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Unlocking the hidden potential of Banana Peel (*Musa Cavendish*) as a functional ingredient in food product development– A Zero waste treasure for Human Being

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Abstract: *Banana, a ubiquitous food crop globally, often results in the disposal of its peel, similar to other agricultural by-products. Bananas, particularly their peels, represent a promising source for creating value-added products such as dietary fiber and bioactive components. This study aimed to investigate the feasibility of utilizing banana peel (Musa Cavendish) as a key ingredient in formulating food products. The objectives included evaluating the impact of banana peel incorporation on the sensory attributes of food products, assessing the nutritive value of such products, and evaluating the economic viability and environmental sustainability of utilizing banana peel in food product development. A variety of food products, including chutney, jam, halwa, pancake, tiki, and bacon, were formulated with 100 grams of banana peel in each.*

Sensory evaluation, conducted by a trained panel, assessed the sensory attributes of the prepared food products. A comparison with control samples was made to understand the effect of banana peel incorporation on the sensory characteristics, utilizing a 9-point hedonic scale rating. Statistical analysis, employing an independent t-test through one-way analysis of variance (ANOVA), was conducted at both 5% and 1% probability levels.

The study revealed that the treated product received the highest score on the 9-point hedonic scale, signifying its strong preference by the panel compared to the control product. Statistical analyses confirmed significant differences between the control and treated products, with the treated product being accepted at both probability levels. Regarding nutritional value, the treated product demonstrated superior nutrition, with higher levels of energy, protein, carbohydrates, fats, dietary fiber, vitamins, minerals, and various bioactive compounds compared to the control product.

The banana peel used in the study proved economically viable and cost-effective, sourced from localestablishments in Patna. Additionally, it showcased environmental sustainability, highlighting its potential as a functional ingredient in food products.

Keywords: Banana Peel, Antioxidant Activity, Dietary Fiber, Sensory Attributes, Food Products

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Introduction:

Banana is the fruit of a plant of the genus Musa (family Musaceae) and is an essential domesticated herbaceous fruit crop in numerous tropical and subtropical regions of India. It is esteemed overall for its availability, affordability, flavour, dietary value, and medicinal properties throughout the year. Banana stands firm on the footing of the second most significant natural fruit crop in India, following mango. Major contributors to worldwide banana manufacturing countries consist of China, Ecuador, the Philippines, Brazil, Indonesia, India, Guatemala, Angola, and Burundi. The key banana producing states in India consist of Andhra Pradesh, Tamil Nadu, Maharashtra, Gujarat, Kerala, and Karnataka. Maharashtra stands apart as the biggest banana-tradingstate, ordering a 96.91% percentage in value.

Banana peel is the outer layer of banana that serves to protects the fruit's inner flesh. The banana peel, constituting approximately one-third of the fruit's weight (35% to 40% of the entire weight), serves as the outer protective layer for the inner flesh. Often taken into consideration waste, peels are usually discarded as a derivative of banana processing, as they have not been extensively studied for potential commercial applications. Research on using banana leftovers to examine their impact on food characteristics has turn out to be a famous practice. Approximately one-third of a banana is wasted due to the fact humans have a tendency to consume only fully ripe fruits. Consequently, the usage of bananas in all ripening stages has gained increasing attention in recent years. as they have not been extensively studied for potential commercial applications**.**

Ripe banana peel holds excellent capacity because of its richness in nutritional fiber, phenolic compounds, sugar components, proteins, potassium, and polyunsaturated fatty acids. Various uses for banana peels were identified, starting from culinary application to water purification, biochemical product manufacturing, and at the same time as an ingredient in inorganic waste production. The upcycling of agricultural by-products, particularly from common food plants like bananas, has garnered large interest.

Despite traditionally being consumed for its medicinal properties in a few regions, banana peels are usually overlooked. Recent studies indicates that banana peels may be converted into useful foods because of their bioactive compounds. Moreover, the use of banana peels and different natural waste from fruits and vegetables as ingredients or raw materials in manufacturing processes can cope with waste disposal and environmental pollution issues.

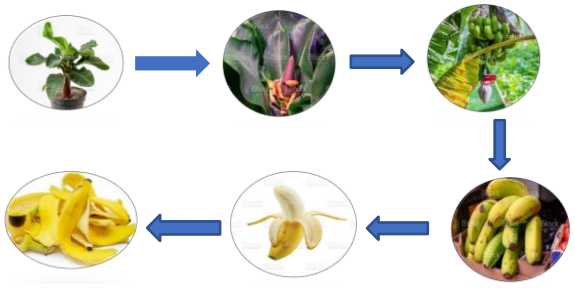

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Plate 1.1. Musa *Cavendish* (Banana Peel)

The utilization of fruit peels in nutrient supplementation is primarily based on their chemical composition. Similar to its pulp counterpart, the peel of a banana is a great supply of nutrients because of the excessive value received from the determination of lipids, carbohydrates, and fiber. The bananapores and skin has better overall nutritional fiber, fat, ash content, however decrease starch and protein content. The banana peel includes antioxidant and bioactive compounds including carotenoids, catecholamines, polyphenols, and excessive quantities of micronutrients established withinside the peel of the genus Musa (Wachirasiri *et al.,* 2008).

Traditionally, bananas peels were used for the treatment of various ailments, which includes burns, anaemia, inflammation, diabetes, and ulcers. Given its nutritional richness, banana peels have discovered programs in diverse food items, including bakery, culinary products, and meat products, providing capacity health advantages because of their bioactive compounds. As the world's population continues to grow and the call for environmentally pleasant agricultural by-products rises, banana by-products and waste goods presents promising possibilities for innovation withinside the nutraceutical and pharmaceutical industries.

