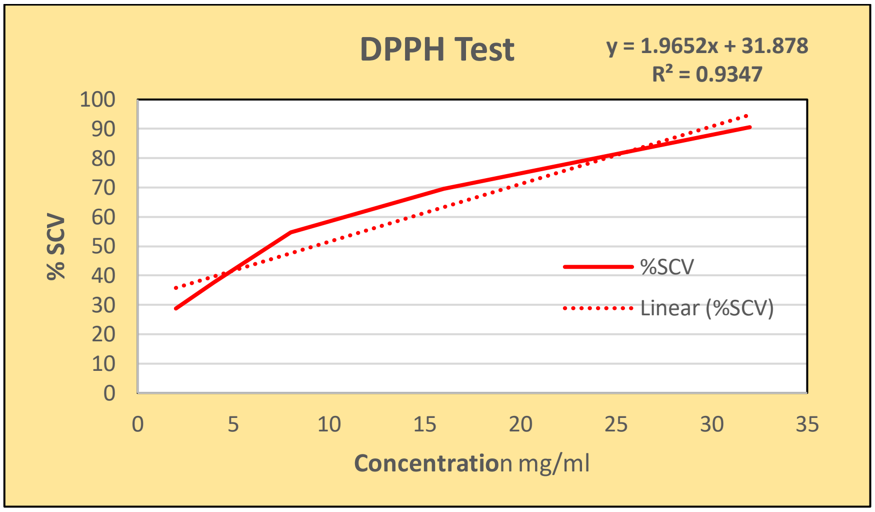


Figure 4.7: DPPH test curve

4.6 Microbiological Analysis:

This study has revealed presence of microorganisms in different types of bread, cake and jam samples prepared from banana with peel flour (BPF). International microbiological standards recommended units of bacterial counts for dry and ready to eat foods are 10^3 to 10^2 for coliforms and < 10^2 cfu/gm for total heterotrophic bacteria.

Table 10 Growth of microbes in the products.

Products	1st day		7th day		15th day	
	TVC CFU/ml	MPN *(E. coli)*	TVC CFU/ml	MPN *(E. coli)*	TVC CFU/ml	MPN *(E. coli)*
BPF Cake	3.1×10^2	Negative	9.3×10^4	Negative	17.5×10^5	Negative
BPF Bread1	2.5×10^2	Negative	7.0×10^3	Negative	11.5×10^5	Negative
BPF Bread2	2.1×10^3	Negative	6.2×10^3	Negative	17.5×10^5	Negative
BPF Jam	3.2×10^2	Negative	13.5×10^4	Negative	18.2×10^5	Negative

In this study ***E. coli*** was absent in day 1, 7 and 15 in the formulated food sample. So it means, formulated bread, cake and jam were free of *E. coli* and hygiene conditions were maintained during food processing and preparation.

Chapter 5: Discussion

The present study was done in CVASU and evaluates the quality characteristics, microbiological analysis, sensory evaluation and antioxidants, phenolic and flavonoid contents. In this chapter all important findings in the current study with its limitation, conclusions and recommendations have been discussed.

5.1. The proximate analysis

The proximate composition of the treatment BPF bread samples and control samples is shown in Table 4.1. There was significance difference ($p<0.05$) among the bread samples in terms of moisture, ash, fat. However, no significant difference ($p>0.05$) among the samples in terms of protein, fiber and carbohydrate.

With regards to the moisture content, the control sample (33%) was significantly ($p<0.05$) higher than bread samples from banana with peel flour (BPF) bread1 (90:10) and bread2 (85:15) which had mean values of 28% and 30% respectively. Lower moisture content depicts that the bread with BPF flour would be more microbiologically stable and can therefore stay on the shelf for a long time when compared to control sample (Sanful et al, 2010).

In terms of ash content, higher ash content was observed in the banana with peel flour bread1 and bread2 with mean value 2.25% and 3.01% where the control had mean value 1.7% respectively. A significant difference ($p<0.05$) existed among the samples this compares well with research work by (Noor Azariah et al, 2012) who reported that the bread substituted with banana flour also had a higher ash content of 0.94% compared to the control samples with ash content 0.50%, respectively. It has been reported that the ash content of plantains and bananas are high due to their high mineral content. A high ash content in a food sample implies that the mineral content of such a food is seemingly high.

Concerning the fat contents there was a significant difference ($p<0.05$) among the samples. The banana with peel flour bread substituted breads had the highest fat contents of 6.09 and 6.92% whereas the control had the lowest fat of 2.47%.

With regards to the crude fiber content, there was a significant difference ($p<0.05$) among the samples substituted with banana with peel flour had a higher fiber content 2.78 and 3.41% whereas the control had a mean value 0.2%. This confirms research by Noor Azariah et al, (2012) in which the fiber content of bread incorporated banana with peel (BPF) flour.

