DEVELOPMENT OF FIBRE FORTIFIED BREAD USING BANANA PEEL POWDER

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TAVANUR-679573, MALAPPURAM

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KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

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2023-2024

DECLARATION

I hereby declare that this thesis entitled "**DEVELOPMENT OF FIBRE FORTIFIED BREAD USING BANANA PEEL POWDER**" is a *bonafide* record or research work done by us during the course of research and the thesis has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "**DEVELOPMENT OF FIBRE FORTIFIED BREAD USING BANANA PEEL POWDER**" is a bonafide record of research work done independently by **Paul N P (2020-06-003), Megha M (2020-06-006), Anitta Sebastian (2020-06-007), Fathima Mufliha (2020-06-010)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associate ship.

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DEDICATED TO THE

FOOD TECHNOLOGY

PROFESSION

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LIST OF SYMBOLS AND ABBREVIATIONS

DW = Dry weight,

FW = Fresh weight

RAE = Retinol equivalent activity

PPO = Polyphenol oxidase

POD= Peroxidase

PAL = Phenylalanine ammonia lyase

KCAET= Kelappaji College of Agricultural Engineering and Technology

WHC = Water holding capacity

OHC =Oil holding capacity

IDF =Insoluble dietary fibre

BPF = Banana peel flour

BPP =Banana peel powder

HPD= Heat pump dryer

ml = Milli liter

INTRODUCTION

CHAPTER I

INTRODUCTION

People are becoming increasingly aware of the importance of a healthy diet. Fruits play a key role in a healthy diet because of the presence of fibre, and a host of vitamins and minerals. Raw bananas are also called green bananas; they are unripe, have a firm flesh and are less sweet than a ripe banana. Scientifically known as Musa, bananas are one of the most widely grown fruits across the world. Because of the presence of phytochemicals and nutrients, bananas are considered an important fruit in terms of nutritional value and properties.

In India bananas are also treasured in their raw form as well, Green Banana is a part of various savory Indian dishes. It can be boiled, steamed, stir-fried, deep-fried with batter, fried as chips, mashed, and curried, and also used as stuffing or in dips. Green bananas are laden with a wealth of dietary fiber, which is valuable for treating digestive and bowel issues. Packed with potassium, which acts as a vasodilator controlling blood pressure levels and augments heart health. It should be cooked well for better assimilation of nutrients.

The long-term objective of our country's economic development is a good balance between a strong industrial sector and a resilient agricultural sector. The development of micro, small and medium scale rural agro industry is seen as a strategic step towards achieving this goal. There are large numbers of micro and small-scale food processing enterprises run by farmers, which produce a wide variety of processed foods. Processed foods /snack foods may be described as mini meals in between main meals. Snacks like banana chips, jack fruit chips, coconut chips etc. are light to eat and serve a variety of useful purposes in our day-to-day life. Banana chips making has already developed into a cottage and small-scale industry in Kerala and the product is in high demand in India as well as abroad, especially in Middle East countries. There is great potential for this to be developed further, exploiting the domestic and fast increasing export demand.

The Nendran banana is a dual-purpose banana, being utilized as a fruit and as in cooked form. Moreover, the chips, oil-fried products of Nendran increase the bioavailability of lipid soluble β-carotene in human diet, was reported by National Institute of Nutrition, India. The chips industry with the production of 2 lakh tons of chips and the value of 500 crores annually, generate equal volume of peel and the amount of waste is expected to increase with the development of clustered processing industries. Peel, the main by-product of banana constitutes 30-40% of the fresh biomass of the Nendran fruit was found to contain much higher beneficial compounds compared to other fruit parts. They are rich source of crude protein (6-9%), crude fat (3.8-11%), total dietary fibre (43.2- 49.7%), polyunsaturated fatty acids, essential amino acids and micronutrients on dry weight basis. Banana peels are also a good source of lignin (6-12%), pectin (10-21%), cellulose (7.6-9.6%), hemicelluloses (6.4- 9.4%) and galacturonic acid (Karthikeyan - 2015). The natural bioactive compounds such as carotenoids, quercetin derivatives, phenolic acids and saponins are found in the peels in high concentration. Like pulp, banana peel flour offers scope for making new processed nutraceutical products.

The volume of organic waste from fruits and vegetables is continually on the rise, posing challenges in terms of waste management and environmental impact. Organic residues hold potential as a valuable source of nutrients, prompting suggestions that they could be utilized as ingredients or raw materials in various production processes to create innovative products (González *et al.,* 2015; Martínez-Fernández de Lara *et al.,* 2017). However, the predominant focus of research often revolves around the treatment of waste to extract bioactive compounds, involving additional processing that, in turn, generates other forms of waste (Anhwange, 2008; Eshak, 2016; Castelo-Branco *et al.,* 2017).

The banana peel, constituting 47-50% of the fruit's weight, currently lacks industrial applications and is often discarded or sporadically employed as animal feed or fertilizer (Ghorade *et al.,* 2011; Fatemeh *et al.,* 2012). Integrating banana peels into food products holds potential to enhance their nutritional value due to their rich concentrations of vitamins, minerals, and fiber, simultaneously addressing the issue of waste accumulation (Garzón *et al.*, 2011).

Bread is a staple food prepared from dough of flour and water, usually by baking. Throughout recorded history and around the world, it has been an important part of many cultures' diets. It is one of the oldest human-made foods, having been of significance since the dawn of agriculture, and plays an essential role in both religious rituals and secular culture.

In a world grappling with food waste and a growing need for sustainable practices, the concept of transforming banana peels, commonly discarded as waste, into a valuable ingredient for fortified bread has emerged as a revolutionary and innovative approach. This novel idea not only addresses the issue of food waste but also aims to enhance the nutritional content of a staple food item – bread. This Project delves into the multifaceted aspects of banana peel powder-fortified bread, exploring the nutritional benefits, sensory attributes, challenges, and the potential impact on public health.

While the nutritional benefits and sensory enhancements are promising, the incorporation of banana peel powder into bread is not without its challenges. Alterations in color, potential bitterness, and changes in texture require meticulous attention to detail during the formulation process. The choice of banana variety, ripeness, and processing methods are crucial factors that influence the final product, necessitating further research to establish optimal formulations that balance nutrition and consumer acceptability.

In this background the project entitled "Development of fibre fortified bread using banana peel powder" was undertaken at Kelappaji College of Agricultural Engineering and Technology (KCAET) Tavanur, Kerala, India with the following objectives:

a) Preparation of fibre fortified bread using banana peel powder

b) To evaluate the quality parameters of fortified bread

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

2.1 Production

Banana (*Musa sp.*) is the second most important fruit crop in India next to mango. Its year-round availability, affordability, varietal range, taste, nutritive and medicinal value makes it the favorite fruit among all classes of people. It has also good export potential. Banana and plantains are grown in about 120 countries. Total annual world production is estimated at 86 million tonnes of fruits. India leads the world in banana production with an annual output of about 14.2 million tonnes.

In India banana ranks first in production and third in area among fruit crops. It accounts for 13% of the total area and 33% of the production of fruits. Production is highest in Maharashtra (3924.1 thousand tones) followed by Tamil Nadu (3543.8 thousand tonnes). Within India, Maharashtra has the highest productivity of 65.70 metric tons /ha. against national average of 30.5 tonnes/ha. The other major banana producing states are Karnataka, Gujarat, Andhra Pradesh and Assam.