Reusing banana production waste, such as skin may also increase enter substances productivity and alleviate the massive waste disposal challenging situations faced by the food sector. Because both fruits have large antioxidant capacity and are wealthy in phenolic compounds in addition to vitamin

Reusing banana peel to expand a food product to increase the nutrient advantage will consequently be the maximum technologically and economically possible option. Around the world, humans are getting extra privy to the want of eating healthy food and health-conscious customers favour foods that provide advantages beyond simply fundamental nutrition.

In conclusion, banana peels, frequently discarded, have confirmed to be a precious and flexible aid with an extensive variety of potential applications. From their use in diverse food preparation to their medicinal properties and contribution to environmental sustainability, banana peels provide an array of advantages that warrant further exploration and usage in various industries.

Table 1.1. Composition of Nutrients in Banana Peels

Nutrient Composition	Unit	Content (Gm/100gm)
Energy	Kcal	290.24
Moisture	Gram	21.96
Carbohydrate	Gram	54.01
Protein	Gram	10.4
Fat	Gram	5.32
Dietary Fiber	Gram	50.25
Calcium	Milligram	19.2
Iron	Milligram	0.61

Source: (Radzi *et al*., 2020)

Objectives:

O1: To investigate the feasibility of utilizing banana peel (*Musa Cavendish*) as a key ingredient in theformulation of food products.

O2: To evaluate the impact of banana peel incorporation on the sensory attributes of food products.

O3: To assess the nutritive value of food products containing banana peel.

O4: To assess the economic viability and environmental sustainability of utilizing banana peel infood product development.

Hypothesis:

H_1: It is significantly feasible to utilize banana peel (Musa Cavendish) as a key ingredient in the formulation of food products, resulting in a significant positive impact on product quality and acceptability.

H_2: The incorporation of banana peel into food products significantly enhances their sensory attributes, including taste, texture, and aroma.

H_3: Food products containing banana peel demonstrate a significantly higher or comparable nutritive value in essential nutrients like dietary fiber, carbohydrate, protein, fat, vitamins, minerals,calcium, and iron compared to products without banana peel.

H_4: The utilization of banana peel in food product development significantly leads to economically viable and environmentally sustainable outcomes, supported by its availability and affordability as a byproduct.

Research Gap:

Banana peels, considered waste from banana fruit, contain a high amount of antioxidants, phenolic content, and minerals. However, these wastes have not received much attention for potential use or recycling, possibly due to their unknown commercial applications. The primary by-product of the banana processing industry is the peel, constituting approximately 30% of the fruit. Banana peels also have commercial potential, as they qualitatively and quantitatively contain more antioxidants than the pulp.

Hence, the present study focuses on "Unlocking the Hidden Potential of Banana Peel (Musa Cavendish) as a Functional Ingredient in Food Product Development – A Zero Waste Treasure for Human Beings." This study aims to contribute to the existing literature and address the research gap by utilizing banana leftovers in their ripening stage. Additionally, the study prepares a food product using fresh banana peel, as its nutrient content is higher than that of dried banana peel or banana peel flour. The study includes a 9-point hedonic scale rating and an independent t-test employing a one-way analysis of variance (ANOVA) for the prepared products.

Completing this research offers a significant benefit to people by providing knowledge and raising awareness about the reusing of banana peel as an essential ingredient in food products due to its nutritional benefits. Moreover, it represents an economically feasible option.

Significance of the Research:

The significance of the study on the potential use of banana peel (Musa Cavendish) in the formulation of food product development as a zero-waste treasure for human beings is multifaceted and extends to various aspects of sustainability, human health, and economic benefits. The study's findings and implications can have a substantial positive impact on the environment. Some key points of significance are:

- **Waste Reduction and Sustainability:** Banana peels are a significant agricultural waste stream, and their utilization in food product development offers a sustainable solution to reduce food waste. By converting

this by-product into edible and nutritious food products, the study contributes to a more sustainable and circular economy, minimizing environmental impact and conserving resources.

- **Nutritional Enrichment:** Banana peels are rich in essential nutrients such as dietary fiber, vitamins (B6, B12, C), minerals (potassium, magnesium), and bioactive compounds like antioxidants. Incorporating banana peel into food products enhances their nutritional profile, providing consumers with access to additional health benefits. This is especially crucial as dietary fiber and certain micronutrients are often lacking in modern diets.
- **Functional Properties:** Banana peels possess unique functional properties, such as water and oil absorption, emulsifying abilities, and gelling properties. These attributes can enhance the texture, stability, and shelf life of food products. The study can unlock novel ways of using banana peel to improve the overall quality of food items.
- **Health Benefits:** The consumption of banana peel-derived products can contribute to better digestive health due to the high fiber content. Additionally, the bioactive compounds present in banana peels, such as polyphenols, have potential health-promoting effects, including antioxidant and anti-inflammatory properties.
- **Affordability and Accessibility:** As a by-product readily available in large quantities, utilizing banana peels as a food ingredient can provide an affordable and accessible source of nutrition. This aspect is especially significant for regions where food insecurity and malnutrition are prevalent.
- **Diversification of Food Product Portfolio:** Incorporating banana peel into food product formulations allows for the development of innovative and unique food items. This diversification expands consumer choices and can open up new markets for food manufacturers, leading to increased competitiveness in the industry.
- **Educational and Awareness Impact:** The study contributes to raising public awareness about food waste and the potential of utilizing unconventional yet nutritious ingredients in food product development. By showcasing the value of banana peel as a zero-waste treasure, it can encourage individuals and businesses to adopt more sustainable practices in their daily lives and operations.
- **Food Industry Applications:** Food companies can benefit from incorporating banana peel in their product development strategies as it aligns with consumer demands for sustainable and nutritious food options. It also presents opportunities for collaboration with banana growers and processors, fostering partnerships that support local economies.

