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Sonia Akter Mitu

JUNE, 2022

DEVELOPMENT OF FUNCTIONAL FOOD (BISCUIT) USING BANANA (*MUSA.I*) PEELS

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Session: July-December, 2019

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

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DEDICATED TO MY BELOVED FAMILY & TEACHERS

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The Author

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Abstract

Banana (*Musa l.*) peel is rich in nutrient but the utilization of its peel in the preparation of biscuit is not popular in Bangladesh. This study examines the manufacturing of biscuits using ripe banana peel flour (BPF) with wheat flour (WF) in different ratio. Nutritional quality and sensory characteristic of biscuit were also determined. One way analysis of variance (ANOVA) was executed to find out the level of significance at $P < 0.05$. Three different formulations were made from banana peel flour and subsequently their proximate compositions were tested. The carbohydrate, fat, protein, ash and fiber were determined at the range of 69.25% to 67.22%, 14.29% to 19.55%, 10.162% to 11.31%, 1.40% to 1.68% and 0.62 to 0.76% respectively. Energy content was found ranging from 447.73- 475.13 kcal/100g and sensory qualities were evaluated. BPF had reduced moisture, protein, and carbohydrate content while having higher fat, fiber, and ash content. When wheat flour was added with 10% BPF, superior quality of fiber (0.68 ±0.01) was found. Moreover, results for fiber content of biscuit 2% and 5% - , 0.67 ±0.03 & 0.68 ±0.01, were found respectively. The freshly formed biscuit was found to be more appealing in terms of its nutritional and functional qualities in addition to this; it is an ample opportunity to utilize this large amount of wastage (banana peel).

Key words: Banana, Biscuit, Banana Peel Powder, Antioxidant, sensory evaluation, Nutritional properties

Chapter 1: Introduction

Hippocrates' credo, "Let food be thy medicine, and medicine be thy nourishment," has reawakened interest some 2,500 years later. Natural foods, particularly those rich in and produced of vegetable origin, have sparked a significant and growing interest in the previous decade. Advertisements and scientific studies have fueled this desire, demonstrating the health benefits that these meals can provide. By transforming agricultural by-products into food, several researchers and food manufacturers are paying more attention to them. By-products of vegetables and plants are normally discarded after harvesting or processing as it is not usually used in food production. (Brito *et al*,;2020). Many researchers are getting more interested in utilizing the usage of byproducts. Banana peel is an important by-product rich in different nutrients that have been used to produce enormous food products (Khatun *et al*.,2021).

Banana is a tropical climacteric fruit that includes a variety of species in the genus Musa of the Musaceae family. It is one of the most favored fruits in the world and the fourth most important crop produced globally (Guyle`ne Aurore *et al.,*2009). Nearly all of the identified cultivars derived from two diploid species, *Musa acuminata* and *Musa balbisiana*, in which the Cavendish variety is the most common (Khoozani *et al.,* 2018). According to the latest FAO statistics, Asia is the world's greatest banana grower, accounting for 54.4 percent of global banana production.

There are two parts of banana; one is the pulp and the other is the peel. The largest by-product of bananas is the peel, which accounts for around 40% of the total weight of the fruit. Banana peel had no purpose until recently and was discarded as waste, resulting in vast amounts of organic waste to be managed. Turning the peel into BPF is one approach to using this valuable by-product. This product can be developed into new products with standardized compositions and functional qualities for a range of manufacturing and household applications. (Mohapatra *et al.,* 2010).

Banana peel extract has more antioxidants and phenolic components than banana pulp, indicating that the peels could be used in a broad range of foods and nutritional supplements. (Khoozani *et al*.,2018). Banana peel is a rich source of starch (3%) crude protein (6-9%), crude fat (3.8-11%), total dietary fibre (43.2-49.7%), and polyunsaturated fatty acids, particular lylinoleic acid and α-linolenic acid, pectin,

essential amino acids (leucine, valine, phenylalanine and threonine), and micronutrients (K, P, Ca, Mg) (Thomas Happi Emaga, 2007). BPF contains significantly more ash, protein, crude fiber, and digestible starch than pulp, making it more effective as a functional addition (Khoozani *et al.,* 2019).

Banana peel includes phenolics, carotenoids, flavonoids, biogenic amines, phytosterols, and other phytochemicals (Pereira andAline,2014). Bananas have a higher antioxidant capacity than various berries, herbs, and vegetables due to the presence of these components. Dietary fiber is well-known for reducing the risk of disorders like constipation, irritable colon, colon cancer, cardiovascular diseases, diverticulitis, and diabetes, according to (Aslam *et al.,*2014). As a result, dietary fiber should be incorporated in foods because it is good for human health.

People are becoming more health-conscious, and they are increasingly interested in eating fruits and vegetables to stay healthy. They prefer to eat raw foods as well as those that have been processed. Consumers are becoming increasingly interested in eating healthy foods, which has led to studies into the quantities of phytonutrients and specific health benefits found in a variety of fruits and vegetables**.** In the recent decade, there has been a surge in consumer interest in vitamins, minerals, unsaturated fatty acids, bioactive substances, and fiber in food items due to the increased focus on functional food products and consumer health and well-being. Fruit by-products, particularly banana by-products, have recently become popular, and many studies are being conducted to determine their influence on culinary characteristics (Cha ´vez-Salazar A *et al.,* 2017).

Because of specialized eating patterns, changing consumer behavior, economic reasons, and commercial demands, WF has been substituted with flour from fruit waste or by-products to manufacture baked items (Khatun *et al.,*2021). However, Biscuits made from banana peels were not previously known to us, and nutritional analyses were not conducted in Bangladesh.

Biscuits are one of the most commonly purchased bakery items. It is consumed by people all over the world due to its mobility, ready-to-eat quality, affordability, prolonged shelf life, and availability in a variety of flavors and tastes (Bakar *et al.,*2018)**.** Fruits and vegetables are essential in human nutrition and commerce. Because biscuits are made with refined wheat flour and other additives, they lack the

health-promoting components of grains such dietary fiber and phytochemicals. The utilization of by-products from fruits, such as apple pomace and orange pomace, has been examined by earlier researchers. Orange pomace contributes to the dietary fiber level of cookies, whereas apple pomace is a rich source of polyphenols with anti-proliferative and antioxidant action (Bakar *et al*.,2018).

Aims and Objectives

1. To develop a healthy functional food product.
2. Formulation of biscuit by using banana peel powder in varying ratio.
3. Optimization of biscuit on the basis of sensory and physiochemical properties.

Chapter 2: Review of Literature

2.1 History of Banana

Banana is considered a tropical climacteric fruit that includes a variety of species in the *Musa* genus of the Musaceae family. It is one of the world's most popular fruits and the world's fourth most significant crop (Amir Amini Khoozani,*et al* 2018). *Musa acuminata* and *Musa balbisiana*, two diploid species, were the ancestors of nearly all cultivars, with the Cavendish variety being the most widespread. Plantain is similar to banana hybrid triploid cultivars in that it is longer, angular, and has a variety of shapes. Plantain is firmer than Cavendish even when mature; therefore it is less useful as a fresh product (Zhang P *et al.,*2005). The majority (54.4%) of the world's banana production comes from Asia that is revealed by the statistics of FAO.