2.2 Chemical Composition of Nendran Banana

The nutritional composition of the Nendran banana is characterized by a rich content of carbohydrates, primarily in the form of natural sugars like glucose, fructose, and sucrose, providing a quick and sustainable energy source. This banana variety is a notable source of dietary fiber, contributing to digestive health and promoting a feeling of fullness. Nendran bananas are also a good source of essential vitamins, particularly vitamin C and vitamin B6, supporting immune function and metabolic processes. With a high potassium content, these bananas contribute to maintaining proper heart and muscle function while regulating fluid balance in the body. Despite being naturally low in fat and protein, Nendran bananas are a nutritious and heart-healthy snack option. Including Nendran bananas in a well-balanced diet can provide an array of essential nutrients crucial for overall health and well-being.

The peel and pulp are good sources of certain biogenic amines (Catecholamines) produced by decarboxylation of amino acids or amination of aldehydes and ketones. Catecholamines include dopamine, serotonin, epinephrine and norepinephrine. Serotonin is crucial for the correct functioning of the nervous system and control of blood pressure in humans. On the other hand, putrescine contributes to physiological processes such as flowering, fruit development and cell division. Putrescine is also used as a quality indicator in various foods. In addition, bananas contain phenolic compounds that help prevent many human disorders such as cardiovascular diseases, obesity and diabetes. (Alzate A *et al*…,2021)

Table 2.1 Chemical composition of Nendran banana

Compound	Content	Unit
Carbohydrate	22-88	g/100g DW
Dietary fibre	2-5	g/100g DW
Protein	1-2	g/100g DW
P	350-485	mg/100g FW
Mg	26-27	mg/100g FW
Vitamin C	12.7	mg/100g FW
Vitamin A	12.4	mg/100g *RAE
Cellulose	5.47	g/100g DW
Phenols	1-8	g/100g DW

(Alzate A *et al*..,2021)

2.3 Banana Peel

A banana peel is the outer covering of the banana fruit. As bananas, whether eaten raw or cooked, are a popular fruit consumed worldwide, with yearly production over 145 million tonnes in 2011, there is a significant amount of banana peel waste being generated as well.

Banana peels are used as feedstock as they have some nutritional value. Banana peels are widely used for that purpose on small farms in regions where bananas are grown. There are some concerns over the impact of tannins contained in the peels on animals that consume them. Banana peels are used as feedstock for cattle, goats, pigs, poultry, rabbits, fish and several other species. Banana peels are also used for water purification, to produce ethanol, cellulose, and lactase and in composting. (Debabandya Mohapatra *et al*., 2010).

2.3.1 Advantages of Banana Peel

- Depression Relief

The high levels of tryptophan in bananas, combined with the B6 in banana peels, can help relieve some symptoms of depression and other mood disorders. Tryptophan turns into serotonin as it breaks down, which can improve your mood. Vitamin B6 can help improve sleep, which has a positive impact on mood over time.

- Digestive Health

Fiber-rich banana peels can help regulate the digestive system, easing both constipation and diarrhea. This can be a particularly important benefit of banana peels for people with Crohn's disease or irritable bowel syndrome.

- Better Eyesight

Vitamin A can help keep your eyes strong and healthy. This vitamin is abundant in both bananas and banana peels.

- May Lower Cancer Risk

Banana peels are packed with polyphenols, carotenoids, and other antioxidants that fight cancer-causing free radicals in your body. Eating more banana peels, especially green, unripe peels, can increase your antioxidant levels and help reduce your risk of cancer.

Studies on the anti-cancer properties of banana peels were done in test tubes, not on humans. Further research is needed to understand whether banana peels can lower cancer risk in people.

- Lower cholesterol

Banana peels have both soluble and insoluble fibers, which lowers cholesterol and keeps cholesterol from adhering to the walls of arteries. This helps lower the risk of cardiovascular diseases.

- Remove splinters

Because banana peels are so high in enzymes, they bring foreign things to the skin's surface, making it much easier to grab the splinter. Apply the peel to the problem area of the skin and leave it for 15 minutes. Then, carefully remove it before removing the splinter.

- Treat acne and sun damage

Banana peels anti-inflammatory characteristics and vitamin C content can help treat a variety of sun-related skin problems, acne, and other skin conditions brought on by prolonged sun exposure.

- Food processing and beverage industry

Banana peel powder was used as a flavoring agent in the food processing industry. Banana peels are used in the production of enzymes like amylase and cellulase. Amylase plays a crucial role in the hydrolyzing of complex compounds (starch) into simpler units (glucose) in the food, beverage, and baking industries. (Manimaran, *et al*..,2016)

Table 2.2 Chemical composition of Banana Peel

PARAMETER	COMPOSITION
Moisture (%)	75.3 ± 3.2
TSS (°Brix)	6.4 ± 0.25
Reducing sugar (%)	12.6 ± 0.47
Non reducing sugar (%)	3.4 ± 0.19
Starch (%)	4.5 ± 0.11
Protein (%)	0.35±0.004

Fat (%)	0.67 ±0.20
Total carbohydrate (%)	22.6 ±1.62
Ash (%)	1.83 ±0.10

(De Matos, *et al.*, 2017)

Table 2.3 Mineral composition of banana peel

PARAMETER	COMPOSITION
P (mg/100g)	618.4 ±25.74
Ca (ppm)	220.0 ±08.3
Mg (ppm)	536.0 ±30.37
Fe (ppm)	12.4 ±0.32
Zn (ppm)	2.8 ±0.06
Mn (ppm)	2.3 ±0.07
Na (ppm)	38.0 ± 2.91

(De Matos, *et al.*, 2017)

2.4 Inhibition of enzyme browning

Organic acids are considered safe and are widely used as postharvest antibrowning agents. Citric acid at 3%(w/v) suppressed PPO(Polyphenol oxidase), POD(Peroxidase) and PAL (Phenylalanine Ammonia Lyase) activities and delayed browning in longkang fruit. Tartaric, citric and ascorbic acids at 3%(w/v) inhibited POD activity and reduced browning in minimally processed yacon tubers after dipping. Although it has been demonstrated that organic acid treatment significantly reduces browning in a variety of tissues, there are no reports about the use of organic acid treatment to minimize browning in banana blossoms.

All chemicals including ascorbic acid, sodium chloride, citric acid, calcium chloride, and sodium carbonates were obtained. One of the slices was dipped in solution of 1% ascorbic acid, sodium chloride, citric acid, calcium chloride, and sodium carbonate separately for 3 min, drained with a paper towel. Beside the chemical treatments, sliced banana samples were immersed directly in water at room temperature, and 65°C water separately for 3 min.

2.5 Fibre fortification

Bread can be enriched with dietary fibre, including wheat bran, gums, such as guar gum and modified celluloses, and β-glucans. However, the addition of these fibers causes a neglected effect on the final bread quality. The most evident effect is the reduction of loaf volume, the increase of crumb firmness, the dark crumb appearance, and also in some cases a modified bread taste is obtained, for instance, when adding guar gum. Moreover, the resultant fibre-rich dough has high water absorption, become shorter and has a reduced fermentation tolerance.