In conclusion, the significance of this study on the potential use of banana peel in food product development extends beyond waste reduction. It encompasses nutritional enrichment, functional benefits, health impacts, affordability, and the potential to diversify the food product market. By turning banana peels into a zero-waste treasure for human consumption, this research contributes positively to both the food and nutrition fields, fostering a more sustainable, health- conscious, and environmentally responsible food industry.

Review of Literature:

Wirawan, *et al.,* (2016) studied that “Quality of Jam Made from Banana King's Peel Jam is a food product with the consistency of gel or semi-solid made from pureed soup”. This study utilizes waste banana peel, especially banana king's peel into refined products by process it into jam. The purpose of this study was to determine the utilization of quality of jam made from banana king's peel. This is qualitative research, the data in this study were

obtained from the data test instrument research. The data have been collected and processed, the data test instrument research. The data have been collected then processed, percentage, and presented in the form of bar chart. As the conclusion of this research is the result from the panelists "Quality of Jam made from Banana King's Peel" in general are looking for average value as a control variable obtain the final value of 73.4%, taste got 87.5%, aroma got 75%, colour got 67.8%, and texture got 62.5%.

Singh *et al*., (2017) studied that Comparative Study of the Properties of Ripe Banana Flour, Unripe Banana Flour and Cooked Banana Flour Aiming Towards Effective Utilization of These Flours. Ripe banana flour, unripe banana flour and cooked banana flour prepared from banana procured from local market were assessed for physicochemical and functional properties such as pH, total soluble solids (TSS), water absorption capacities, and oil absorption capacities at 40, 60 and 80°C, colour values L*, a* and b*, bulk density foaming capacity and foaming stability, emulsion activity and stability, dispersibility and wet ability. Data obtained were analysed by standard deviation and average based. All statistical analyses showed that physicochemical and functional properties prepared from ripe green and cooked banana were different from each other. pH, TSS, WAC, bulk density and colour values used to discriminate between ripe, unripe and cooked banana flour.

Taiyeba *et al*., (2020) reported that “Utilization of Potato Peels Powder and Sweet Potato Peels Powder for the Preparation of the Value-Added Food Products” was carried out with the Objective to determine the Nutritional Composition of mix Powder. The dehydration of Potato peel and sweet potato peel was done through tray drying at 60-650C for 10 hours. The products prepared were Cookies and Muffins by incorporation of dehydrated potato peel powder and sweet potato peel powder mix in different proportions and served as Treatments T1, T2, and T3 respectively T0 without incorporation of dehydrated potato peel powder and sweet potato peel powder served as control. Three replications of control and treatments for all three products were carried out and mean values were obtained. Sensory evaluation was carried out using the nine- point Hedonic scales. Data obtained were statistically analyzed by using analysis of variance (ANOVA), (t)test and critical difference (CD) techniques. On the basis of findings, it was observed that in case of Cookies and Muffins value addition at 5% incorporation level with the potato peel powder and sweet potato peel powder the best product with regard to sensory attributes and overall acceptability.

Badilla *et al*., (2022) studied that Potential use of banana peel (Musa cavendish) as ingredient for pasta and bakery products. 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 a 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.

Materials and Methods:

The study entitled Potential Use of Banana peel (*Musa Cavendish)* in formulation of food products development- A zero waste Treasure for Human Being. Analyze previous research studies on the utilization of banana peel in various food products to identify gaps and areas for further investigation. The details of material, procedure and techniques adopted during the course of investigation elaborated under the following headings.

Raw Materials Procurement: Fresh and high-quality banana peels of the *Musa Cavendish* variety was sourced from local food establishments, juice shops, and markets in Patna. This step ensures the availability of consistent and suitable raw materials for the research study.

Experimental Site: The experimental preparations has conducted in the cookery lab of the P.G. Department of Home Science, Patna Women's College, Patna University, Bihar. This facility provides a controlled and conducive environment for conducting the research.

Sample Preparation: The collected banana peels was undergone thorough washing, cleaning,and sorting to remove any impurities. The peels were cut into small pieces, making them ready for further processing in the subsequent steps.

Treatments and Replication of the Product: The primary ingredient was substituted on a trial basis to assess its acceptability. Each control and treatment condition underwent three replications for thorough examination and reliability.

Formulation of Food Products: A range of food product formulations, including Chutney, Jam, Halwa, Pancake, Tiki and Bacon were prepared by banana peel. Different concentrations of banana peel extracts were incorporated to assess their impact on the final products. The formulations were adhered to food safety and quality standards to ensure the products safety and acceptability. On the basis of trial food product will be developed.

Organoleptic Analysis Sensory Evaluation of Prepared Products: Sensory evaluation test was conducted using a trained panel to assess the sensory attributes of the prepared food products. The panel evaluate the taste, texture, aroma, and overall acceptability of the products containing banana peel extracts. A comparison with control samples was made to understand the effect of banana peel incorporation on the sensory characteristics of the food products. The products were judged for the qualities such as body and texture, taste and flavour, colour and appearance and over all acceptability with the help of nine-point hedonic scales (B. Srilakshmi, 7th edition).

Plate 1.2. Sensory Evaluation of Food Products by Panel Members

Cost of the Prepared Products: The cost analysis was performed to calculate the total expenses involved in preparing thefood products that incorporate banana peel extracts. This includes costs related to raw materials, equipment, labor, packaging, storage, and transportation. Evaluating the costof the prepared products will provide insights into their economic feasibility and commercial viability.