The protein contents of the control and the banana with peel flour substituted samples were 9.2 and 10.36, 11.38% respectively. There was no significant difference ($p>0.05$) between the samples. This observation agrees with research work in which no wheat flours were substituted into bread (Asiedu, 1989). The presence of gluten that forms a large portion of wheats accounts for the relatively high protein content observed in the control sample.

The carbohydrate contents were seen to be high in the bread substituted with BPF flour with values of 46.633 and 47.26% for BPF bread-1 and BPF bread-2, respectively. The control sample had 45.966% carbohydrate content. A similar observation was seen in other research works where bread from 100% wheat flour had the lowest carbohydrate content. The high carbohydrate content of the bread substituted with BPF flour due to high levels of sugar and dietary fiber present in the banana and its peel. There was no significant difference ($p>0.05$) among the samples in terms of carbohydrate.

Banana with peel flour jam is especially prepared for the obese and diabetes patients, which content no extra sugar and artificial pectin. The control banana jam contained protein 5.95%, carbohydrate 57.69%, fat 0.967%, moisture 31.12%, Ash 1.5%. where the formulated jam moisture content 27.93%, protein 6.42%, crude fat .93%, crude fiber 8.85%and ash 2.53%.

The result of the proximate chemical composition of banana with peels flour cake and control cake shown in Table 4.2, it indicated that it contained 27.34% moisture, 10.21% protein, 3.10% crude fiber, 12.61% fats, 2.39% ash and 48.33% total carbohydrate and control cake contain 25.09% moisture, 9.34%crude protein and 15.82% fat, fiber 0.8%, ash 0.31% and total carbohydrate 44.64% . There was significant difference ($p<0.05$) among crude fat, crude fiber and ash.

With regards there was no significant difference ($p>0.05$) with moisture, protein. These results are comparable to the result reported by Anhwange et al, (2009) who reported that the banana peels are good sources of nutrients especially carbohydrate, ash and fiber. This illustrates that the peels are useful in the treatment of constipation and improve general health to the high content of fiber. Also, the high level of carbohydrates leads to improve baked characteristics of BPF cake such as their textures and structures which are desirable for baked goods.

5.2 Microbiological analysis

This study has revealed presence of microorganisms in different types of bread, cake and jam samples prepared from banana with peel flour (BPF). International microbiological standards recommended units of bacterial counts for dry and ready to eat foods are 10^3 – 10^2 cfu/g for coliforms and $<10^3$ cfu/gm for total heterotrophic bacteria (Daniyan and Nwokwu, 2011).

Escherichia coli

The presence of *E. coli* in ready-to-eat foods is undesirable because it indicates poor hygienic conditions which have led to contamination or inadequate heat treatment. Ideally E. coli should not be detected and as such a level of<3per gram (the limit o most probable number test) has been given satisfactory criteria for this organism. Levels exceeding 100 per gram are unacceptable and indicates level of contamination (Hamakar, 2005). In this study there were *E coli* was absent in day 1, 7 and 15 in the formulated food sample. So, it means the formulated bread, cake and jam were free of *E coli* and hygiene conditions were maintained during food processing and preparation.

Total Viable Count (TVC)

Table 10 shows the total viable count in formulated bread, cake, jam at first day (Day 1) to 15 day at every 7 days interval. According to the WHO Standard (1994), the acceptable range of TVC is 2.0 x10^5 cfu/g. The microbiological parameters of all the formulated bread, cake, jam samples were higher than the permitted standards after seven days. It was also observed that the present study of 2 bread and 2 cakes samples showed permitted bacteria level for consumption at first day, but all of bread and cake samples were unacceptable for consumptions from 7th day to 15th day.

5.3. Sensory analysis

The results of the sensory evaluation of the bread prepared from the banana with peel flour (BPF) is shown in Table 4.4. The mean values of the individual attributes from the sensory evaluation indicates that the panelists liked the products. A significant difference among the two different samples in terms of aroma, taste, mouthfeel, texture and overall acceptability.

With respect to the Aroma, the panelists liked the BPF Bread-2 sample which had the highest mean score of 4.55%. There was significant difference ($p<0.05$) between 2 formulated BPF bread1 and BPF Bread2. From other research works, aroma increases with increasing banana flour content. This is because, banana possesses a distinct aroma which is usually imparted into foods they are incorporated (Jordan et al, 2001). In terms of taste, there was no significant difference ($p>0.05$) between the two formulated bread. These values indicate that the panelists liked slightly and neither liked nor disliked the products. The mean values of the overall acceptability of the samples showed that no significant difference ($p>0.05$) existed between the two formulated samples. The BPF bread-2 sample had the highest mean score of 5.35. This indicated that the BPF bread2 was the most preferred sample.