2.6 Study on fibre fortification

An experimental study was designed to formulate ready to eat cookies by incorporating banana and banana peel flour which is normally unused in Bangladesh but contains excellent amount of nutrients especially dietary fiber, essential vitamins and minerals. Cookies were prepared by replacing 5 % (sample-1), 10 % (sample-2) and 15% (sample-3) of wheat flour with banana and banana peel flour. The proximate analysis and sensory parameters of those cookies were compared with control cookies where no banana and banana peel flour were added and designated as normal cookies (0% substitution). Functional properties were also evaluated and a significant difference found ($P<0.05$) in WHC (Water holding capacity), OHC (Oil holding capacity), swelling capacity, emulsion activity, emulsion stability and flour dispersibility in banana peel flour when compared to wheat flour. On proximate analysis of cookies, significant variation ($P<0.05$) was also observed in protein, ash, fiber and carbohydrate content of banana and banana peel flour cookies in a comparison to normal cookies. The increasing the substitution of banana and banana peel flour in cookies increased the ash and crude fiber content remarkably. About 15% substitution of banana and banana peel flour in cookies increased 93.25% crude ash (mineral) and

197.56% crude fiber than normal cookies. Energy values of the cookies were also evaluated and ranged between 480 Kcal and 513 Kcal per 100 g, with sample-3 cookies having the lowest value. In conclusion, the addition of both banana and banana peel flour in cookies by replacing 10% wheat flour were more acceptable with all quality characteristics (Woranong Thongsombat,2007).

Antioxidant and Dietary Fibre Content of Noodles Produced From Wheat and Banana Peel Flour, study aimed to utilize flour from banana peel to develop functional noodles. Banana peel flour was substituted in wheat flour at 11, 13 and 15 %, was used to produce noodles. Composite noodles produced were evaluated for cooking characteristics, dietary fibre content, glycemic index, colour attribute and sensory evaluation. Result of cooking characteristics of the noodles indicated that the noodles containing banana peel flour had higher water uptake (10.25 – 11.25%) and cooking loss (6.28 – 7.59%) contents but an interestingly lower optimum cooking time (4.19 – 3.65 min) than their counterparts containing only wheat flour. The IDF value of the noodles varied from 8.26 - 12.18%. The highest value was observed in sample 13% and 15% banana peel flour supplemented with wheat flour while the lowest value was recorded in sample 100 % wheat flour. Increase in addition of banana peel flour led to an increase in antioxidant properties and dietary fibre content of the noodles. The glycemic index of the noodles varied from 58.74 - 65.28%. The highest value was observed in sample 100% wheat flour while the lowest value was recorded in sample 15% banana peel flour supplementation. It was concluded that the use of flours from banana peels as composites of wheat had good potential for production of nutritionally and functionally superior noodles compared to the use of wheat alone. This study may be an economically viable approach towards promoting utilization of food wastes for production of value-added products in developing countries.

The consumption of fruits and vegetables involves the disposal of the inedible parts, conveying challenges such as waste management and environment pollution. In recent years, there have been multiple studies aimed at finding alternatives that reduce the negative impact of food/agricultural waste. Since most studies done with by-products recommend their careful selection, the aim of this study was to verify if discarded banana peels could be disinfected until microbiologically safe and to determine if they could still provide nutrients to formulate food products with sensory characteristics acceptable to a consumer market after disinfection. Banana peels were collected from markets, restaurants, and greengrocers. They were disinfected, dried, and pulverized to obtain flour which was subjected to microbiological and proximal analysis. Once its microbial safety was assured, this flour was incorporated into bakery and pasta products, replacing wheat flour with 5–20% banana peel flour (BPF). The sensory evaluation of the different products was carried out and, after verifying that the products were sensory acceptable, the proximal analysis was implemented. The formulated products were suitable for the addition of BPF up to 10%, in which the Acceptability Index was higher than 80% and significant increases in fiber and fat were achieved. We conclude that waste banana peel flour can be incorporated into bread and pasta products for human consumption to provide nutrients which might contribute to reduce this type of waste and to recover nutrients from otherwise disposed banana peels.

This study's objective was to show how nutritious banana peel powder. Moreover, to use BPP as a cheap alternative to wheat flour in bread. The results of BPP at different concentrations (0, 2,6 and 10%), as well as the sensory qualities of bread. The BPP is also regarded as a beneficial protein source (7.6%), ash (9.66%). Physical and chemical characteristics of bread made by partially replacing wheat flour with banana peel powder were examined. It has been established that banana peel contains a significant amount of nutrients which should not be disregarded or squandered. Banana peel can become a value-added product in the food sector by being processed into powder. The powder's flow ability declines. Banana peel was discovered to have a high tapped density 0.41 g/ml, and Carr's Index 14.21 %, pH value was 6.15. This powder was high in total dietary fiber 17.99 %. Additionally, functional properties of this powder were high, the water-holding capacity 6g/g, oil-holding capacity 3.4g/g and swelling capacity 15.33 ml/g. As a result, this study showed that the ripe banana peel powder has a chance to be used as a functional food ingredient. It is advised that BPP be utilized up to 6 % to complement and enhance the qualitative qualities of bread as a result of this research at a level that has several health advantages. numerous dishes gain nutritional value from the banana peel. banana peels as a cheap and abundant source, utilization, and enrichment of nutrients. (Saifullah Ramli, *et al..,2009)*

2.7 Drying Study

Heat pump-assisted drying is an energy-efficient process because the heat is recoverable. However, the economic feasibility of the heat pump dryer (HPD) is debatable because high grade energy (electricity) is used. The conventional drying methods have unavoidable challenges such as the low drying quality and high energy consumption etc. To achieve the higher quality of dried products and higher energy efficiency of drying facilities, the heat pump drying is recognized as the effective way. 250g of banana peels were thoroughly washed in distilled water followed by dipping in hot water for few seconds then in 0.1%, 0.5% and 1% citric acid solution for 10 minutes to reduce enzymatic browning. After draining it was sliced manually using clean knives into approximately 2X2 cm square pieces for uniform drying. Weighed samples were spread on the perforated trays were dried in a heat pump drier at a temperature of 700C. The moisture content of the peel at hourly intervals was calculated from the weight loss of the sample during drying. (Marilyn, *et al..*,1995)

2.8 Preparation of Banana peel flour

The Banana peel was cut into pieces and blanched using citric acid blanching method and dried in heat pump dryer. The dried peel slices were finely powdered with the help of a mixer grinder which was sieved through a clean sieve of 40 mesh screen to obtain fine banana peel powder. The powders were packed separately in LDPE covers and were sealed and kept in a refrigerator for further analyses. (Abbas *et al..*,2010)

2.9 Bread Development

Measure maida, sugar, salt, milk powder, yeast, vanilla Powder, water, oil, and bread modifier accurately using appropriate measuring utensils. In a small bowl, dissolve yeast in a portion of warm water. Allow it to activate for about 5-10 minutes until it becomes frothy. In a large mixing bowl, combine maida, sugar, salt, milk powder, and vanilla powder. Ensure even distribution of ingredients. Make a well in the center of the dry ingredients. Pour the activated yeast mixture, remaining water, and oil into the well. Gradually incorporate the dry ingredients into the wet mixture. Knead the dough on a floured surface for about 10-15 minutes until it becomes smooth and elastic. Place the kneaded dough in a greased bowl, cover it with a damp cloth, and allow it to rise in a warm place for 1-2 hours or until it doubles in size. After the dough has risen, punch it down to release excess air. Shape the dough into a loaf and place it in a greased baking pan. Allow the shaped dough to rise for an additional 30-45 minutes until it reaches the desired size. Preheat the oven to a temperature of 180°C (350°F). Place the baking pan in the preheated oven and bake the bread for approximately 25-30 minutes or until the crust turns golden brown, and the bread sounds hollow when tapped. Allow the freshly baked bread to cool in the pan for a few minutes before transferring it to a wire rack to cool completely. Once cooled, slice the bread and serve as desired. The bread-making process is successfully executed through precise measurements and sequential steps, ensuring the creation of delicious bread.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

This chapter deals with the methodology adopted for obtaining dried banana peel powder and preparation of product and its quality evaluation.