2.1.1 Types of Banana

Bangladesh has a wide variety of bananas that fit into various ecological niches. Fruit size, shape, color, and scent preferences, as well as nutritional, medicinal, and cultural aspects, are all reflected in the diversity. There are cultivars for both dessert and cooking. After the last hands have set, commercial growers frequently remove the male bud. Kola is the Bengali word for banana. It's usually found after a cultivar's name. Starting with the most important, this website seeks to document the country's variety. (Islam, 2004). Sagor, Sorbi, Chini Champa, Mehersagar, Gerasundari, Agniswar, Kanthali Kola, Atia Kola, Bitchi Kola, Kacha Kola (ProMusa, 2021)

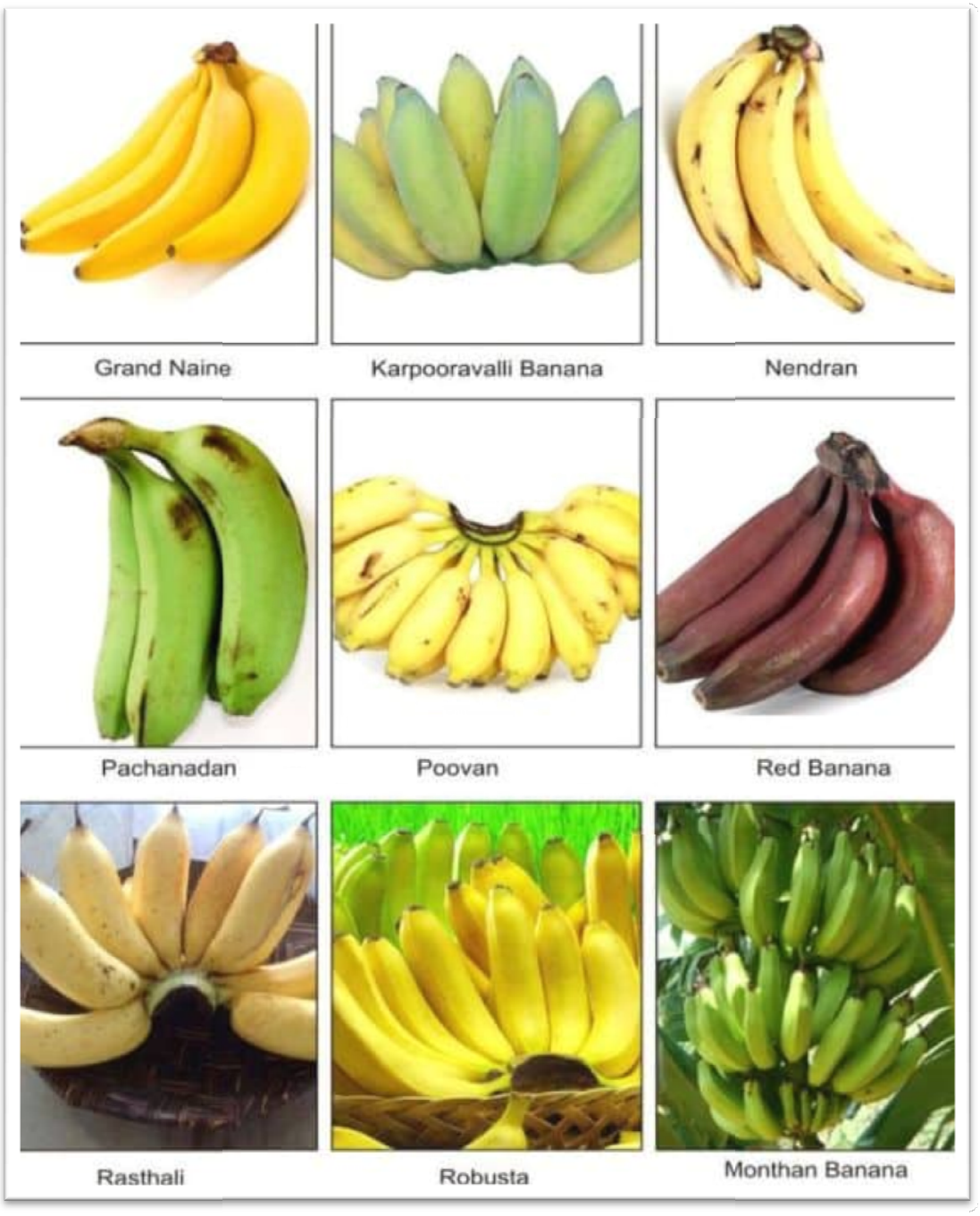


Figure 2.1.1: Images of different types of Banana

Taxonomy of Banana

Class : Magnoliopsida

Superorder: Lilianae – monocots, monocotyledons, monocotyledons

Order Zingiberales

Family: Musaceae – banana

Genus: *Musa.*

2.1.2 Origin and Distributation

Bananas that are edible originated in the Indo-Malaysian area, which stretches all the way to northern Australia. In the 3rd century B.C., they were only known by hearsay in the Mediterranean region, and they are thought to have arrived around Europe in the 10th century A.D. Portuguese seafarers transported the plant from the West African coast to South America in the early 16th century. The origins of the Pacific cultivars may be traced back to eastern Indonesia, from where they moved to the Marquesas and, eventually, to Hawaii.

While Colombia and Ecuador are the top exporters, Brazil is South America's largest producer of bananas, producing over 3 million tons annually for local consumption. Venezuela produced 983,000 tons of grain in 1980. Honduras, Panama, and to a lesser extent Costa Rica account for the majority of large-scale commercial production for export to North America (where banana plantations can cover 60 square miles). The Windward Islands of Martinique and Guadeloupe are the principal growers in the West Indies, and they have been exporting to Europe for many years. Green bananas are the people of Western Samoa's staple food, and vast quantities are exported.

According to reports, it is the most consumed fruit, accounting for 16.8% of all fruit produced globally, followed by apples and oranges, which account for 11.4 percent each FAOSTAT. (2013). The increasing demand brought on by population expansion, as well as the development in cultivated area and productivity, can be used to explain the increase in banana production (Vu Hung T. *et al* 2018).

2.2 Utilization and Economic importance of Banana

2.2.1 Banana plant:

Utilizing Musacea plants as a composite material and for energy production through decomposition Ultra VU (Clarke *et al.,* 2007). The banana plant has an extremely juicy aerial stem called a pseudostem, which is a clustered, cylindrical agglomeration of leaf stalk bases called a petiole. (Anuj Yadav,*et al* 2016). Indonesia and Southeast Asia are thought to be the origins of the banana and the sites of its first domestication. Most triploid bananas and plantains are connected to two wild diploids, *Musa accuminata* (AA) and *Musa balbisiana* (BB) (Gebre-Mariama and Seifu 1999).

2.2.2 Parts of Banana Plants

Bananas are a large semi-perennial herbaceous plant with corms, roots, pseudostems, leaves, inflorescences, stems, and bunch. One of the largest herb groupings in the world, the banana plant can reach a height of 15 meters, and its fruit is categorized as climacteric (Cordenunsi *et al*.,1995).

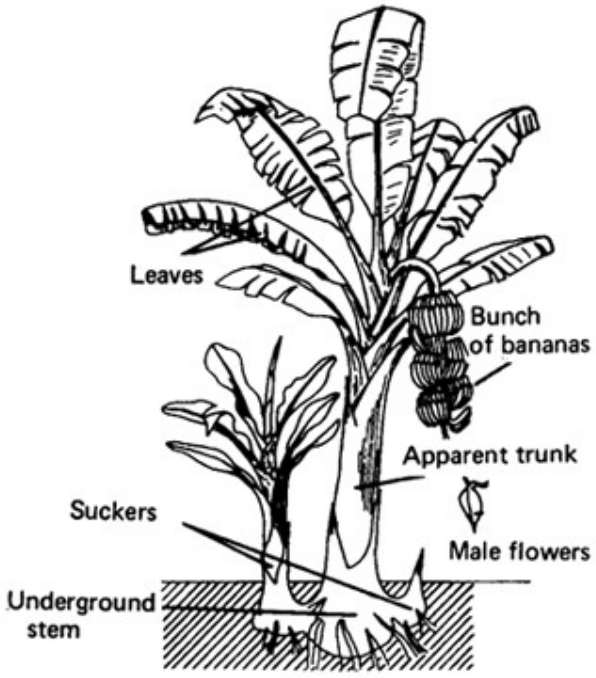


Figure 2.2.2: Parts of Banana plants

2.2.3 Banana peel

Banana peel extract has proven to be safe for use on healthy human cells by the National Cancer Standard Institute, so it can be safely executed as a natural source of antioxidant for value addition. The use of banana peels as a substrate for the synthesis of citric acid by *A. niger* was studied. *Aspergillus niger* uses banana peel as an affordable media to produce citric acid (Kareem *et al.,* 2011). By using wheat flour banana peel noodles is also made. Partial incorporation of banana peel into yellow noodles is a significant way for controlling hydrolysis of starch (Ramli *et al.,* 2009).