The statistically analyzed results for sensory evolution result of cake shown in Table 4.5. The results revealed the acceptance of incorporation of banana with peel flour. There was a significant ($p<0.05$) difference between the control and the formulated cake in terms of color and appearance. There was no significant ($p>0.05$) difference in terms of taste, odor and overall acceptability between the BPF cake and the control cake. The finding indicates that the color of cake sample, Control was more acceptable than formulated samples. In terms of flavor, sample control and formulated were equally acceptable. The texture of the samples was not equally acceptable. The sensory panelists gave more preference on formulated sample other than control. The test for overall acceptability revealed that BPF cake sample secured the highest score.

The sensory evaluation of jam shown in Table 4.6 the results indicated that the panelist scored the product in the parameter of overall acceptability was 4.5, which means neither like nor disliked the product. Color is not accepted to the panelist because banana contain antioxidants which influenced various chemical reactions as like Millard reaction, that's why color was not accepted to the panelist.

5.4. Antioxidants analysis

Phenolics and flavonoid contents and antioxidants activity in the BPF products:

The total phenolic and flavonoid content in the BPF powder, BPF bread, BPF cake, BPF jam and the control products are described in the Table 4.7 and table 4.8 respectively. The phenolic and flavonoid contents were measured as gallic acid equivalent and quercetin equivalent. The BPF, BPF bread, BPF cake, BPF jam harbored higher amounts flavonoid and phenolic compounds, which were much higher than those detected in apple, plum pear using products (Chun et al, 2005). The gallic acid contents in Banana with peel powder (BPP), BPP formulated bread-1, BPP formulated bread-2, BPP formulated cake, control cake and BPP jam were 24.090mg/g, 19.859mg/g, 21.674 mg/g, 17.123g/g, 11.898mg/g, 17.6320 mg/g respectively. Flavonoid contents in Banana with peel flour (BPF), BPF formulated bread-1, BPF formulated bread-2, BPF formulated cake, control cake and BPF jam were 13.141mg/g, 11.3461mg/g, 11.7307 mg/g, 9.94 mg/g, 9.3358mg/g, 9.9358 mg/g respectively.

In this study, flavonoid content is higher in banana with peel flour (BPF) 24.090 mg/g and phenol content 13.141 mg/g. Formulated BPF bread-2 contained higher amount flavonoid (21.647mg/g) and phenol (11.7307 mg/g). Formulated jam and cake had similar amount of flavonoid and phenol content. Wide applications of phenol and flavonoid include as an antioxidant, anti-carcinogenic and also aids decreasing the complications of cardiovascular disease.

Several previous studies have focused on the relationship between the antioxidant activity of the phenolic compounds, their activity as hydrogen donating free radical scavengers and their chemical structure. It has also been demonstrated that the presence of the -CH=CH-COOH group in the hydroxylated cinnamates ensures greater hydrogen donating ability and subsequent radical stabilization than the carboxylate group in the hydroxy benzoates (Rice-Evans et al, 1996). Therefore, the phenolics and flavonoids in the developed products were evaluated for their antioxidant efficiencies via a DPPH scavenging activity. The DPPH radical is widely utilized to evaluate the free radical scavenging capacity of antioxidants (Tung et al, 2007). The radical scavenging activities of the sample extracts were determined from the reduction in the optical absorbance at 517 nm owing to the scavenging of the stable DPPH free radical. The DPPH free radical scavenging activities of the BPF, BPF Bread, BPF jam and the BPF cake were showed in the Figure 4.7. The radical scavenging activity can be evaluated by determination of IC_{50} values. The IC_{50} value in DPPH test was 9.22. High IC_{50} values indicate low l antioxidant activity. The results of the DPPH test indicated that the BPF, BPF bread, BP cake, BPF jam extract functioned as effective free radical scavengers. The radical scavenging activities of BPF remained after product development. Therefore, the antioxidant activities of BPF, BPF bread, BPF cake and jam were attributed to the contributions of phenolic and flavonoid compounds.

Chapter 6: Conclusion

Banana contained higher amount of antioxidant substances and potentially high amount of dietary fiber. In addition, it has also been found that banana peel exhibit antibacterial and antifungal properties. These results indicated that banana peels contain valuable functional ingredients for human consumption, especially to be incorporated in bakery product such as whole meal bread, cake. Food applications for banana peel flour for achieving two goals; first, helping the environment through sustainability by utilizing secondary processing products and second, creating a new outlook for consumers and producers for generating value-added food products. Besides adding nutritional value to food products, BPF also stands out for not creating production waste, thus representing the complete use of the fruit, increasing the yield and reducing manpower costs due to peeling which is not required. The mean score of taste was significantly varied among bread, cake and jam and the post-hoc suggested the mean significant in case of all formulated products compared with the control product ($p<0.05$). There was significant difference in all attributes including crust, flavor, texture, taste, crumb, appearance and overall acceptability between the banana with peel flour using products and control products. Sensory evaluation showed that banana with peel flour bread-2 (15%) was more preferred compared to that of the BPF bread-1 (10%). In addition 10% BPF Treated bread and 15% BPF treated bread were lower in protein and moisture when compared to the control bread sample from wheat flour. Proximate composition of the BPF bread-2 and BPF formulated cake had significantly ($p<0.05$) higher contents of moisture, protein, ash and fiber. The carbohydrate content in BPF bread-2 and BPF cake were significantly higher than the other varieties. Banana with peel flour formulated bread, cake and jam contained higher amount of phenol, flavonoid and antioxidant activity. The microbial analysis showed that bread, cake and jam were unacceptable for consumption at 15th day. The developed products appear to be an additional benefit for human health and can be appropriate parts in diet plan.