3.1 Collection of banana peel

Banana peels of raw and matured Nendran variety which is the main by-product of chips industry was procured from nearby shop were used for this study.

3.2 Pre-treatments

Two fifty grams of banana peels were thoroughly washed in distilled waterfollowed by dipping in hot water for few seconds then in 0.1%, 0.5% and 1% citric acid solution for 10 minutes to reduce enzymatic browning. Afterdraining it was sliced manually using clean knives into approximately 2 x 2 cmsquare pieces for uniform drying.

3.3 Moisture content determination

The moisture content of the peel sample was determined using infrared moisture meter by keeping a small quantity of three samples of peels.

3.4 Drying studies

The banana peel samples were weighed and spread on the perforated trays for drying in a heat pump drier at a temperature of 70^0C. The weight of samples were measured and recorded in one hour interval. The moisture content of the peel at hourly intervals was calculated from the weight loss of the sample.

Plate 3.1 Heat pump dryer

3.5 Preparation of peel powder

The dried peel slices were finely powdered with the help of a mixer grinder which was sieved through a clean sieve of 40 mesh screen to obtain fine banana peel powder. The powders were packed separately in LDPE covers and were sealed and kept in a refrigerator for further analyses.

Plate 3.2 Banana peel powder

3.6 Preparation of bread

Table 3.1 ingredient list

Ingredients	Blank (B0)	5% of banana peel powder (B1)	7.5% of banana peel powder (B2)	10% of banana peel powder (B3)
Maida (All-Purpose Flour)	300g	28 g	277.5 g	270 g
Banana peel powder	0	15 g	22.5g	30 g
Sugar	82.5 g	82.5 g	82.5g	82.5 g
Salt	3.22 g	3.225 g	3.225g	3.225 g
Milk powder	1.875g	1.875 g	1.875g	1.87 g
Yeast	2.625g	2.625 g	2.625g	2.625 g
Vanilla powder	0.9 g	0.9 g	0.9 g	0.9 g
Water	187.3ml	187.3 ml	187.3ml	187.3ml
Oil	20 ml	25 ml	27 ml	30 ml
Bread modifier	0.7 mg	0.7 mg	0.7 mg	0.7 mg

Plate 3.3 Baked bread

Measured maida, sugar, salt, milk powder, yeast, vanilla extract, water, oil, and bread modifier accurately using appropriate measuring utensils. In a small bowl, dissolved yeast in a portion of warm water. Allowed it to activate for about 5-10 minutes until it became frothy. In a large mixing bowl, combined maida, sugar, salt, milk powder, and vanilla powder. Ensured even distribution of ingredients. Made a well in the center of the dry ingredients. Poured the activated yeast mixture, remaining water, and oil into the well. Gradually incorporated the dry ingredients into the wet mixture. Kneaded the dough on a floured surface for about 10-15 minutes until it became smooth and elastic. Placed the kneaded dough in a greased bowl, covered it with a damp cloth, and allowed it to rise in a warm place for 1-2 hours or until it doubled in size. After the dough had risen, punched it down to release excess air. Shaped the dough into a loaf and placed it in a greased baking pan. Allowed the shaped dough to rise for an additional 30-45 minutes until it reached the desired size. Preheated the oven to a temperature of 180°C (350°F). Placed the baking pan in the preheated oven and baked the bread for approximately 25-30 minutes or until the crust turned golden brown, and the bread sounded hollow when tapped. Allowed the freshly baked bread to cool in the pan for a few minutes before transferring it to a wire rack to cool completely. Once cooled, sliced the bread and served as desired. This detailed procedure ensured the preparation of delicious and freshly baked bread.

3.7 Sensory evaluation

Sensory evaluation of bread samples was done immediately after bread loaves were cooled to room temperature. Bread loaves were sliced, and sensory evaluation was performed using nine-point hedonic scale (See *et al.,* 2007). The bread was then cut into slices using a bread knife. Sensory evaluation was performed using 20 untrained panelists comprising of graduate students and staff members of Department of Processing of Food Engineering & Technology, KCAET, India. They were advised to rinse their mouth with water between tasting the consecutive samples. Bread was analyzed on the basis of visual appearance, Odour, texture, taste, mouthfeel and overall acceptability on 9-point hedonic scale (1 – dislike extremely,2 – dislike very much, 3 – dislike moderately, 4 – dislike slightly, 5 – neither like nor dislike, 6 – like slightly, 7 – like moderately, 8 – like very much and 9 – like extremely). The major sensory parameters like, appearance was judged visually, texture was judged through sense of touch, and taste and mouthfeel were judged by the perceptible character and eating quality.

3.7.1 Colour analysis

The color parameters of the crumb and crust were determined using a Lovibond tintometer. The color was recorded using CIE-L* a* b* uniform color space (CIE-Lab), where L* indicates lightness, a* indicates hue on a green (-) to red (+) axis, and b* indicates hue on a blue (-) to yellow (+) axis. Color measurement of the samples was performed at three different angles and average was found.

3.7.2 TPA analysis

Plate 3.4 TPA analysis

TPA analysis is done by two loadings with a cylindrical probe (diameter=36 mm), the deformation speed is 1.7 mm/s, the relative deformation is 40 %, slice thickness' e.g. 25 mm or 2*12.5 mm. The TPA method gives the most parameters, like hardness, springiness, cohesiveness, gumminess, chewiness. The peak force of compression was recorded as bread hardness or firmness. Springiness is the ratio of the height of sample springs back during the first compression compared to maximum deformation.

3.8 Qualitative Analysis of banana peel fortified bread

The stored breads were subjected to various tests to find out the crude fibre content, carbohydrate content, protein content, colour, texture, sensory analysis. The procedures of the tests are as given below:

3.8.1 Crude fibre estimation using fibra plus extraction unit

Materials used were Sulphuric acid solution (0.225 ± 0.005N): 1.25g concentrated Sulphuric acid was diluted to 100 ml, and Sodium hydroxide solution (0.313 ±0.005N):1.25g sodium hydroxide was dissolved in 100ml distilled water. 5g (w) of powdered sample was taken in a crucible. The crucible was placed in the Fibra Plus extraction unit, then 1.25% H_2SO_4 was prepared and boiled on a hot plate. The acid was pouredinto the Fibra Plus tubes up to the marking. The instrument was switched on, "Program1" (450°C for 5 min, 400°C for 30 min) was selected, and then started. The acid was drained after the alarm (the green power button was turned on), and the knob was turnedto vacuum. The Fibra Plus tube knob was opened to handle clogging, then switched topressure, the pressure button was pressed, and returned to vacuum. The sample was washed with distilled water and the process was repeated with preheated 1.25% Na2OHsolution. After draining, the sample was washed with water. The sample was placed ina hot air oven for 2 hours and then cooled in a desiccator. The sample was weighed (w1). It was burned in a muffle furnace, and the weight was recorded (w2).