Data Analysis and Application of Statistical Test: Data collected from various aspects of the research, such as sensory evaluation, nutritional analysis, and cost analysis, was analyzed using appropriate statistical methods. Statistical tests, such as independent t- test, ANOVA, will be applied to identify patterns, trends, and significant differences within the data. The application of statistical tests was ensuring the validity and reliability of the research findings and help draw objective conclusions based on the data.

Development of Consumer Awareness Materials: A poster was created for the purpose of giving education and knowledge regarding awareness of banana peel among the youth. A poster was entitled awareness regarding banana peel, which include the information related to the underutilized of banana peel, importance of banana peel and potential application of banana peel in food production. A poster was crafted with the aim of economically fostering awareness and knowledge among the youth about banana peel.

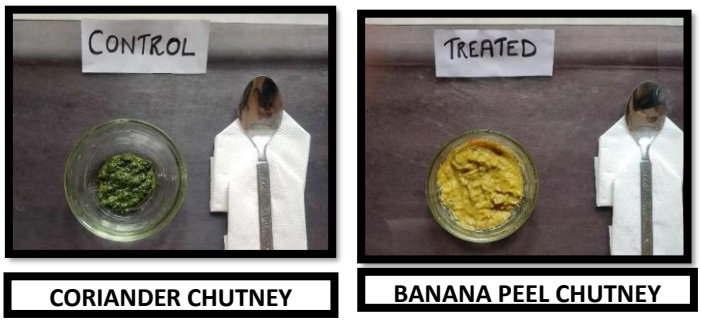
Plate 1.3. Giving Information about Utilization of Banana Peel inDifferent Food Products through Poster

Results and Discussion:

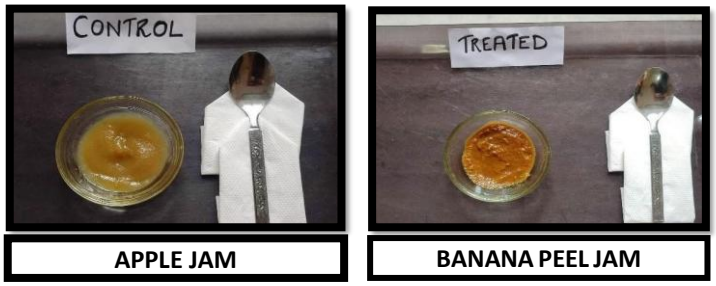
The data recorded in the present study, entitled 'Unlocking the Hidden Potential of Banana Peel(*Musa Cavendish)* as a Functional Ingredient in Food Product Development– A Zero Waste Treasure for Human Beings,' are discussed in this chapter. Various aspects, as per the methodology, have been tabulated and analyzed statistically. The results obtained from the analysis are presented and discussed in the following sections.

Objective 1. To investigate the feasibility of utilizing banana peel (*Musa Cavendish*) as a key ingredient in the formulation of food products.

Product 1.

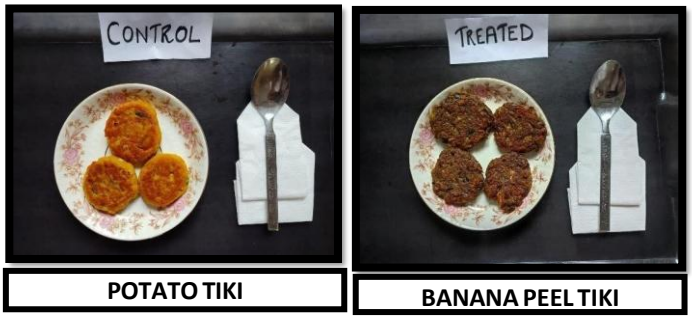


Product 2.

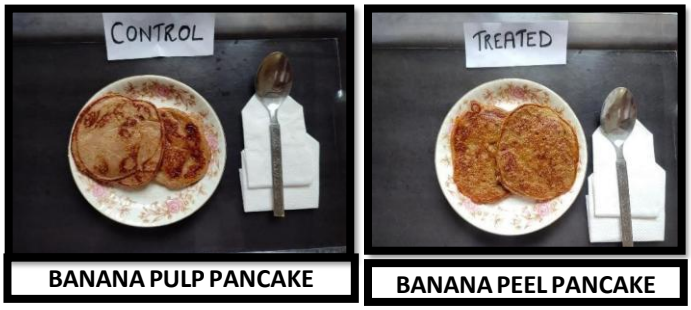


Product 3.

Product 4.



Product 5.



Product 6.

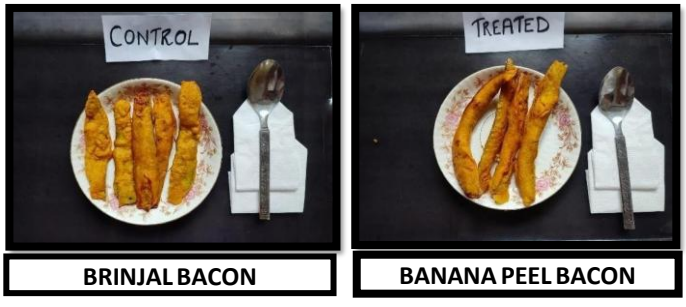


Fig. 1.1. Formulation of Food Products

Interpretation: The Fig. 1.1 shows that that a range of food product were formulated, that includes Chutney, Jam, Halwa, Pancake, Tiki and Bacon that were prepared by banana peel. The control and treated products were taken for analysis. In control products, food products were taken for the comparison that were prepared by the conventional method and in treated products banana peel was incorporated to make the food products. The formulations were adhered to food safety and quality standards to ensure the products' safety and acceptability.

Objective 2. To evaluate the impact of banana peel incorporation on the sensory attributes of food products.