Chapter 7: Recommendations for future Aspect

The finding of the study indicates that banana with peel flour's product are the good source for fiber, ash, protein and CHO.

In the current study bread quality was not so good due to use o hand mixing and humidity was not maintained properly during proofing time. So, improvement in mixing dough and maintaining required humidity may increase the quality of bread.

For bread and cake preparations microwave oven was used in this study. But it would be better to use modern rotary gas oven to have better quality of bread.

There was some modifications were required for cake and jam for improve the consumer acceptance and marketing the products.

Due to short period of time and lack of availability minerals and broad microbial analysis was not done. In future some more microbial analysis may enriched the products acceptance level.

Overall acceptance of bakery food products is usually influenced by its making method, ingredients and how they baked. So, the modern instruments, standard procedure and quality control assessment should be ensured for consumer acceptance.

Also, further studies, especially clinical trials are needed to be considered in order to confirm the health benefits of banana flour enriched food product.

References

Agama-Acevedo E, Islas-Herna´ndez JJ, Pacheco-Vargas G, OsorioDı´az P, Bello-Pe´rez LA (2012) Starch digestibility and glycemic index of cookies partially substituted with unripe banana flour Food. Sci Technol 46:177–182.

Alba K, MacNaughtan W, Laws AP, Foster TJ, Campbell GM, Kontogiorgos V (2018) Fractionation and characterisation of dietary fibre from blackcurrant pomace Food Hydrocoll 81:398–408.

Ahnwange BA(2008). Chemical composition of *Musa sapientum* (banana) peels. J Food Technol 6(6):263–266

BBS (Bangladesh Bureau of Statistics), (2016). Statistical Year Book of Bangladesh, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Borges AM, Pereira J, Silva Ju´nior A, de Lucena EMP, de Sales JC (2010) Stability of cake pre-mixture made with 60% of green banana flour. Cienc Agrotecnol 34:173–181.

Cherian BM, Pothan LA, Chung TN, Mennig G, Kottaisamy M, Thomas (2008). A novel method for the synthesis of cellulose nanofibril whiskers from banana fibers and characterization. J Agric Food Chem 56:5617–5627.)

Davey MW, Keulemans J, Swennen R (2006). Methods for the efficient quantification of Fruit provitamin A contents. J Chromatogr A 1136:176–184.

Edwards WP.(2007). The science of Bakery Products. The Royal Society of Chemistry, 1st edition.167- 177.

Emaga TH, Andrianaivo RH, Wathelet B, Tchango TJ, Paquot M (2007). Effects of the stage of maturation and varieties on the chemical composition of banana and plantain peels. Food Chem 103:590–600

Garcia-Amezquita LE, Tejada-Ortigoza V, Heredia-Olea E, SernaSaldı´var SO, Welti-Chanes J (2018). Differences in the dietary fiber content of fruits and their by-products quantified by conventional and integrated AOAC official methodologies. J Food Compost Anal 67:77–85.

Gonza´lez-Montelongo R, Gloria Lobo M, Gonza´lez M (2010). Antioxidant activity in banana peel extracts: testing extraction conditions and related bioactive compounds. Food Chem 119:1030– 1039.

Gomes AAB, Ferreira ME, Pimentel TC (2016). Bread with flour obtained from green banana with its peel as partial substitute for wheat flour: physical, chemical and microbiological characteristics and acceptance. Int Food Res J 23:2214–2222.

Happi Emaga T, Robert C, Ronkart SN, Wathelet B, Paquot M (2008). Dietary fibre components and pectin chemical features of peels during ripening in banana and plantain varieties. Bioresour Technol 99:4346–4354.

Heim KE, Tagliaferro AR, Bobilya DJ (2002). Flavonoid antioxidants: chemistry, metabolism and structure activity relationships. J Nutr Biochem 13: 572–584.

Ho LH, Abdul Aziz NA, Azahari B (2013). Physico-chemical characteristics and sensory evaluation of wheat bread partially substituted with banana (Musa acuminata X balbisiana cv. Awak) pseudo-stem flour, Food Chem 139:532–539.

Hossain MF, (2014). A Study of Banana Production in Bangladesh: Area, Yield and Major Constraints, ARPN J Agric Biolo Sci 9(6): 206.