There are four types of banana flour, each with a varied chemical makeup, depending on the stage of ripening. Cereal-based products have received more attention than other food products due to the structure of BF. Bread, pasta, confectionaries, and gluten-free items are the principal starch-based foods targeted for enrichment with BF products (Khoozani *et al*., 2018). The peel's antacid properties against stomach ulcers have also been well-documented. Banana peel flavonoid leucocyanidin has been demonstrated to dramatically thicken the stomach's mucous membrane layer (Imam& Akter, 2011). Flour made from banana peels has been used in the food business as a thickening agent or source of carbohydrates (mostly dietary fiber) (Alkarkhi *et al.,*2011).

2.2.4 Banana fiber

It is an excellent substitute for wood pulp in the paper industry and decreases the environmental impact of deforestation due to its high cellulose content. Writing paper, anti-grease paper, check paper, and hard board can all be made using banana fiber as a substitute for other raw materials. (Yadav *et al.,*2016).

2.3 Nutritional properties

The nutritional makeup of fresh banana differs between research, owing to differences in plant species, genetics, habitat, ecology, and harvesting conditions. Banana peel is a reach source of Starch (3%), crude protein (6-9%), crude fat (3.8-11%), (Emaga et al.2008), total dietry fibre (43-49.7%) and poly saturated fatty acid particularly linolic acid and á linolic acid, pectin, essential amino acid like threonine, valine phynylalanine and micro nutrients (K, P, Ca and Mg) (Emaga *et al.,* 2007). Additionally, lignin (6-12%), pectin (10-21%), cellulose (7.6-9.6%), hemicelluloses

(6.4-9.4%), and galactouronine acid are all abundant in banana peel.(Yadav *et al.,*2016).

2.4 Functional properties

2.4.1 Functional Food

The term "functional food" first emerged in Nature in 1993 in an article titled "Japan Explores the Boundary between Food and Medicine**"** (Swinbanks D and O'Brien J 1993)**.** Any meal or food ingredient that may give a health advantage in addition to the typical nutrients it contains is referred to as functional food. It can be defined as entire, fortified, enriched, or enhanced foods that provide health advantages in addition to basic nutrients when consumed at effective levels as part of a diversified diet on a regular basis by consumers (Rama, 2019). The capacity of healthy ingredients used to minimize the risks, promote health, and lessen associated treatment (M., Nicoletti 2012).

2.4.2 Functional foods from plant sources

Irresistible evidence from epidemiological, in vivo, in vitro and clinical trial data indicates that a plant-based diet can reduce the risk of chronic diseases, particularly cancer. According to the World Cancer Research Fund, there is compelling evidence that a high intake of fruits and vegetables protects against a variety of respiratory and digestive malignancies (Boffetta P *et al*., 2010). Numerous epidemiological studies have found a negative relationship between the ingestion of fruits and vegetables and chronic illnesses including hepatocellular carcinoma and cardiovascular disease. It has been suggested that phytochemicals are to blame for the observed protective effect reported by (Schreiner M and Huyskens-Keil S., 2006).

Recently, there has been a surge in interest in studies on food components such as anthocyanins and other phenolic compounds, partially due to their antioxidant activity, which may be linked to health advantages such as a reduction in heart disease and cancer (Seeram *et al*.,2002). More research is needed to support the possible health advantages of foods for which diet-health links have not been sufficiently scientifically confirmed.

2.5 Antioxidants

Antioxidants are the molecules responsible for scavenging free radicals and protecting our bodies from different free radical-related ailments. Through initiation, propagation, and termination, the mechanism is linked to a free radical-mediated oxidative process. Antioxidant production occurs both inside the body and naturally in many foods (Alam *et al.,* 2020).

2.6 Medicinal and health benefit

To lead a healthy life what we need is healthy food. Banana is such kind of food that not only fulfilled our nutritional requirements but also refreshing us. Fruits are used as a supplement to basic diets. When compared to grains, many fruits have far better nutritious potential. Bananas are one of the most significant and often consumed fruits. Bananas are one of the oldest cultivated plants and have a high nutritional value. The banana is one of those fruits that have nutritious value in all of its sections. This plant's entire structure has nutritional and therapeutic value (Kumar *et al.,* 2012).

Many medical uses for banana plant components have been recorded in various regions across the world. Several studies have been published that support the traditional health advantages of bananas.

1. Banana reduces the risk of blood pressure as it is the best source of potassium that maintains normal blood pressure and normal heart function (Kumar *et al*.,2012).
2. Banana contains non digestible fiber like-cellulose, alpha cellulose and alpha Glucans that can help to restore the activity of bowl movement (Kumar et *al.,* 2012).
3. The magnesium concentration of bananas has been found to be a good cancer-fighting agent. Bananas include vitamin C, which is an anti-oxidant that lowers the risk of cancer (Ranjha *et al.,* 2020)
4. A study done in the United States found that men who consume more potassium, magnesium, and fiber have a lower risk of stroke. A diet high in fiber can help with hemorrhoids, diabetes, cardiovascular disease, gastrointestinal disease, constipation, and excessive cholesterol (Mateljan, 2007)

5. Banana is the best way to get rid of heartburn as it helps to lessen acidity. Mixture of banana and milk is the best solution of reducing acid secretion (Kumar,*et al* 2012)
6. Bananas are high in potassium, which is important for nerve function (Ranjha *et al.,* 2020)
7. For a newborn baby bananas are the greatest solid food. It is a fortified food for baby since it contains Vitamins A, B 2, B 6, C, E, Niacin, Folate, and Pantothenic Acid, as well as potassium, fiber, calcium, magnesium, phosphorus, selenium, iron (Kumar *et al.,* 2012)
8. Banana flowers served as a drugs for dysentery, boils, bronchitis, and diabetes (Rita *et al*.,2020)
9. Using banana sap, treatment of leprosy, fever, digestive problems, nosebleeds, and insect bite can be done (Rita *et al.,* 2020).
10. According to traditional medicine, the peel can treat a variety of ailments, such as burns, anemia, gastroenteritis, ulceration, inflammation, hypoglycemia, cough, snakebite, and heavy bleeding (Pereira A. M., 2015).

2.7 BPF Biscuit

Biscuits are one of the most popular snacks among both children and adults. Biscuits have the potential to be used as carriers of dietary fiber due to their widespread consumption (Rahman *et al.,* 2020)**.**

Chapter 3: Materials and Methods

3.1 Study Area

The experiment was conducted in the laboratory of the department of Applied Chemistry and Chemical Technology, Department of Food Processing and Engineering of Chattogram Veterinary and Animal Sciences University (CVASU), Chattogram. The experiment was carried for a period of six months from 1st November 2021 to 15th April 2022.

3.2 Experimental design

To begin, a location was chosen from which bananas would be harvested. Following the gathering of samples, it was utilized to make banana peel powder from ripe bananas. After that, this powder was utilized to make BPP biscuits. The proximate composition (moisture, ash, crude fat, protein, crude fiber and carbohydrate) of banana peel flour was determined after processing the nutritional composition, antioxidant capacity, and microbial load of each product category were examined, as well as consumer acceptability tests.