Calculation

Weight of sample = w

Weight of crucible plus sample after keeping it in hot air oven = $w1$

Weight of the crucible plus sample after burning in muffle furnace = $w2$

$w3 = w1 - w2$

% Of crude fibre = $\frac{w3}{w}$x 100

Plate 3.5 Fibra plus extraction unit

3.8.2 Carbohydrate by Anthrone method

The carbohydrate estimation was conducted based on the methodology outlined by Hedge and Horfreiter, as described in "Carbohydrate Chemistry," utilizing the anthrone method. The materials used included 2.5 N-HCl, Anthrone reagent (prepared by dissolving 100 mg anthrone in 100 ml of ice-cold 95% H_2SO_4, to be freshly prepared before use), and a standard glucose solution (100 mg in 100 ml water, with a working standard obtained by diluting 10 ml of stock to 100 ml distilled water, and stored refrigerated after adding a few drops of toluene).

For the analysis, 100 mg of the sample was taken in a boiling tube and hydrolyzed by placing it in a boiling water bath for three hours with 5 ml of 2.5 N-HCl. After cooling to room temperature, neutralization was carried out with solid sodium carbonate until effervescence ceased. The volume was then made up to 100 ml, followed by centrifugation, and the supernatant was collected.

In the subsequent steps, varying volumes (0, 0.2, 0.4, 0.6, 0.8, and 1 ml) of the working standard were added to tubes, with '0' serving as the blank. The volume was adjusted to 1 ml in all tubes, including sample tubes, by adding distilled water. To each tube, 4 ml of anthrone reagent was added, and the mixture was heated for 8 minutes in a boiling water bath. After rapid cooling, the green to dark green color at 630 nm was measured. A standard graph was then plotted with the concentration of the standard on the X-axis and the absorbance on the Y-axis. The amount of carbohydrate present in the sample tube was calculated based on the graph.

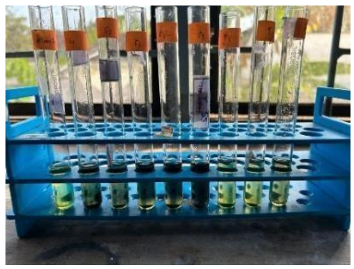

Plate 3.6 carbohydrate estimation

Calculation

Amount of carbohydrate present in 100mg of the sample=

$$\frac{mg\ of\ glucose}{volume\ of\ test\ sample} \times 100$$

3.8.3 Crude fat

Plate 3.7 Soxhlet apparatus

The apparatus and equipment used in the experiment included a balance machine, filter paper, cotton, cellulose thimble, hot air oven, and Soxhlet apparatus. The reagent employed was n-hexane with a concentration of 95%.

To begin the procedure, square filter paper was transformed into a narrow thimble and securely stapled. This thimble was then placed on the balance machine, and its weight was recorded. Subsequently, 4.5g of solid sample was ground and deposited onto the thimble. A layer of cotton was added to cover the sample, and the opening was sealed by folding filter paper.

The Soxhlet extraction unit was set up with the sample inside, and an ample amount of n-hexane was added. The apparatus ran for approximately 6 hours, during which water was circulated through the condenser. After extraction, the sample was removed, and the flask was rotated to evaporate excess solvent. The weight of the flask containing the extracted fat was recorded.

The next step involved placing the flat-bottomed flask in a hot air oven set at 110°C for 30 minutes, followed by cooling in a desiccator. The final weight of the flask, now containing the extracted fat, was then determined.

Calculations

W1= weight of round bottom flask

W2 = weight of round bottom flask + weight of oil

Total fat = W2 – W1

3.8.4 Protein estimation

Protein estimation by Lowry's method involves various materials and reagents, including 2% Sodium Carbonate in 0.1 N Sodium Hydroxide (Reagent A), 0.5% Copper Sulphate in 1% potassium sodium tartrate (Reagent B), alkaline copper solution (Reagent C), and Folin-Ciocalteau reagent (Reagent D). The principle of the method relies on the development of a blue color resulting from the reduction of phosphomolybdic-phosphotungstic components in the Folin-Ciocalteau reagent by amino acids like tyrosine and tryptophan present in the protein. Additionally, the color developed by the biuret reaction of the protein with alkaline cupric tartrate is measured in Lowry's method.

The procedure involves the extraction of protein from the sample, typically carried out with buffers used for enzyme assays. The sample is weighed, ground, and centrifuged, and the supernatant is used for protein estimation. In the estimation step, working standards and sample extracts are pipetted into test tubes, and reagents C and D are added successively. After incubation, the developed blue color is measured at 660 nm, and a standard graph is drawn for protein quantification.
For calculation, the amount of protein is expressed in mg/g or 100 g of the sample.

3.8.5 Ash content

Ash content measurement using a muffle furnace is a common analytical method to determine the amount of inorganic material present in a sample. This method is often employed for the analysis of organic materials, such as food, biomass, and other organic substances. The general procedure involves heating the sample to a high temperature in a muffle furnace to burn off organic matter, leaving behind the inorganic ash.

3.8.6 water activity

Plate 3.8 Water activity meter

Water activity measured by ensuring the sample was to be at room temperature to prevent condensation during testing. It was cut into small, uniform pieces to facilitate accurate measurements. The water activity measuring equipment was turned on, and sufficient time was allowed for it to stabilize. Care was taken to ensure that the equipment was clean and free from any residues that could interfere with measurements.

A small, representative portion of the bread sample was placed in the sample chamber of the water activity meter. The sample chamber was securely closed to create an isolated environment for measurement. The equipment was allowed to equilibrate with the sample for a sufficient period to obtain accurate readings. The water activity reading displayed on the equipment was then recorded, ensuring that the reading had stabilized.

After obtaining the measurements, the sample chamber and any other components were cleaned according to the equipment's cleaning guidelines. The water activity reading obtained for the bread sample was interpreted. Water activity values typically range from 0 to 1, with lower values indicating less available water in the sample.

RESULT AND DISCUSSION

Chapter 4

RESULTS AND DISCUSSION

The outcomes of various experiments conducted to fortify bread using banana peel powder and the various quality parameters involved are analyzedand discussed in this chapter.

4.1 Banana peel

The effect of citric acid on prevention of enzymatic browning was studied by analyzing the colour values of powdered banana peel. The colour values of banana peel treated with different concentrations of citric acid is shown in Table 4.1. From the table it can be clearly observed that the banana peels that were dipped in 0.5% citric acid for 10 minutes showed lowest L* value. This implies that the treatment with 0.5% citric acid resulted in a better colour retention. Similar results were also reported by Yueminj *et al.* (2004) for fresh Chinesewater chestnut.

- **Table 4.1** Banana peel powder color analysis

parameters	**(blank) b0**	**(0.1% citric acid blanching) b1**	**(0.5% citric acid blanching) b2**	**(1% citric acid blanching) b3**
L*	44.7	46.3	51.7	53.8
a*	5.5	5.5	5.8	5.9
b*	18.6	18.1	19.3	20.4
c*	19.4	18.9	20.2	21.2

h*	73.4	73.3	73.2	73.9

Based on the pretreatment done to banana peel 3.2

A = 0.1g in 10 minutes

B =0.5g in 10 minutes

C =0.5g in 20 minutes

D = 1g in 10 minutes

4.1.1 Moisture content

The moisture content of the banana peel was estimated by infrared moisture meter and found to be 83%.

4.1.2 Drying

According to the findings of Kumar in 2015, the drying kinetics of banana peel revealed that drying at 70°C resulted in a lighter color. As a result, the pre-treated banana peel was subjected to drying in a heat pump drier at 70°C, for Six hours.

Table 4.2 Relationship between drying time and moisture content.