Islam MR, Azad AK, Abuhena , Haldar, Rahman S (2016). Analysis of Genetic Variation between five Banana Fruit Varieties by RAPD Markers, J Bio Eng R and Review 3(1).

Jordan MJ, Tandon K, Shaw, PE and Goodner, KL (2001). Aromatic profile of aqueous banana essence and banana fruit by gas chromatography - mass spectrometry (GC-MS) and gas chromatography-olfactometry (GC-O). J Agric Food Chem 49: 4813-4817.

Kaur A, Kaur S, Singh M, Singh N, Shevkani K, Singh B (2014). Effect of banana flour, screw speed and temperature on extrusion behaviour of corn extrudates. J Food Sci Technol 52:4276–4285.

Kanazawa K, Sakakibara H (2000). High content of dopamine, a strong antioxidant, in Cavendish banana. Agric Food Chem 48:844–848.

Khamsucharit P, Laohaphatanalert K, Gavinlertvatana P, Sriroth K, Sangseethong K (2018). Characterization of pectin extracted from banana peels of different varieties. Food Sci Biotechnol 27:623–629.

Kitts DD (1994). Bioactive substances in food: identification and potential uses. Can J Physiol Pharmacol 72:423–434.

Kris-Etherton PM (2002). Bioactive compounds in foods: their role in the prevention of cardiovascular disease and cancer. Am J Med 113:71S–88S.

Kusuma SAF, Febrianti M, Saraswati A (2018). Comparison of unripe banana peel of kepok (Musa paradisiaca L.) and klutuk (Musa balbisiana colla): phytochemical and anti-dysenteriae activity. J Pharm Sci Res 10:911–914.

Lewis DA, Fields WN, Shaw GP (1999). A natural flavonoid present in unripe plantain banana pulp sapientum L. var. paradisiaca) protects the gastric mucosa from aspirin-induced erosions. J Ethnopharmacol 65:283–288.

Mohamed A, Xu J, Singh M (2010). Yeast leavened banana-bread: formulation, processing, colour and texture analysis. Food Chem 118:620–626.

Moongngarm A, Tiboonbun W, Sanpong M, Sriwong P, Phiewtong L, Prakitrum R, Huychan N (2014). Resistant starch and bioactive contents of unripe banana flour as influenced by harvesting periods and its application. Am J Agric Biol Sci 9:457–465.

Mukul, AZA and Rahman MA (2013). Production and Profitability of Banana in Bangladesh -an Economic Analysis, International Journal of Economics, Finance and Management Sciences 1(3): 159-163.

Nasrin TAA, Noomhorm A, Anal AK (2015). Physico-chemical characterization of culled plantain pulp starch, peel starch, and flour. Int J Food Prop 18:165–177.

Noor Azariah AA, Ho LH, Noor Shazliana AA, Rajeev B (2012). Quality evaluation of steamed wheat bread substituted with green banana flour. Int Food Res J 19(13):869- 876.

Olaoye OA, Onilude AA, Idowu OA (2006). Quality characteristics of bread produced from composite flours of wheat, plantain and soyabeans. Afri J Biot 5(11).

Pereira A, Maraschin M (2015). Banana (Musa spp) from peel to pulp: ethnopharmacology, source of bioactive compounds and its relevance for human health. J Ethnopharmacol 160:149–163.

Pokorny J, Yanishlieva N, Gordon M (2001). Antioxidants in Food Practical Applications. CRC Press, Inc., Boca Raton, FL, USA. 26 :1-3 .

Ramli S, Alkarkhi AFM, Shin Yong Y, Min-Tze L, Easa AM (2009). Effect of banana pulp and peel flour on physicochemical properties and in vitro starch digestibility of yellow alkaline noodles. Int J Food Sci Nutr 60:326–340.

Rice-Evans CA, Miller NJ, Paganga G (1996) Structure-antioxidant activity relationships of Flavonoid And phenolic acids. Free Radic Biol Med 20: 933–956.

Sanful RE, Darko (2010). Utilization of Soybean Flour in the Production of Bread. Pakistan J Nutri 9 (8): 815-818..

Segundo C, Roma´n L, Lobo M, Martinez MM, Go´mez M (2017b). Ripe banana flour as a source of antioxidants in layer and sponge cakes. Plant Foods Hum Nutr 72:365–371.

Sheikh BY, Sarker MMR, Kamarudin MNA, Ismail A (2017). Prophetic medicine as potential Functional food elements in the intervention of cancer: a review. Biomed Pharmacother 95:614–648.

Singh B, Singh JP, Kaur A, Singh N (2016). Bioactive compounds in banana and their Associated health benefits—a review. Food Chem 206:1–11.

Someya S, Yoshiki Y, Okubo K (2002). Antioxidant compounds from bananas (Musa Cavendish). Food Chem 79:351–354.