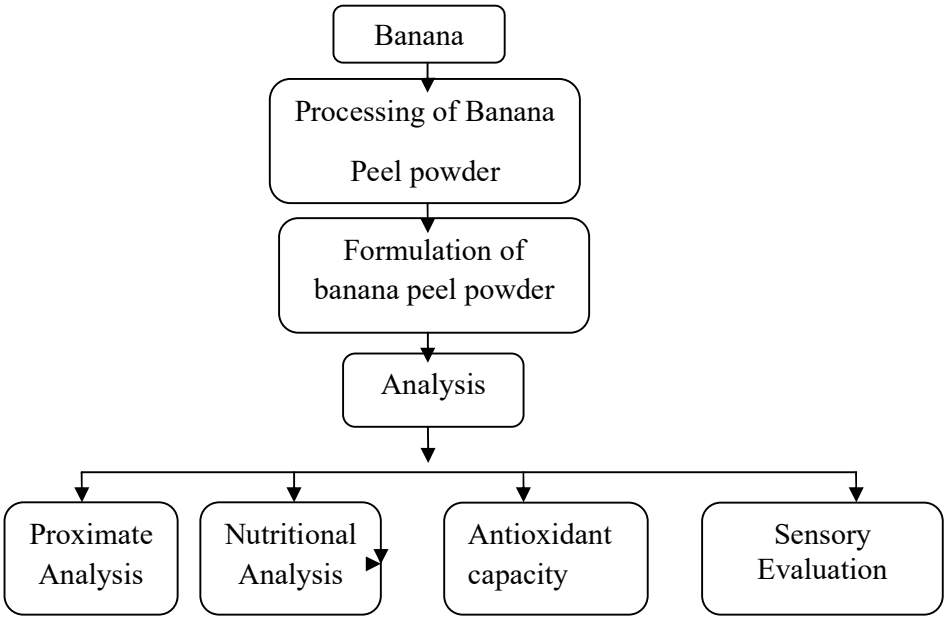


Figure 3.2: Study design

3.3 Collection of Sample

Fresh samples of Banana- Sagor (*Musa sapientum*) were collected from the local market and super shop of Chattogram district. Banana fruits were carefully chosen in order to their freshness. Other raw ingredients for biscuits formulation such as wheat flour, sugar, baking powder, baking soda ,butter were purchased from the local market Other consequential materials required for the experiment were received from the laboratory stocks.

3.4 Preparation of BPF

After receiving, the fresh banana peels were washed away thoroughly with water to remove dust and debris. Then the peel was cut into small pieces. After that it was then blanched for 5mins followed by cold water. Collected peel was placed on trays and dried in a cabinet drier at 60^{o} C for 12 hour's. Dried banana peel smoothed by using a grinder and then sieving to separate large particles. Hereafter, the peel powder packed in a zipper bag and stored in an air tight container until used.

3.4.1 Flour formulations

Composite flour is formulated in varying ratio according to the table.

Ingredient	Control Biscuit	BPF fortified Biscuit (2%)	BPF fortified Biscuit (5%)	BPF fortified Biscuit (10%)
Wheat flour	150 gm	147gm	142.5 gm	135 gm
BPF	-	3 gm	7.5gm	15 gm
Powdered sugar	67 gm	67 gm	67 gm	67 gm
Egg	1 no.	1 no.	1 no.	1 no.
Baking powder	5 gm	5 gm	5 gm	5 gm
Baking soda	1 gm	1 gm	1 gm	1 gm
Butter	50 gm	50 gm	50 gm	50 gm
Banana flavor	2 drops	2 drops	2 drops	2 drops
Salt	1 gm	1 gm	1 gm	1 gm

3.5 Preparation of Biscuit

Sweet biscuits were made using the traditional creamery method. First of all egg, sugar powder and butter were mixed together with a beater to form cream. Then all powdered ingredients- wheat flour, BPP using the proportions given in table 1, common salt, baking powder, baking soda were blend together for preparing biscuit. Then 1to 2 drop of banana flavor are added in the dough and blend it again. Water as required for proper consistency was used as the recipe for preparing biscuits. To make the dough, the mixture was continued to be combined for 5 minutes. The dough was consistently sheeted on a platform using a wooden rolling pin. In a baking oven, circular star-shaped biscuits were cut out and baked for 15 minutes at 220°C. Then the biscuits were cooled, and stored in an air tight packet until tested.

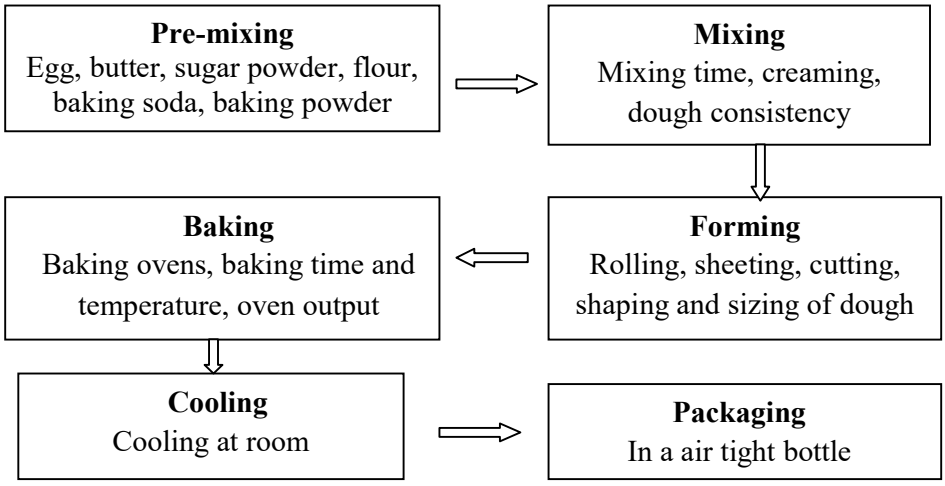


Figure 3.5: Processing steps of Biscuit

3.6 Physicochemical analysis of Biscuit

Biscuit samples incorporated with Banana Peel Powder were analyzed for moisture, protein, fat, fiber, ash, as per the methods of AOAC 2016. These samples were also analyzed antioxidant analysis.

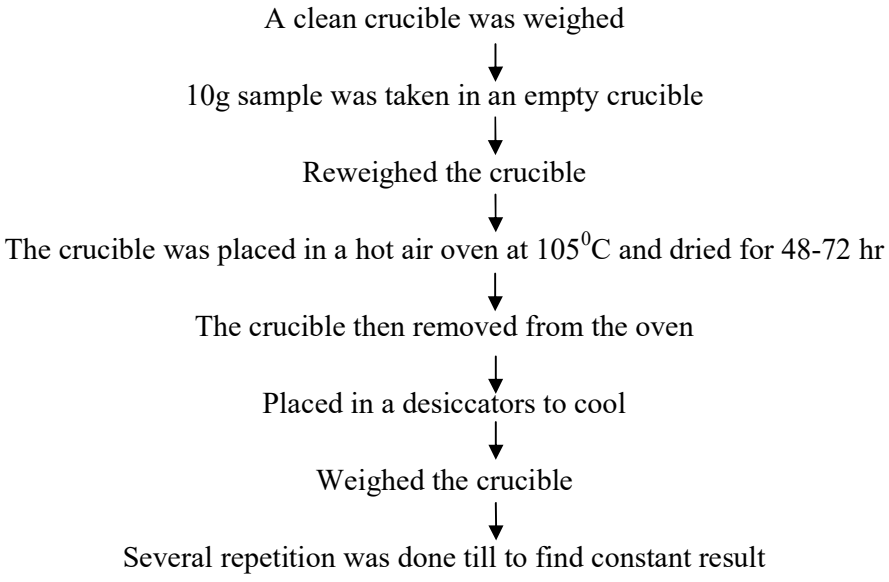
3.6.1 Moisture content

Principle:

The most significant and frequently used parameter in the processing and testing of meals is moisture determination. The moisture content is directly important economically to both the processor and the consumer since the percentage of dry

matter in a portion of food is adversely related to the amount of moisture it contains. However, the impact of moisture on food quality and stability is substantially more significant. Association of Official Analytical Chemists (AOAC, 2016) standard's method was used to measure the water level.