Table 2.1 The average sensory scores of different parameters in control and treated sample of chutney.

Sensory Characteristics	SCORE ON 9 POINTS HEDONIC SCALE				
	Appearance and Colour	Taste and Flavour	Smell and Odour	Texture and Mouth Feel	Overall Acceptability
C_o (Control)	8.23	8.4	7.73	7.9	8.14
T_o (Treated)	8.46	8.63	8.06	8.23	8.49
T%	15.33	6.28	62	37	13
C.D	0.043	0.066	0.043	0.036	0.036

S = Significant, NS = Non-Significant

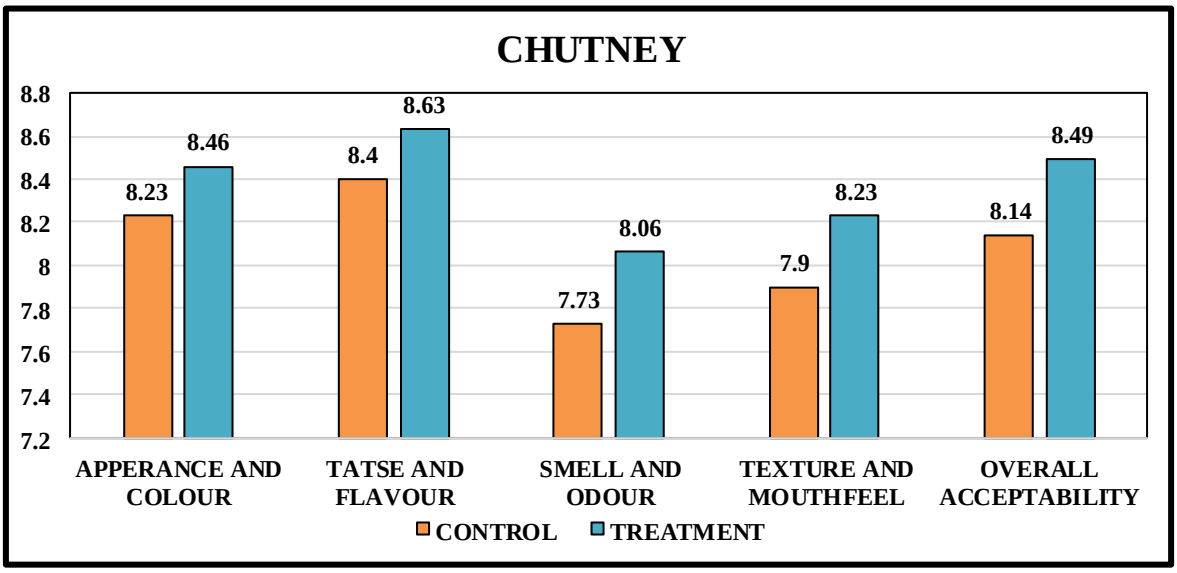


Fig. 1.2. Sensory scores of different parameters in control and treated sample of chutney

Interpretation: The Fig. 1.2 shows that the mean score of chutney in relation to taste and flavour is highest and scoring shows that the T_O banana peel chutney (8.63) had the maximum score followed by C_O coriander leave chutney (8.4) respectively. The panel judges liked the taste and flavour of treated product (banana peel chutney) that was spicy and tangy in their opinion.

Table 2.2. The average sensory scores of different parameters in control and treated sample of jam

Sensory Characteristics	SCORE ON 9 POINTS HEDONIC SCALE				
	Appearance and Colour	Taste and Flavour	Smell and Odour	Texture and Mouth Feel	Overall Acceptability
C_O (Control)	7.91	8	7.8	8.3	8
T_O (Treated)	8	8.5	8.3	8.5	8.3
T%	8.25	7.03	6.28	0.48	13
C.D	0.072	0.0601	0.062	0.147	0.065

S = Significant, NS = Non-Significant

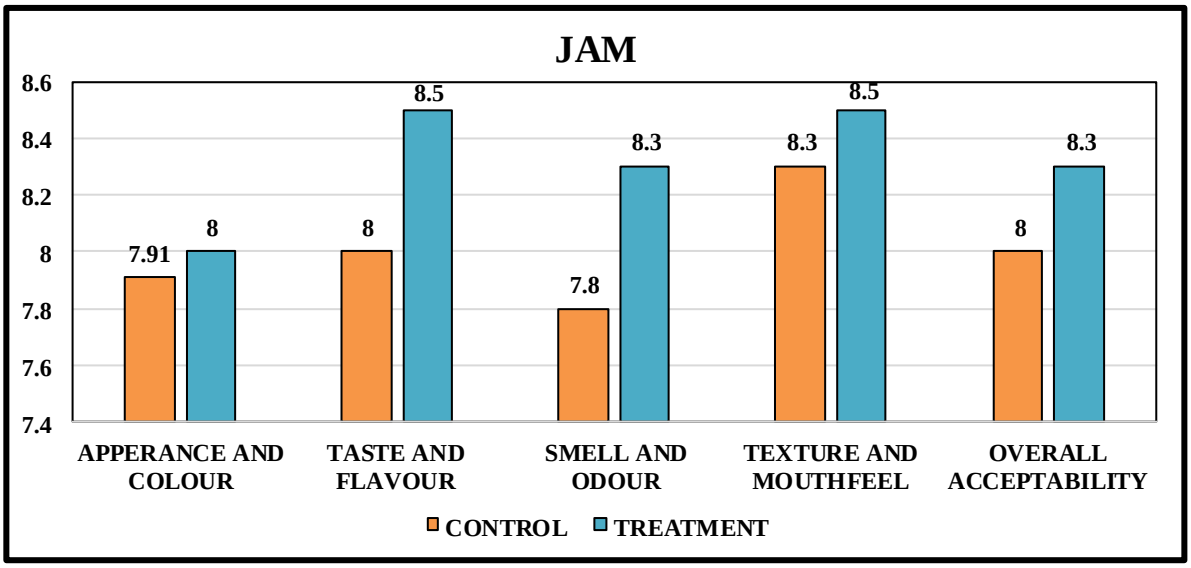


Fig. 1.3. Sensory scores of different parameters in control and treated sample of jam