Von Atzingen DANC (2015). Repair of surgical wounds in rats using a 10% unripe Musa Sapientum peel gel. Acta Cir Bras 30:586–592.

Yan L, Fernando WMADB, Brennan M, Brennan CS, Jayasena V, Coorey R (2016). Effect of extraction method and ripening stage on banana peel pigments. Int J Food Sci Technol 51:1449–1456.

Zhang P, Whistler RL, Bemiller JN, Hamaker BR (2005). Banana starch: production, physicochemical properties, and digestibility—a review. Carbohydr Polym 59:443–458.

Appendix i: Sensory Evaluation Form

“Sensory Evaluation of Banana with Peel Based Products (Cake, Bread, Jam)”

Questionnaire

I am a student of Chittagong veterinary and animal sciences university. As the requirement of thesis, the following questions have been designed to find out **The Organoleptic Properties of the Developed Products.**

Your cooperation will be highly appreciated.

Part A

1. **Gender –**
   a) Male **b)** Female

2. **Age-**
   a) 18-23 **b)** 24-30 **c)** 31-40 **d)** 41+

3. **Educational Qualification-**
   a) Undergraduate **b)** Graduate **c)** Post Graduate

   d) Others________ (Please specify)

Part B

Sensory Evaluation of Formulated Bread (BBF Bread1)

[Please put your degree of agreement with the following questions in the above 7 point Hedonic scale and put a tick (✓) mark on your respective answer. (1 is very much disliked, 7 is very much liked)]

S.N.	Parameters	Very much liked (7)	Liked a lot (6)	Liked (5)	Liked and did not liked (4)	Disliked (3)	Much disliked (2)	Very much disliked (1)
1	Crust							
2	Aroma							
3	Taste							
4	Shape							
5	Internal Texture							
6	Appearance							
7	Overall acceptability							

Sensory Evaluation of Formulated Bread(BBF Bread2)

[Please put your degree of agreement with the following questions in the above 7-point Hedonic scale and put a tick (✓) mark on your respective answer. (1 is very much disliked, 7 is very much liked)

S.N.	Parameters	Very much liked (7)	Liked a lot (6)	Liked (5)	Liked and did not liked (4)	Disliked (3)	Much disliked (2)	Very much disliked (1)
1	Crust							
2	Aroma							
3	Taste							
4	Shape							
5	Internal Texture							
6	Appearance							
7	Overall acceptability							

Sensory Evaluation of BPF formulated Cake

[Please put your degree of agreement with the following questions in the above 7-point Hedonic scale and put a tick (✓) mark on your respective answer. (1 is very much disliked, 7 is very much liked)

S.N.	Parameters	Very much liked (7)	Liked a lot (6)	Liked (5)	Liked and did not liked (4)	Disliked (3)	Much disliked (2)	Very much disliked (1)
1	Crust							
2	Aroma							
3	Taste							
4	Shape							
5	Internal Texture							
6	Appearance							
7	Overall acceptability							

Sensory Evaluation of Control Cake

[Please put your degree of agreement with the following questions in the above 7-point Hedonic scale and put a tick (✓) mark on your respective answer. (1 is very much disliked, 7 is very much liked)]

S.N.	Parameters	Very much liked (7)	Liked a lot (6)	Liked (5)	Liked and did not liked (4)	Disliked (3)	Much disliked (2)	Very much disliked (1)
6	Color							
7	Taste							
8	Flavor							
9	Texture							
10	Appearance							
11	Overall acceptability							

Sensory Evaluation of JAM

[Please put your degree of agreement with the following questions in the above 7-point Hedonic scale and put a tick (✓) mark on your respective answer. (1 is very much disliked, 7 is very much liked)]

S.N.	Parameters	Very much liked (7)	Liked a lot (6)	Liked (5)	Liked and did not liked (4)	Disliked (3)	Much disliked (2)	Very much disliked (1)
1	Color							
2	Taste							
3	Texture							
4	Overall acceptability							

THANK YOU

Appendix ii: Sensory evaluation panelist work

Sensory panelists don’t do it

1. Eat, Drinks or Smoke within 90 minutes.
2. Use gum, mints etc flavored item within 30 minutes.
3. Wear perfumes, cologne and fragrance item during test.
4. Talk and comment during evaluation.
5. Taste if you have a lot of prior knowledge about the manufacturing which you may dislike.
6. Taste if you have a cold.
7. Share the product with other.