Procedure



3.6.2 Assessment of Crude Fat

Principle: Via putting food samples into organic solvents like chloroform or methanol and separating the filtrate by filtration, fat content can be calculated. The filtrate is divided into separate funnels, the mixture is dried to measure the extract, and then the estimated fat percentage is calculated. The crude fat content of the samples was ascertained following AOAC (2016) procedures utilizing a soxhlet instrument.

3.6.3 Assessment of Crude Protein

Reagents used: Concentrated H_2SO_4, Digestion mixture (Potassium sulphate 100gm + Copper sulphate 10gm + Selenium dioxide 2.5gm), Boric acid solution, Alkali solution, Mixed indicator solution, Standard HCl (0.1N).

Principle: The nitrogen content of samples, both organic and inorganic, is evaluated using the Kjeldahl method. For the purpose of estimating the protein content, Kjeldahl nitrogen is assessed in foods and beverages, meat, feeds, cereals, and forages. The

Kjeldahl method is also used to estimate the nitrogen content of soil, wastewater, and other specimens. It is an accepted procedure that is described in multiple normative sources, including (AOAC, 2016).

Procedure

The basic idea behind this method is to digest the sample using concentrated sulfuric acid (H_2SO_4) and a digestion combination. This causes protein to be oxidized and destroyed as well as to convert organic nitrogen to ammonia, which then leaves in the acid mixture as ammonium bisulphate.

Making the digest alkaline, distilling the discharged ammonia into a standard acid solution, and determining the amount by titration are the steps used to quantify the extent of ammonia nitrogen.

A 0.5g sample and a piece of ash-free filter paper were placed in cleaned and dried 100 ml Kjeldahl flasks. The digestion chamber was heated for six hours until the content became clean after adding 10 ml of concentrated H_2SO_4 and a 1:1 gm digestion combination (sodium sulphate and mercuric oxide). The digesting process was finished, the beaker was allowed to cool, and the digested liquid was put into a 100 ml volumetric flask and diluted with distilled water until the desired consistency was reached.

After infusing 5 ml of 50% NaOH and 2.5 ml of 15% $Na_2S_2O_3$, 10(10 ml) of that solution was placed into a micro kjeldahl distillation unit. For ten minutes, the solution was steam-distilled. The distillate was collected in solutions of 2% boric acid with an indicator and titrated with 0.02N HCl. A similar blank digestion was undertaken without the substances at the same time.

3.6.4 Estimation of Crude Fiber

Principle: The water-insoluble fraction of carbohydrates known as "crude fiber" is largely composed of cellulose, hemicellulose, and lignin. By boiling a definite amount of fat-free food in a weak acid solution (1.25% H_2SO_4) for 30 minutes, followed by a weak alkali solution (1.25% NaOH) for 30 minutes at constant volume, and then subtracting ash from the residue obtained, it can be computed through digestion. The

AOAC method was used to determine the crude fiber (2016). The residual material was then heated to 550°–600°C (white ash, 4-6 hours) in a muffle furnace.

Procedure

A 500 ml beaker was weighted down with about 20.4731 g of sample.

↓

It was then given 200 ml of boiling 0.255 N (1.25 percent w/v) sulfuric acid.

↓

Adding water at periodic intervals allowed the mixture to boil for 30 minutes while sustaining the same volume.

↓

At the end of this time, a glass rod was placed inside the beaker aids in smooth boiling.

↓

The mixture was filtered through a shirting cloth, and the residue was then thoroughly rinsed in hot water to remove any remaining acid.

↓

Following that, the substance was moved to the same beaker and 200 ml of boiling 0.313 N (1.25 percent) NaOH was added.

↓

The mixture was boiled for 30 minutes while maintaining the same volume, and then filtered via shirting cloth.

↓

After washing the residue with the same proportion of ether and alcohol until the residue was free of alkali, it was dried.

↓

It was then moved to a crucible, dried for the next day at 80° to 100° C, and weighed.

↓

The crucible was heated in a muffle furnace for two to three hours at 650° C, cooled, and then weighted once more.

↓

The difference in numbers showed the weight of the crude Fiber.

3.6.5 Ash content

Ash content was determined by methods of AOAC (2016). Ash content is the inorganic residue remaining after destruction of organic matter. 10 gram dried biscuit was taken in a pre-dried weighed crucible. It was then burned to charcoal. The charcoal was then taken in a muffle furnace and heat at around 600°C for 4 hours till

the charcoal was completely removed. The crucible was then taken out of the furnace. Cool it in a desiccators carefully and then weighed.

Procedure

The vacant crucible was removed, held in a desiccator for an hour, then dried at 105°C before being weighed up to a steady weight. About 1 gm of sample was taken in the weighted empty crucible. 1 drop of Nitric acid was added and then on a low flame, the specimen in the crucible was burnt and the crucible was then kept in muffle furnace and temperature was set to rise to 650° Cand kept it constant for three hours. Then it was removed, cooled and kept in a desiccators and weight of crucible with ash was taken.

3.6.6 Determination of total carbohydrate

By estimating the difference between the Nitrogen Free Extractive and the carbohydrate content (NFE), it was specified as the deviation from 100 from the sum of the other proximate components.

Calculation: So, it was estimated using the following equation:

% CHO = 100% - % (Protein + Fat + Fiber + Ash + Moisture content).

3.6.7 Determination of Antioxidant capacity by DPPH scavenging method

Extract preparation

In a Felcon tube, a 1 gram sample was collected. Then, 10 ml of 100% methanol was added, and the mixture was left for 72 hours. After a 4-hour interval, repetitive straining was performed. Supernatant was collected after 72 hours, and methanoic extract was detected.

Procedure

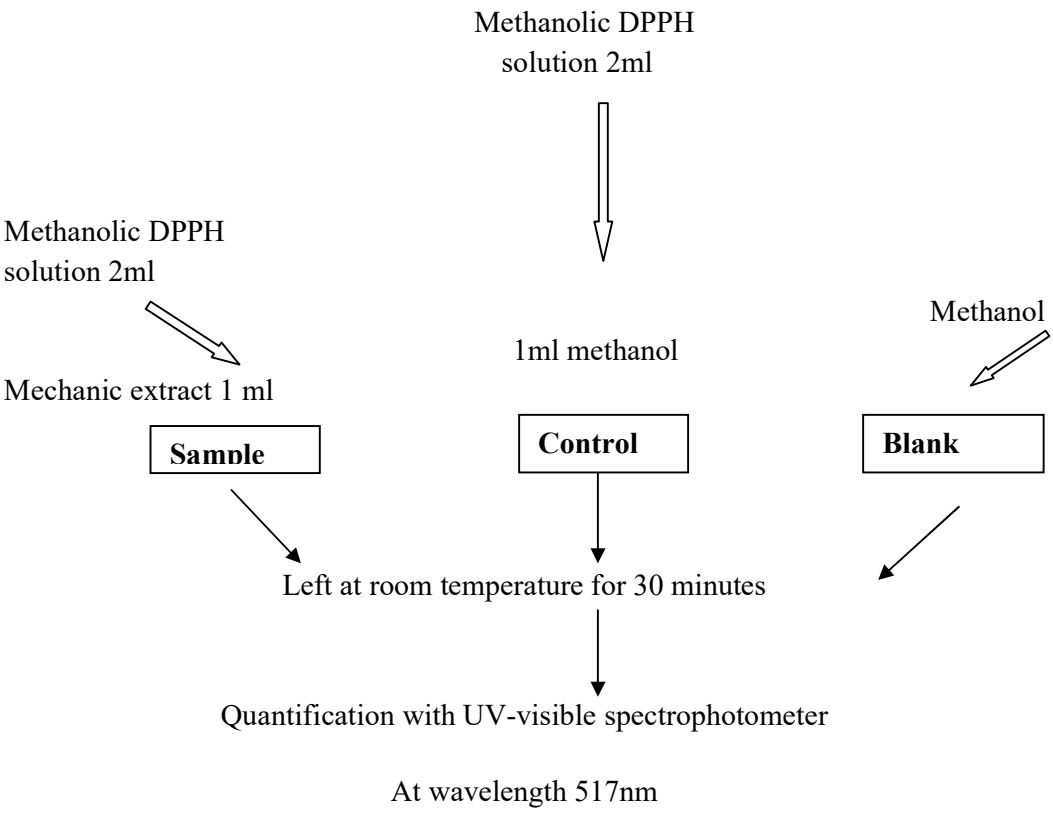
With a few minor adjustments from the method published by Azlim et al. (2010), the antioxidant permeability of the extracts was measured using the DPPH assay. Methanoic DPPH solution was created by dissolving approximately 6 mg of DPPH in 100 mL of pure methanol.