Interpretation: The Fig. 1.3 indicates that the mean score of jam in relation to taste and flavour and texture and mouthfeel is the highest and scoring shows that the T_O (banana peel jam) had the maximum score in both taste (8.5) and texture (8.5) followed by C_O (apple jam) taste (8) and texture (8.3). The taste and flavour of the treated products made from banana peel, gives a strong sweet flavour which was highly liked by the panel members and the texture of banana peel jam was rough due to the content of high amount of dietary fiber in banana peel and it gives a good mouthfeel.

Table 2.3. The average sensory scores of different parameters in control and treated sample of halwa.

Sensory Characteristics	SCORE ON 9 POINTS HEDONIC SCALE				
	Appearance and Colour	Taste and Flavour	Smell and Odour	Texture and Mouth Feel	Overall Acceptability
C_O (Control)	7.85	7.91	7.58	8	7.43
T_O (Treated)	8.25	7.75	7.83	8.08	7.97
T%	31.7	2.25	6.5	4.6	2
C.D	0.164	0.020	0.005	0.100	0.154

S = Significant, NS = Non-Significant

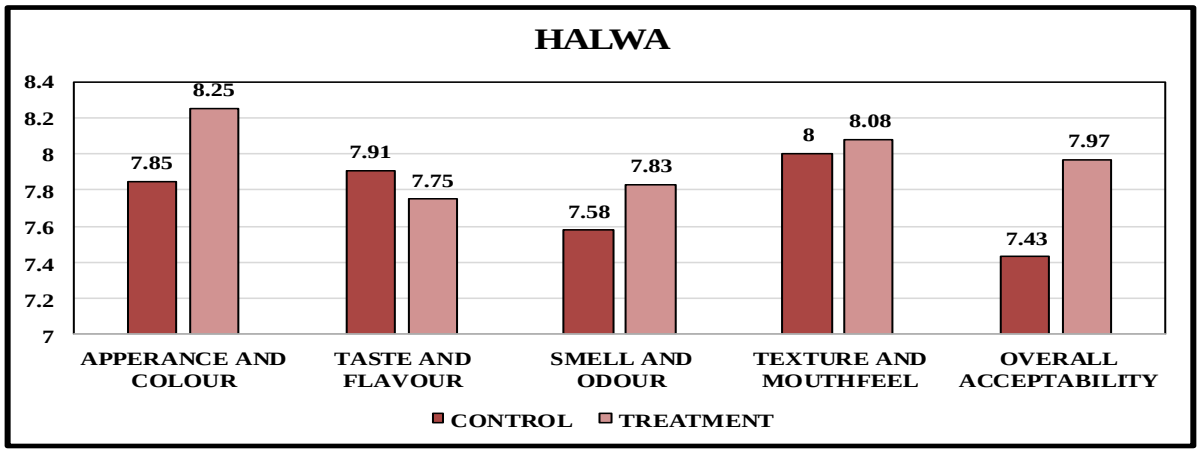


Fig. 1.4. The sensory scores of different parameters in control and treated sample of halwa.

Interpretation: The Fig. 1.4 indicates that the mean score of halwa in relation to appearance and colour is highest and scoring shows that the T_O banana peel halwa (8.25) had the maximum score followed by C_O suji halwa (7.85) respectively. The appearance and colour of banana peel halwa was light brown and attractive to the eyes of the panel judges and well- liked by them.

Table 2.4. The average sensory scores of different parameters in control and treated sample of tiki.

Sensory Characteristics	SCORE ON 9 POINTS HEDONIC SCALE				
	Appearance and Colour	Taste and Flavour	Smell and Odour	Texture and Mouth Feel	Overall Acceptability
C_O (Control)	8.3	8.46	8.4	8.5	8.48
T_O (Treated)	8.6	8.5	8.46	8.56	8.52
T%	4.5	6	18	4	4.57
C.D	0.18	0.051	0.079	0.025	0.74