Time (hour)	Weight (g)	Moisture(%)
1	20.86	76.21
2	13.57	50.33
3	9.66	35.36
4	7.46	27.16
5	2.93	11
6	2.56	9.38

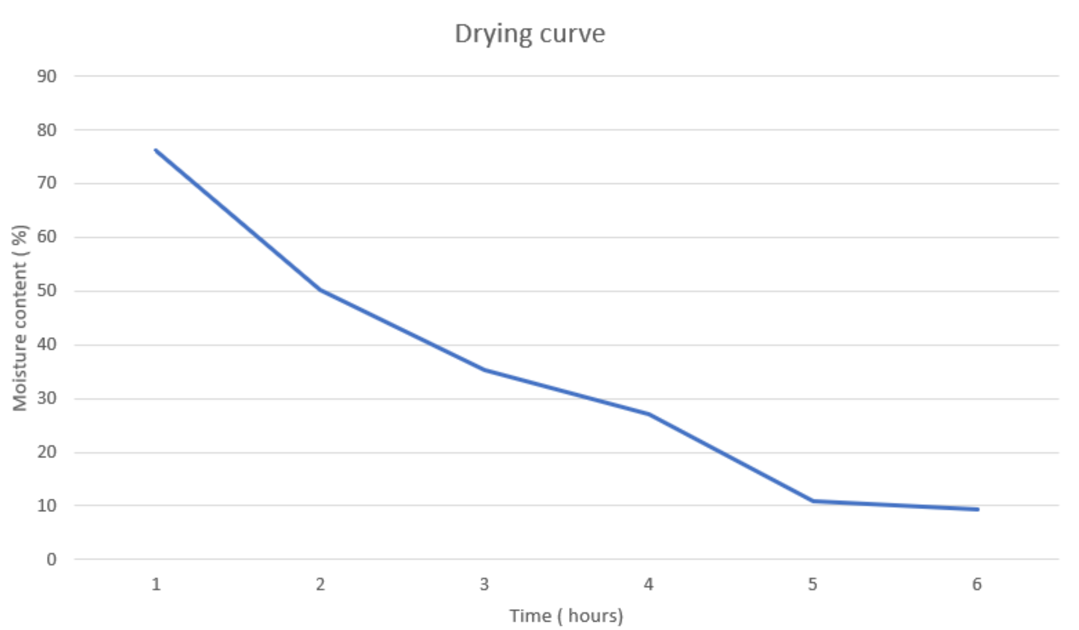

Fig 4.1 Graphical representation of drying curve

4.2 Results of qualitative analysis of bread

4.2.1 Sensory analysis

The scores given for different treatments on different organoleptic traits namely colour,flavour, texture and overall acceptability are presented in Table.

Table 4.3 sensory analysis

	MEAN SCORE					
Sample	Appearance	Flavour	Texture	Odour	Mouthfeel	Overall acceptability
B0	8.5	8.5	8	8	8.24	8.5
B1	6.16	8	7.33	6.83	7.16	7.33
B2	6.66	7.33	6.5	7	6.83	6.83
B3	7.16	7	6.16	6.66	5.83	6.33

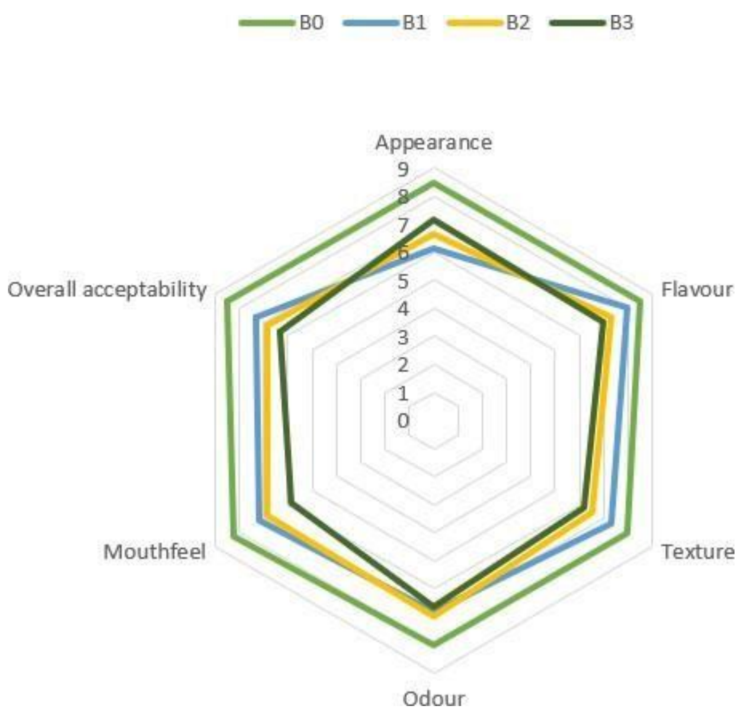

Fig 4.2 Spider web diagram of sensory analysis

From sensory analysis it is found that B1 is closer to the B0 bread without banana peel and as the B3 is found to be not preferred by the panelist so it is excluded from the quality analysis.

4.3 Chemical Composition of Bread

Table 4.4 Proximate chemical composition of bread with and without banana peels

Sample	**Moisture %**	**Crude fiber %**	**Fats %**	**Carbohydrate%**	**Protein %**	**Ash%**
B0	19.16	0.64	0.61	54.56	9.7	15.33
B1	21.96	1.48	0.79	48.6	12.5	14.67
B2	24.04	1.69	1.10	43.2	13.94	16.03

The results of the chemical composition of bread made from Maida and banana peels flour (BPF) formulas are shown in the Table. There was an increase in moisture, protein, fiber, fat and ash contents of bread made from (BPF).

4.3.1 Crude fibre

The fiber content of B2 and B1 bread (1.69% and 1.48%) was increased as compared to the control bread B0 (0.64%). The fiber content of bread increased with the increase in banana peel flour. The increase in fiber content leads to an increase in water requirement for the bread preparation. The fiber, in general, may cause firmer crumb structure by a thickening effect on the area that surrounds the air bubbles in fiber added dough (Schleibinger *et al*., 2013). Crude fiber is anti-diabetic (WHO, 2004).

4.3.2 Carbohydrate

The absorbents values obtained from the experiment; glucose curve plotted to get the corresponding concentrations. From the concentration values, the final carbohydrate value was determined. Carbohydrate content (54.56%) of the control bread decreased to 48.6% and 43.2% in B1 and B2. Bread containing few carbohydrates is important to decrease the risk of diabetes resulting from the high glycemic index (WHO, 2004). A daily diet containing small amounts of carbohydrates leads to a reduction level of ketone bodies in the blood (Johnston et al., 2006).