Then, 2 ml of DPPH solution was added to 1 ml of methanoic extract. The mixture was then gently agitated and allowed to sit at room temperature for 30 minutes in the

dark. Using a UV-VIS spectrophotometer, the absorbance was recorded at wavelength using 517nm (UV-2600, Shimadzu Corporation, and USA).

Methanol was used as a blank and the control was obtained by combining 1 mL of methanol with 2 mL of DPPH solution. Trolox provided as the reference, and methanol served as the blank. (Akther, 2020). The diminution in intensity of the samples in contrast to the DPPH standard solution acted as a reference for the scavenging mobility.

The calibration standard curve was drawn using TEAC composite (Trolox equivalent antioxidant mobility), which was also employed as the standard. On a dry weight (DW) basis, the values were presented as mg/100 g of Trolox equivalents (TE) per gram of powder.



3.7 Energy estimation

Using the following equation, the amount of protein, fat, and carbohydrate in each type of foodstuff was calculated along with its energy content. (Baer *et al*.,1997).

Energy = (Protein × 4.1) + (Fat × 9.2) + (Carbohydrate × 4.1)

3.8 Cost analysis

The cost of the banana peel powder-based biscuit was computed based on the total cost of the ingredients used to make the biscuit. The sum was shown in taka and examined for the cost per biscuit packet.

3.9 Sensory analysis

3.9.1 Affective test

This test will determine the degree of acceptability of "BPP fortified Biscuit". It was done by 10 panelist consisting equal male and female in the CVASU premises. The test was performed by untrained panel. There were 3 formulations of Biscuit and from those, panelists were asked to choose the best one from their degree of acceptability.

There were 5 points degradation used to evaluate the attributes of the sample with ranging score -1(dislike extremely) and score-5 (like extremely). The sensory attribute that panels had evaluated includes color, smell, texture, taste, overall acceptance.

Table 3: Grading system for sensory assessment

Ranks	Score
like very much	5
like slightly	4
neither like nor dislike	3
dislike slightly	2
dislike very much	1

3.10 Statistical Analysis

Statistical Analyses were done by using the software Minitab Version 14.0. One-way analysis of variance was performed on the collected data (ANOVA). Fisher's LSD test was used after statistical software to see whether there were any statistically significant differences between them; level of significance is ($p < 0.05$). Ten panelists agreed to participate in the experiment, the outcomes of which are described below

Chapter 4: Results

4.1 Proximate composition of wheat flour and BPF

Table 2 demonstrates the proximate composition of wheat flour and BPP that is used in this study. It was found that BPP contained higher amount of fat (6.31 ± 0.07), fiber (14.85 ± 0.30) and ash (8.6 ± 0.47), and characterized by lower amount of moisture (9.00 ± 0.10), protein (8.58 ± 0.50), and carbohydrate (52.66 ± .21) content compared to wheat flour.

Table 4.1: Proximate composition of Wheat flour and Banana Peel Flour (BPF)

Variables	Moisture (%)	Fat (%)	Protein (%)	Fiber (%)	Ash (%)	CHO (%)
Wheat flour	12.01±0.02	1.08±0.02	10.07±0.5	1.12±0.05	0.88±0.5	74.84± .25
BPF	9.00 ± 0.10	6.31±0.07	8.58±0.50	14.850.30	8.6±0.47	52.66± .21

4.2 Sensory Evaluation

Table 2 represents the sensory attributes of different experimented process biscuit. Here the mean score of color ranged from 1.2 to 2.3. Result showed that there was no significant difference between product A and B, but there was a significant difference between product A and C as well as product B and C. In terms of smell the mean score ranged from 1.5 to 2.2 which showed that there was no significant difference between product B and C but there was a significant difference between A and B as well as A and C. The mean score of taste ranged from 1.4 to 2.6 which implied that there was no significant difference A and B, but significantly difference with product C. The incorporation of banana peel powder did not affect the texture; however the mean value of product A tasted the best as compare to the product B and C. The highest overall acceptability was observed in product A; although, it was significantly different from product C but not in terms of product B.

Table 4.2: Sensory score of Experimented Processed Biscuit

Products	Color	Smell	Taste	Texture	Overall acceptability
(A)2% BPF+98% Wheat flour	2.1± 0.87[a]	2.2± 1.10[a]	2.5 ± 1.17[a]	2.7 ± 0.94[a]	2.6 ± 0.96[a]
(B)5%BPF+ 95%Wheat flour	2.3± 0.67[a]	1.8± 0.63[b]	2.6 ± 0.51[a]	2.4 ± 0.84[a]	2.6 ± 0.97[a]
(C)10%BPF +90%Wheat flour	1.2± 0.42[b]	1.5± 0.57[b]	1.4 ± 0.51[b]	2.3 ± 0.67[a]	1.5 ± 0.52[b]

Legends: Means ± SD and values in the same column with the same superscripts are statistically significant (P<0.05)

4.3 Proximate Composition

Nutritive value of Banana biscuit is shown in Table 4.3, almost all samples are significantly different. 10%BPF fortified biscuit contained the highest percentage of crude fiber (0.76±0.02%) & 5% BPF fortified biscuit contained highest percentage of fat (18.12±0.03%) and Sample B contain the most abundant percentage of crude protein (1.76±0.03%). The lowest percentage of crude fiber (0.62±0.02%), crude fat (14.16±0.29%) and crude protein (10.16 ±0.76%) found in control biscuit, BPF fortified 2% and BPF fortified 10% respectively.

Table 4.3: Proximate compositions of Biscuit Sample

Variables	Moisture (%)	Fat (%)	Protein (%)	Fiber (%)	Ash (%)	CHO (%)
Control Biscuit	2.20±0.26[d]	15.33 ±0.28[c]	11.31± 0.06[a]	0.62±0.02[b]	1.40±0.17[c]	69.25±0.28[a]
BPF fortified Biscuit (2%)	6.78±0.12[a]	14.29 ±0.03[d]	10.90±0.10[b]	0.67±0.03[b]	1.46±0.07[c]	65.89±0.17[c]
BPF fortified Biscuit (5%)	3.92±0.10[b]	18.12± 0.12[a]	10.46± 0.89[c]	0.68±0.01[b]	1.60±0.2[b]	65.21±1.02[c]
BPF fortified Biscuit(10 %)	3.60±0.53[c]	19.55± 0.58[b]	10.16±0.76[d]	0.76±0.02[a]	1.68±0.2[a]	64.25±1.75[b]

Legends: Means ± SD and values in the same column with the same superscripts are statistically significant (P<0.05)

4.4 Antioxidant capacity

From the table 4.5, Antioxidant capacity was shown to be significantly highest (2.605±0.001 mg TE/100 g) in 10% fortified biscuit and significantly lowest (0.0984 ± 0.001 mg TE/100 g) in 2% fortified biscuit.