S = Significant, NS = Non-Significant

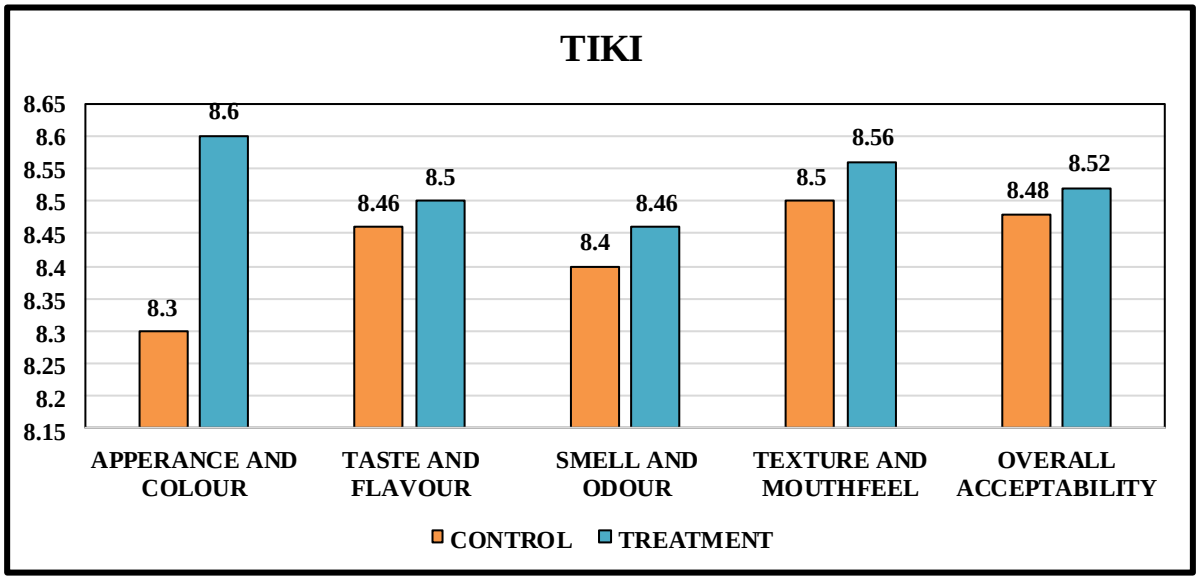


Fig. 1.5. The sensory scores of different parameters in control and treated sample of tiki

Interpretation: The Fig. 1.5 indicates that the mean score of tiki in relation to appearance and colour and texture and mouthfeel is the highest and scoring shows that the T_O (banana peel tiki) had the maximum score in both colour (8.6) and texture (8.56) followed by C_O (potato tiki) colour (8) and texture (8.3). The appearance and colour of banana peel tiki was reddish brown and the texture of banana peel tiki was very crispy and crunchy and easily chewable and aftertaste of the tiki is very palatable and it has greater impact on the mouthfeel. The tiki was like very much by the panelist.

Table 2.5. The average sensory scores of different parameters in control and treated sample of pancake

Sensory Characteristics	SCORE ON 9 POINTS HEDONIC SCALE				
	Appearance and Colour	Taste and Flavour	Smell and Odour	Texture and Mouth Feel	Overall Acceptability
C_O (Control)	7.91	7.8	8.1	7.9	7.8
T_O (Treated)	8.5	8.4	8.4	8.4	8.4
T%	13	4.54	9	4	4.9
C.D	0.085	0.245	0.079	0.167	0.318

S = Significant, NS = Non-Significant

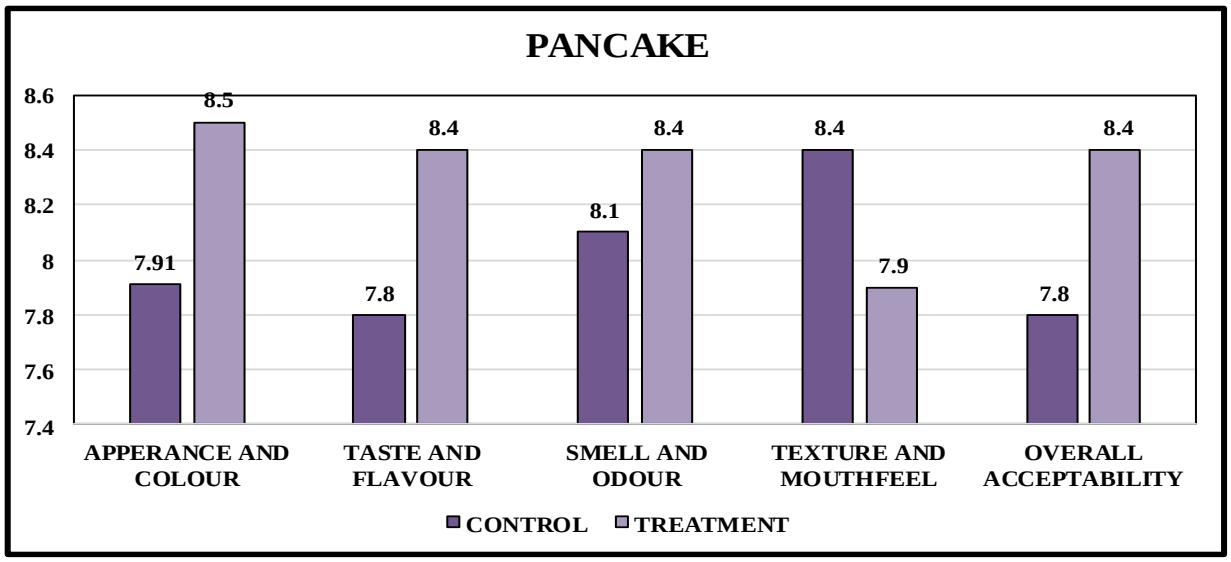


Fig. 1.6. The sensory scores of different parameters in control and treated sample of pancake.

Interpretation: The Fig. 1.6 indicates the mean score of pancake in relation to appearance and colour is highest and the scoring shows that the T_O banana peel pancake (8.5) had the highest score followed by C_O banana pulp pancake (7.91) respectively. The appearance and colour of banana peel pancake was dark brown which was giving the pleasant effect to the panel members.