Table 4.5 Concentration and absorbance of standard glucose

Concentration	Absorbance
0	0
0.2	0.163

0.4	0.23
0.6	0.356
0.8	0.449
1	0.607

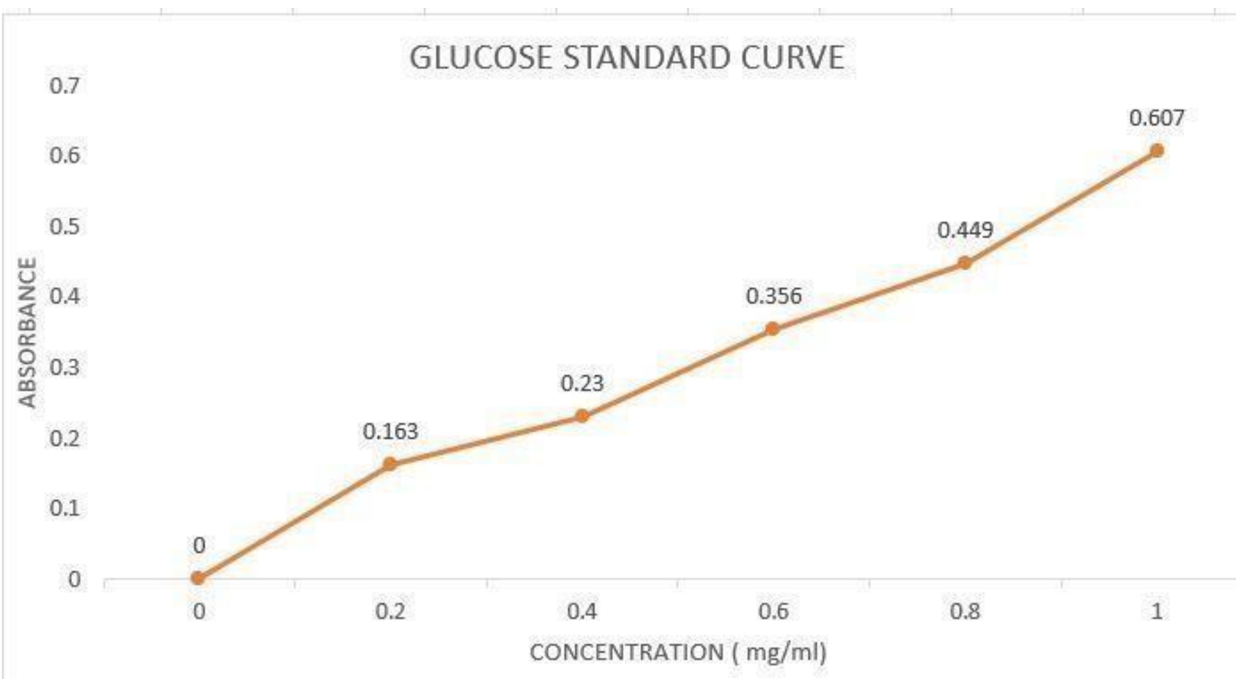

Fig 4.4. Graphical representation of standard curve

B0 – Bread without fiber

Concentration of carbohydrate in 100 mg of sample = 54.56 mg

B1 – Bread with 5% fiber

Concentration of carbohydrate in 100 mg of sample = 48.6 mg

B1 – Bread with 10% fiber

Concentration of carbohydrate in 100 mg of sample = 43.2 mg

4.3.3 Moisture Content

The addition of banana peel powder leads to the increase in moisture content of bread. The moisture content of B1 and B2 bread was 21.96% and 24.04% which was increased from 19.16% in B0 control bread. This due to the addition of banana fiber to bread leads to the increase in water absorption of bread as banana fiber was considered as a good water binder, so there is an increase in moisture content of bread (Chen *et al.*, 1988). The results are the same as there is an increase in water absorption as a concentration of banana powder increased in bread.

4.3.4 Fat content

The addition of banana peel powder is increasing fat content of bread in few amounts. The structure of bread is improved by increasing fat content of bread. The fat content of B1 and B2 bread was 0.79% and 1.10% which was higher than the control bread (0.61%).

4.3.5 Protein content

BPF affected the protein content of bread. The protein content of Banana fortified bread (B1, B2) was higher (13.94% and 12.5%) as compared to the control bread (9.70%). Protein is necessary for reducing protein-energy malnutrition and physiological functioning (WHO, 2004)

4.3.6 Ash content

The ash content of Blank bread (B0), Bread fortified with 5% and 7.5% banana peelpowder (B1 and B2) was 15.33%, 14.67% and 16.06% respectively. With respect to the given data the ash content increases with the increase in concentration of Banana peel powder.

4.3.7 Colour analysis

In the color analysis of the bread sample for our project report, we employed a calibrated colorimeter to assess the color space values of the representative bread portion. The procedure involved ensuring a uniform sample surface, recording the colour data, and comparing it to established standards for precise colour characterization. Multiple measurements were conducted across the bread sample to validate the consistency of the color analysis results.

- **Table 4.6** Colour analysis of bread

	Banana peel concentration		
Parameters	**B1 (5%)**	**B2 (7.5%)**	**B3 (10%)**
L*	42.5	40.5	38.6
a*	4.5	5.2	5.9
b*	14.5	14.6	14.8
c*	15.2	15.5	15.9
h*	72.6	70.7	68.9

By comparing various colour spaces using colourimeter, the banana peel powder of 0.5 g in 10 minutes and that of fortified bread containing concentration of 5% BPF is more accepted. L* value is high in the sample with 5% BPP. High L* value indicate high lightness and product having 5% BBP concentration is more lighter as compared to others.

4.2.9 Texture analysis

Hardness of different bread samples were analysed through texture analysis

Table 4.7 Hardness of bread

SAMPLE	HARDNESS(N)
B0	10.5
B1	26.89
B2	23.95
B3	24.90

Banana peels contain a significant amount of fiber, particularly insoluble fiber, which adds bulk and texture to foods. When incorporated into bread dough, banana peel powder could impart a slightly grainy or fibrous texture to the bread. The degree of texture variation would depend on factors such as the amount of banana peel powder used and its particle size. Finely ground powder might integrate more smoothly into the dough, while coarser powder could create a more noticeable texture.

SUMMARYAND CONCLUSION

SUMMARY AND CONCLUSION

Processed foods /snack foods may be described as mini meals in between main meals. Snacks like banana chips, jack fruit chips, coconut chips etc. are light to eat and serve a variety of useful purposes in our day-to-day life. Banana chips making has already developed into a cottage and small-scale industry in Kerala and the product is in high demand in India as well as abroad, especially in Middle East countries. Peel, the main by-product of banana constitutes 30-40 % of the fresh biomass of the Nendran fruit was found to contain much higher beneficial compounds compared to other fruit parts. They are rich source of crude protein (6-9 %), crude fat (3.8-11 %), total dietary fibre (43.2- 49.7 %), polyunsaturated fatty acids, essential amino acids and micronutrients on dry weight basis. Banana peels are also a good source of lignin (6-12 %), pectin (10-21 %), cellulose (7.6-9.6 %), hemicelluloses (6.4- 9.4 %) and galacturonic acid. The natural bioactive compounds such as carotenoids, quercetin derivatives, phenolic acids and saponins are found in the peels in high concentration. Significant quantities of banana or plantain peels, equivalent to 40% of the total weight of fresh banana, are generated as a waste product in industries producing banana chips. At present, these peels are not being used for any other purposes and are mostly dumped as solid waste at large expense. It is thus significant and even essential to find applications for these peels as they can contribute to real environmental problems.

Since there has been minimum research in the field of banana peel processing and storage, the present study of "Development of fibre fortified bread using banana peel powder" was under taken at Kelappaji College of Agricultural Engineering and Technology, Tavanur to reduce the wastage of banana peel which is a rich source of fiber, amino acids and carotenoid.

Banana peel, of 'Nendran' variety, was used for the study. The suitable pretreatments including dipping in 1% citric acid for 10 minutes to reduce enzymatic browning was done. Then the samples were dried using heat pump drier at 70^0C.The dried peel slices were finely powdered with the help of a mixer grinder which was sieved through a clean sieve of 40mesh screen to obtain fine banana peel powder, packed in LDPE pouches and stored. The stored peel powder was subjected to colorimeter tests to find out the correct pretreatment combination and thus develop the bread.