Table 4.4: Antioxidant capacity of Biscuit

Formulations	Total Anti-oxidant Capacity (TAC) (mg TE/100 g)
BPP fortified Biscuit (2%)	0.984 ± 0.001[c]
BPP fortified Biscuit (5%)	2.108 ±0.005[b]
BPP fortified Biscuit(10%)	2.605 ± .001[a]

4.5 Cost Analysis

Table 4.5: Production cost of BPF Biscuit

Heads	Tk	Quantity used	Total tk(for 3 formulations)	Total tk (for control)
Expenditure Raw materials				
Fresh Banana	60tk/dozen	3	66	-
Wheat flour	45tk/ kg	575 gm	19	7
Sugar	90tk/kg	268gm	18	6
Butter	292tk/250gm	200gm	138	46
Baking soda	40tk	5	6	2
Baking Powder	50tk	20	3	1
Egg	60tk	4	30	10
Flavor	60tk	6-7drop		
Sub total			280	72
Packaging cost			9	3
Total production cost			289	75

In the table, control Sample having without additional flavor and banana peel powder. But the formulation product contains peel powder as well as flavoring agent.

By following this recipe, we can prepare 150gm BPP biscuit. For formulated biscuit 70gm banana peel powder was found from three dozen of banana and 25.5gm BPP was used. So, the cost is-

For 3 Formulated biscuit = 289tk

Per formulation = 289/3tk

= 96/90gm biscuit

For control sample the amount is = 75tk/90gm biscuit

4.6 Energy content

From the figure 4.1, Energy content in BPP 5% was calculated in highest amount (475.13 kcal/100g) and lowest (447.73 kcal/100g) in BPP2%.

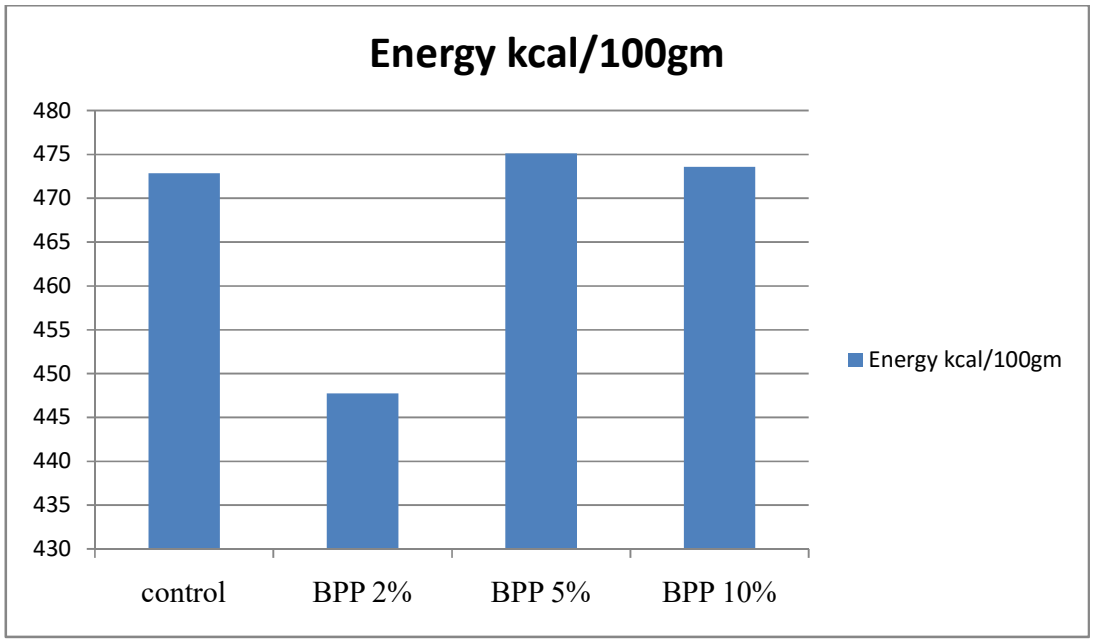


Figure 4.6: Comparison of energy content among Biscuit

Chapter 5: Discussion

5.1 Proximate Composition of BPF& Control

Higher content of fiber (14.85 ± 0.30) implies that the BPF composition is ideal for use in the baking sector to create functional foods, primarily high-fiber baked goods. Maximum ash content in BPF (8.6 ± 0.47) may be exerted to high percentage of mineral content present in BPF.

5.2 Proximate composition of wheat flour and BPF

Higher content of fiber in 10% formulated biscuit (0.76 ±0.02) implies that the composition of BPF offering the best for incorporation in the bakery sector to make a functional food mainly high fiber baked foodstuff. Maximum ash content (8.6 ± 0.47) may be exerted to high percentage of mineral content present in BPF. So, it can be opined that because of their high mineral content, flour banana peels produced a lot of ash during the test. The result aligns with the result of (Bakar *et al.,* 2018). High amount of ash found in biscuit due to presence of biological mineral content in banana peel. The ash content of any food comprises the degree of inorganic substitute left behind after the organic stuff in the food has been broken down. As certain minerals are lost in processing step, the ash content does not correspond to the mineral content thoroughly (Hernawati *et al.,* 2017). In this study it is showed that control biscuit (11.31 ± 0.06) has the highest protein percentage followed by 10% formulated biscuit (10.16 ± 0.76). Fat percentage is high in 5% formulated biscuit (19.55±0.12).

The highest amount of fiber found in 10% formulated biscuit (0.76 ±0.02) compared to others. Banana peels combined with flour cookies created a little hard, gritty, and crumbly texture. The texture of the biscuit was gritty and crumbly, and it was less crisp. Flour biscuits with the inclusion of banana peels have high fiber content and can be used as functional foods. This biscuit is expected to be a snack that can help people with hypercholesterolemia lower their blood cholesterol levels or keep their lipid and blood sugar levels in check.

Moisture content is an important parameter of food stuffs which denotes the shelf life and freshness of the product. Moisture content of the control biscuit was found to be (2.20 ±0.26) while addition of BPF increased the moisture content to (3.92 ± 0.10) in 2% formulated biscuit. Lower moisture level contributes to the textural capacity,

enhanced biscuits as well as the suppression of chemical and biological processes. Where high moisture content in 2% formulated biscuit may have the shorter shelf life. Baking items' moisture content, which measures stability and sensitivity to microbiological contamination as well as water activity and activity index, directly correlates with how long they may be stored (Mashu *et al.,*2019).

Protein content in control sample is high (11.13±0.06), where formulated biscuit 2%, 5%, 10% show lower protein content. This may happen because of lower protein content found in banana peel flour. Addition of egg, butter did not increase the level of protein significantly, but it can meet the protein requirement with addition of banana peel flour.

According to USDA fat content of biscuit is 8.5gm which may vary depending on processing. Fat content of biscuits in addition to banana peel flour are higher than the standard limit. This is due to higher fat content present in banana peel and subsequently for adding raw materials.

Carbohydrate content is high in control sample whether fortified biscuit 2% contains low amount. This may be because of the reduction of wheat flour. Moreover, the higher the fat content the lower the carbohydrate content. (Hernawati *et al*., 2017).

So, it can be concluded that the product has the highest opportunity to become a functional food as it contains handsome amount of fiber, fat, protein compare to WF biscuit.

5.3 Antioxidant capacity

All of the samples in table 4.4 demonstrate a significant difference in antioxidant capacity. DPPH was a widely used substrate for evaluating antioxidant activity, particularly in the study of biological and chemical compounds' free radical scavenging abilities. The findings shows that antioxidant capacity ranged from (0.984 ± 0.001) to (2.605 ± .001) mg TE/100g for a different types of formulated biscuit. Sample C had a relatively higher level of antioxidant capacity. (2.605) than that of sample A(0.984).Baked goods' antioxidant potential is increased by processing steps such as baking and microwave roasting, according to studies (Baba *et al.,* 2015). The addition of banana peel powder reveals that increasing the amount of antioxidant

capacity in the flour makes hydrogen transfer atoms work more effectively (Krystaijan *et al*.,2015).

5.4 Sensory Evaluation

This is a fantastic conclusion because the quality of a food ingredient can be partly assessed by its flavor. The majority of participants identified the banana peel flavor since the flour inclusion banana peels still imparts a distinct flavor. The sense of smell and taste are intertwined.