Sensory panelists should

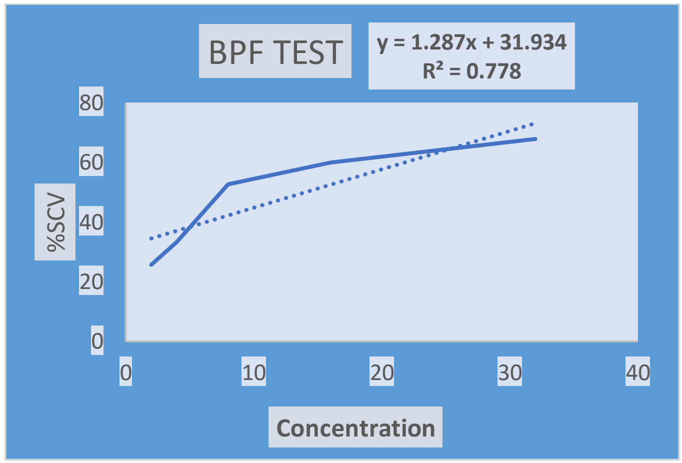
1. Be attractively dressed and well groomed.
2. Be tactful and concerned about the exhibitors and their feelings.
3. Have a pleasant manner; smile and be prompt.
4. Avoid consulting with spectators.
5. Hide personal likes and dislikes.
6. Be familiar with the products being judged.
7. Take the time to get a general picture of the entries.
8. Recognize quality standards.
9. Don’t give top placing if entries are not worthy.
10. Don’t rule out unfamiliar ways of doing things if the results obtained are satisfactory. Judge the results that you see, rather than what ‘‘might’’ have been done.
11. Make quick and firm decisions.
12. Offer reasons for decisions, encourage the exhibitor to continue, to learn and to improve.
13. Offer compliments and constructive criticism.
14. Be fragrance neutral.
15. Participate regularly.
16. Take sensory evaluation seriously.
17. Take your time and focus during test.
18. Follow the method and instruction precisely.
19. Be confident in initial judgment.
20. Rest and cleanse your palate for next sample.

Remember

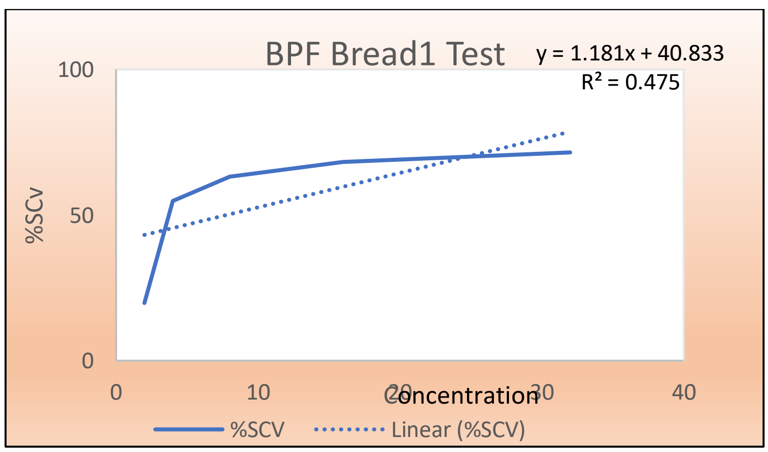
No food entry is so poorly done that it is not worthy of an encouraging comment.
No food entry is so well done that some improvement may not be made.

Appendix iii: Antioxidants activity curves

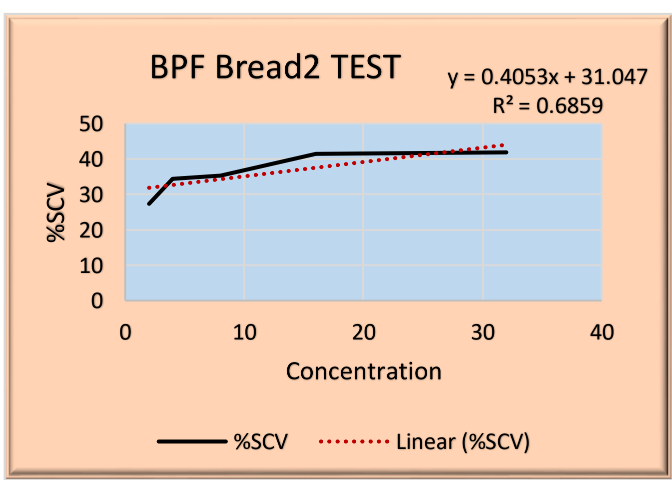
Curve for Banana with peel powder:



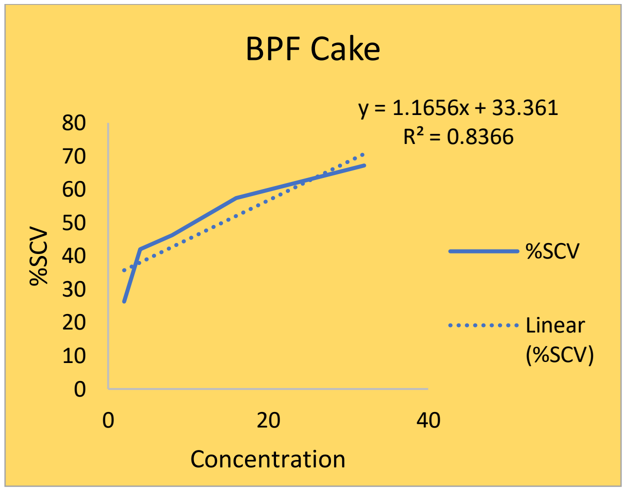
Curve for BPF Bread1:



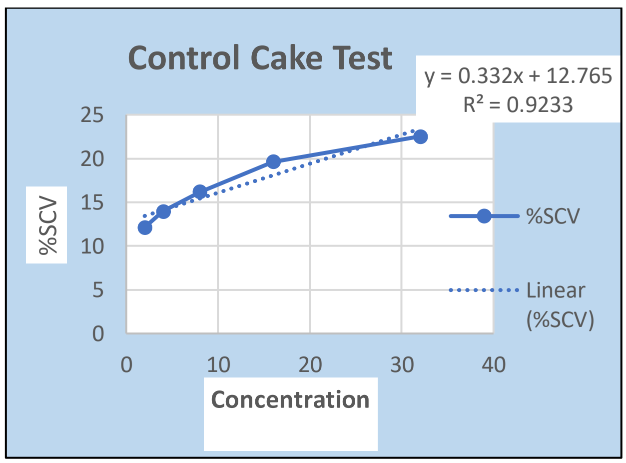
Curve for BPF Bread2:



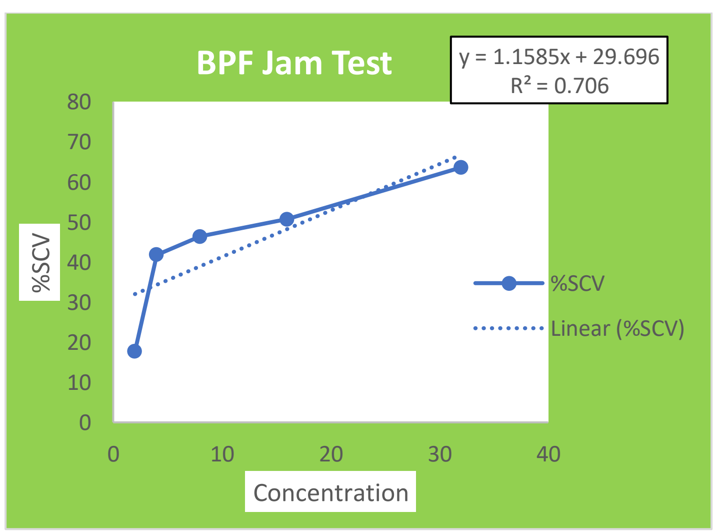
Curve for BPF Cake:



Curve for Control Cake:



Curve for BPF Jam:



Appendix iv: Photo Gallery

Banana (Raw material)

Drying of Banana slice

Bread Preparation

Final Bread

Cake preparation

Before Baked

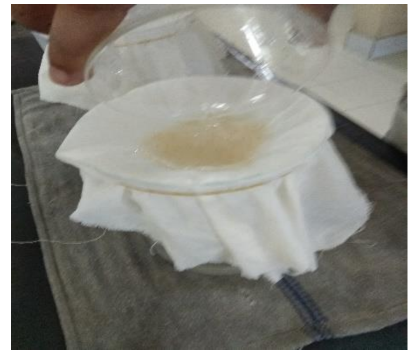
After baked

Jam preparation

Moisture Analysis

Protein Determination

Crude Fat Determination

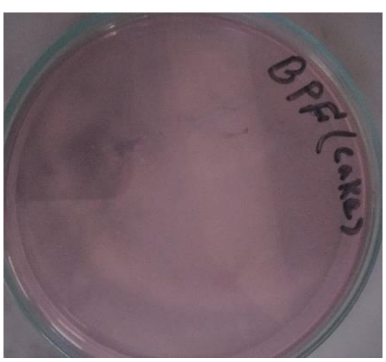


Fiber Estimation

Ash Estimation

Sensory Panel

Sensory Panel



Microbiological Analysis

phenolic and Flavonoid contents

DPPH scavenging Activity

Brief Biography

Afruza Akter passed Secondary School certificate examination with grade point Average (GPA) 5.00 in 2010 and Higher Secondary Certificate Examination with GPA 4.80 in 2012. Afruza Akter received The B.Sc. (Hon's) in Food Science and Technology from the Faculty of Food science and Technology of Chittagong Veterinary and Animal sciences University, Chittagong, Bangladesh in 2017. Now she is a candidate for the degree of M.S. in Applied Human Nutrition and Dietetics under the department of Applied Food Science and Nutrition, Faculty of food Science and Technology, Chittagong Veterinary and Animal sciences University, Chittagong, Bangladesh. She has boundless interest in exploration on the clinical nutrition and dietetics to improve the nutritional status of the patients by providing care and consultation to patients to remove diabetes, kidney disease, obesity and underweight.