The development of fiber-fortified bread using banana peel powder has emerged as a noteworthy strategy to augment the nutritional content of traditional bread products. In this research endeavor, banana peel powder, recognized for its high dietary fiber content, was successfully incorporated into the bread formulation. The experiment revealed a substantial increase in the overall fiber content of the bread, positioning it as a potential contributor to improved digestive health and weight management. Beyond the nutritional enhancement, the addition of banana peel powder imparted a distinct flavor and color to the bread, and it was found that composition containing 95% flour and 5% peel was most accepted, offering a unique sensory experience for consumers. Importantly, consumer feedback indicated a positive acceptance of the fiber-fortified bread, with many expressing appreciation for its taste and texture. This research not only holds promise for enhancing the nutritional quality of bread but also addresses sustainability concerns by repurposing banana peels, thereby reducing food waste.

In conclusion, the development of fiber-fortified bread using banana peel powder presents a viable and innovative avenue for improving the nutritional profile of baked goods, contributing to both consumer health and sustainable food practices. Further exploration into optimization for mass production and a deeper understanding of potential health benefits associated with regular consumption is warranted for comprehensive implementation.

REFERENCE

REFERENCE

- "Ahmad, B. A., Zakariyya, U. A., Abubakar, M., Sani, M. M., & Ahmad, M. A. (2019). *Pharmacological activities of banana. Banana Nutrition-Function and Processing Kinetics,* 1-20."
- Alam, M. J., Akter, S., Afroze, S., Islam, M. T., & Sayeem, E. H. (2020). *Development of fiber and mineral enriched cookies by utilization of banana and banana peel flour. Journal of microbiology, biotechnology and food sciences*, 10(3), 329-334.
- Anhwange, B. A., Ugye, T. J., & Nyiaatagher, T. D. (2009*). Chemical composition of Musa sapientum (banana) peels. Electronic Journal of Environmental, Agricultural and Food Chemistry,* 8(6), 437-442. (composition peel)
- DebabandyaMohapatra ,Sabyasachi Mishra and Namrata Sutar.2010. *Banana and its byproduct utilization*.J.Scient and Ind.Res.69:323-329.
- Durgadevi, P. K. S., Saravanan, A., & Uma, S. (2019*). Antioxidant potential and antitumour activities of Nendran banana peels in breast cancer cell line.* Indian J. Pharm. Sci, 81(3), 464-473.
- "Falcomer, A. L., Riquette, R. F. R., de Lima, B. R., Ginani, V. C., & Zandonadi, R. P. (2019*). Health Benefits of Green Banana Consumption: A Systematic Review. Nutrients,* 11(6), 1222.
- Gomes, A. A. B., Ferreira, M. E., & Pimentel, T. C. (2016*). Bread with flour obtained from green banana with its peel as partial substitute for wheat flour: Physical, chemical and microbiological characteristics and acceptance. International Food Research Journal, 23*(5).
- Kaewjumpol, G., Srisamlee, S., Beckles, D. M., & Luengwilai, K. (2021). *Enzymatic browning in banana blossoms and techniques for its reduction. Horticulturae*, 7(10), 373.

- Karthikeyan, M. S. (2015). *Development of value added products from banana peel* (Doctoral dissertation, Department of Home Science, College of Agriculture, Vellayani).
- Kumar, K. S., Bhowmik, D., Duraivel, S., & Umadevi, M. (2012). *Traditional and medicinal uses of banana. Journal of pharmacognosy and phytochemistry*, *1*(3), 51-63.
- lzate Acevedo, S., Díaz Carrillo, Á. J., Flórez-López, E., & Grande-Tovar, C. D. (2021). *Recovery of banana waste-loss from production and processing: a contribution to a circular economy*. Molecules, 26(17), 5282.
- M. Zhang and Z. Huan, "*Expiremental setup of an air source heat pump for dryingbanana chips,"* 2013 Proceedings of the 10th Industrial and Commercial Use of EnergyConference, Cape Town, South Africa, 2013, pp. 1-6.
- Manimaran, D. S., Nadaraja, K. R., Vellu, J. P., Francisco, V., Kanesen, K., & BinYusoff, Z. (2016). *Production of biodegradable plastic from banana peel.* Petrochem. Eng, 1, 1-7.
- Oguntoyinbo, O. O., Olumurewa, J. A. V., & Omoba, O. S. (2023). *Antioxidant and Dietary Fibre Content of Noodles Produced From Wheat and Banana PeelFlour.* IPS Journal of Nutrition and Food Science, 2(2), 46-51.
- Prasertsan, S., & Saen-Saby, P. (1998*). Heat pump drying of agricultural materials*. Drying technology, 16(1-2), 235-250.
- Segura-Badilla, O., Kammar-García, A., Mosso-Vázquez, J., Sánchez, R. Á. S., Ochoa-Velasco, C., Hernández-Carranza, P., & Navarro-Cruz, A. R. (2022). *Potential use of banana peel (Musa cavendish) as ingredient for pasta and bakery products*. *Heliyon*, *8*(10).
- Segura-Badilla, O., Kammar-García, A., Mosso-Vázquez, J., Sánchez, R. Á. S., Ochoa-Velasco, C., Hernández-Carranza, P., & Navarro-Cruz, A. R. (2022). *Potential use of banana peel (Musa cavendish) as ingredient for pasta and bakery products*. *Heliyon*, *8*(10).

- Shammari, B. B. (2023, December). *The Influence of Adding Banana Peel Powder on the Quality of Pan Bread.* In IOP Conference Series: Earth and Environmental Science (Vol. 1262, No. 6, p. 062027). IOP Publishing.
- Wang, J., Rosell, C. M., & de Barber, C. B. (2002*). Effect of the addition of different fibres on wheat dough performance and bread quality*. Food chemistry, 79(2), 221-226.
- Yildiz, G. (2018). *The effect of different chemical agents on the prevention of enzymatic browning in banana.* Journal of Food Science and Engineering, 7, 86-91.

Abstract

This study explores the utilization of banana peel, a by-product of banana chip production, in developing fiber-fortified bread. The research conducted at Kelappaji College of Agricultural Engineering and Technology demonstrates the potential of banana peel powder as a rich source of fiber, amino acids, and carotenoids. The study involves suitable pretreatments, drying processes, and colorimeter tests to determine the optimal conditions for banana peel powder incorporation into bread.

The fiber-fortified bread not only exhibits a substantial increase in overall fiber content, promoting digestive health and weight management, but also introduces a distinct flavor and color. Consumer feedback indicates positive acceptance, particularly for compositions containing 95% flour and 5% peel. This innovative approach not only enhances the nutritional profile of bread but also addresses sustainability concerns by repurposing banana peels, contributing to reduced food waste.

The chemical composition analysis reveals increased moisture, protein, fiber, fat, and ash contents in bread made from banana peel flour formulas. The study suggests potential anti-diabetic properties associated with increased crude fiber and emphasizes the importance of reducing carbohydrate content for managing diabetes risk. Moreover, the addition of banana peel powder positively influences moisture absorption, fat content, protein levels, and ash content in the bread.

In conclusion, the development of fiber-fortified bread using banana peel powder presents a promising avenue for enhancing nutritional quality, consumer health, and sustainable food practices. Further exploration into mass production optimization and understanding potential health benefits is recommended for comprehensive implementation.