The Maillard process, which is one of the most important flavor sources, is supposed to be increased by using an oven or a microwave. Aside from protein, one of the chemicals suspected of being the source of bitter or astringent taste is fat. Fat is an important ingredient in biscuit production since it enhances the aroma and gives the finished product a crisp texture. Food flavor is assessed using the senses of smell, taste, and oral stimulation. Tannin is the bitter flavor of flour-based banana peel biscuits. The presence of tannins in foodstuffs is likely to result in a bitter taste in biscuits when flour banana peels are added. It is well known that phosphatidylcholine, amino acids, and peptides have a bitter taste (Damayanthi *et al.,* 2007). Excessive bitterness has been linked to lipid and protein breakdown.

The biscuit gets its biscuit brown hue from the banana flour. Phytochemical compounds in banana peels give them a brown hue. Furthermore, wet heating will boost the yellow color component while diminishing the white color component. According to the results of the investigation, BPF with WF, which means for a 5 %formulated biscuit, was shown to have better organoleptic properties than other compositions.

Chapter 6: Conclusion

Banana is a popular food product in ready-to-eat foods because of its health benefits. In terms of sensory perception, biscuit from banana peel flour has the highest appeal. The physicochemical test was performed for BPF biscuit which showed significant differences**.** The study showed that fruit and vegetable peels, a typical waste product found in food processing facilities, would be used for culinary uses. The development of new types of biscuit using BPF was bliss. The BPF fortified biscuit showed the great source of crude fiber content, rich in protein, fat also a good source of carbohydrate, in proximate analysis. Because it has a high concentration of phytochemicals such as antioxidants and bioactive substances, it is classified as a functional food. The nutritional values were found to be satisfactory, which aided in the improvement of nutritional status. Consumers can use this method because it is inexpensive and simple to make biscuit. This study identifies a promising possibility of processing banana peel into biscuits for the benefit of Bangladeshi growers, processors, and consumers. It should also be noted that selling the highest quality biscuit of international standard can generate foreign cash, which can help Bangladesh's national economy. Further research with other necessary ingredients is required for trials with various types of fruits in the creation of biscuits.

Chapter 7: Recommendations and Future Perspectives

In Bangladesh, more than half of the population suffers from malnutrition; in these circumstances, this enriched biscuit, which is available in rural regions, could be an excellent source of nutrients and energy. In the area of developing BP biscuits, we came up with some promising results. It also has a higher commercial value and is more marketable. The process from medium and large scale production can be adopted by modern food enterprises. The following suggestions and opportunities for future research effort are given based on the current investigation.

a) The current research could be repeated to corroborate the experimental results.
b) The recipe can be tweaked further, and you can try producing mixed peel biscuits with different fruit ratios using different recipes.
c) Because it is simple to prepare , It may also be stored for a long period of time and is recommended throughout the full season
d) It will be beneficial from an economic standpoint for individuals who are economically disadvantaged.
e) Other fruits accessible in markets, such as apple, mango, and others, should undergo similar studies.
f) For the enhancement of BP biscuits, modern packaging and storage conditions will be devised.
g) Aromatic flavor can be incorporated for value addition.
h) The findings will be beneficial from a therapeutic standpoint because they have medical significance.
i) Even though there was enough data in the sample to make statistical comparisons between the analytical data. Due to the small number of samples studied and the necessity for results to be validated by a bigger study, our conclusion should be treated with care.
j) Enough efforts should be made to improve the nutritional value of commercially accessible biscuit.

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.

Appendices

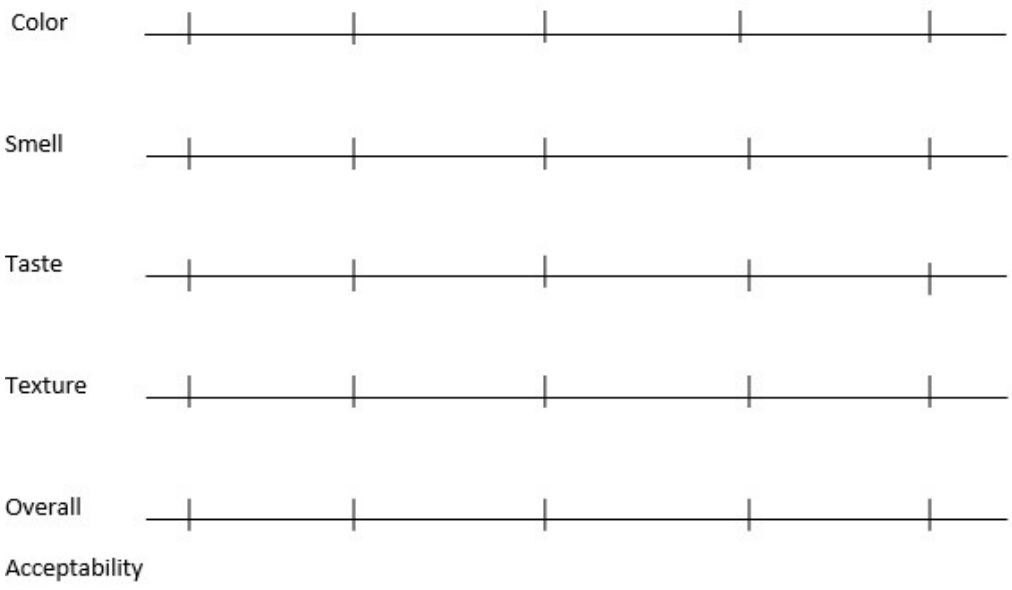
Appendix A: Questionnaire for Sensory test of Biscuit

Date: .....

Name: .....

Instruction

You are given two samples. Please rinse your mouth with water before starting. Taste each sample, from left to right. Rinse your mouth with water between samples. Evaluate the following attribute(s) these samples of Biscuit. Make a circle on the horizontal line based on your preference.



Appendix B: Photo Gallery

Appendix A1: Pictorial Presentation of Banana Peel Powder processing.

Banana

Washing

Blanching

Spreading

Drying

Dried peel

Blending

Banana peel powder

Appendix A1.2 Biscuit making process

Weighing raw ingredients

Blending all ingredients

Biscuit shaping

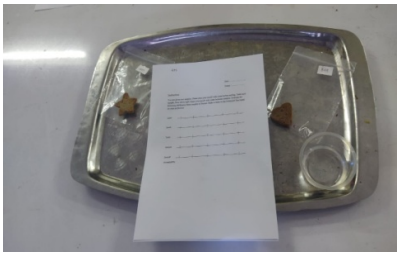
Baked biscuit

2%BPF biscuit

5%BPF biscuit

10%BPF biscuit

Appendix A2: Sensory Evaluation



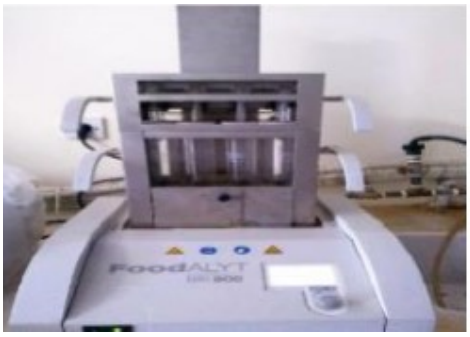
Evaluation form

Evaluation

Appendix A3: Proximate Analysis

Crude Fiber

Fat determination



Protein Digestion

Antioxidant measurement

Brief Biography

Sonia Akter Mitu passed the Secondary School Certificate Examination in 2011 from Bangladesh Navy High School, and then Higher Secondary Certificate Examination in 2013 from Government Hazi Mohammad Mohsin College, Chattogram. She obtained her B.Sc. (Honors) in Food Science and Technology from the Faculty of Food Science and Technology at Chattogram Veterinary and Animal Sciences University, Chattogram, Bangladesh. Now, she is a candidate for the degree of Master of Science in Food Chemistry and Quality Assurance under the Department of Applied Chemistry and Chemical Technology, Chattogram Veterinary and Animal Sciences University (CVASU). She has an immense interest to work in improving the health status of people through proper guidance and suggestions and to create awareness among people about food safety and nutrition.