Table 2.6. The average sensory scores of different parameters in control and treatedsample of bacon

Sensory Characteristics	SCORE ON 9 POINTS HEDONIC SCALE				
	Appearance and Colour	Taste and Flavour	Smell and Odour	Texture and Mouth Feel	Overall Acceptability
C_O (Control)	8.5	8.41	8.85	8.66	8.51
T_O (Treated)	6.31	8.5	8.6	6.31	8.53
T%	2	7.5	10.52	3	2.6
C.D	0.035	0.385	0.048	0.015	0.007

S = Significant, NS = Non-Significant

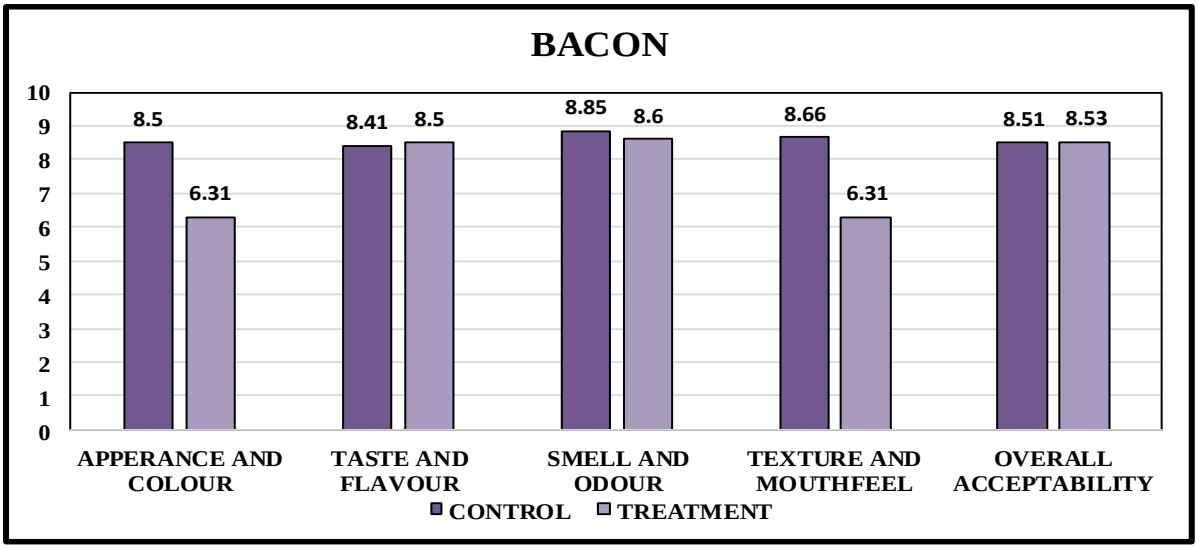


Fig. 1.7. The sensory scores of different parameters in control and treated sample of bacon

Interpretation: The Fig. 1.7 indicates that the mean score of bacon in relation to taste andflavour and texture and mouthfeel is the highest and scoring shows that the T_O banana peel bacon had the maximum score in both taste (8.5) and texture (8.5) followed by C_O brinjal bacontaste (8) and texture (8.3). Whereas in appearance and colour and smell and odour the C_O had score the maximum value. The taste and flavour of the bacon was spicy and savoury and the texture and mouthfeel of banana peel bacon was crispy and the mouthfeel after eating the baconwas very tasty and it was accepted and extremely liked by the panel judges.

Objective 3. To assess the nutritive value of food products containing banana peel.

Table 3.1. Nutritive Value of Food Products

Food Products	Energy (kcal)	Protein (g)	Fat(g)	Dietary Fiber (g)	Carbohydrate(g)	Calcium (mg)	Iron(mg)
Coriander chutney (C_O)	102.5	4.15	5.73	2.38	8.85	191	2.31
Banana peel chutney (T_O)	348.74	10.89	10.4	51.43	56.56	21.75	1.5
Apple Jam(C_O)	108.54	0.44	0.55	1.4	25.64	22.2	1.06
Banana peel Jam (T_O)	340.78	10.28	5.37	50.65	66.25	31.4	1.01
Suji Halwa(C_O)	766	10.43	25.5	0.2	104.5	16	1.66
Banana peel Halwa(T_O)	544.64	10.43	20.4	50.25	83.83	52.2	0.67
Potato Tiki(C_O)	240.3	5.93	11.3	4.51	40.52	48.7	5.19
Banana Peel Tiki (T_O)	433.54	14.68	16.6	54.36	71.93	57.9	5.32
Banana pulp pancake (C_O)	306.33	5.23	6.99	2.19	55.62	39.35	2.31
Banana peel pancake (T_O)	480.57	14.07	12.0	52.04	82.43	41.55	2.56
Brinjal Bacon (C_O)	254.7	8.09	23.5	6.15	26.88	50.2	5.18
Banana peel Bacon (T_O)	520.94	16.73	27.4	55.1	76.89	51.4	5.41

Interpretation: The Table 3.1 shows the nutritive value of control product and treated product. The result revealed that the treated product has higher nutritional content compared to control product. The peel of banana is a good source of nutrients due to high value obtained from the determination of protein, fat, dietary fiber, carbohydrate, calcium and iron. The total dietary fiber content in food products made from banana peel is highest as compared to the control product. The higher fiber content can contribute to better digestive health. The energy content of treated product is also high followed by protein, fat, carbohydrate, calcium and iron. Hence, incorporating banana peel into food productsenhances their nutritional profile, providing consumers with access to additional health benefits. This is especially crucial as dietary fiber and certain micronutrients are often lacking in modern diets.

Objective 4. To assess the economic viability and environmental sustainability of utilizing banana peel in food product development.

Table 4.1. Costing of Control Products

Product Name	Ingredients	Amount for standard recipe	Purchase prices
CHUTNEY	Coriander leaves	100gm	20
	Garlic	10gm	5
	Ginger	10gm	3
	Green chilli	10gm	3
		Total	**31**
JAM	Apple	100 gm	10
	Sugar	22gm	5
		Total	**15**
HALWA	Suji	100gm	10
	Coconut milk	50gm	15
	Sugar	10gm	5
	Ghee	20gm	20
		Total	**55**
TIKKI	Potato	100gm	10
	Onion	25gm	5
	Besan	25gm	3.5
	Green chilli	5gm	3
	Oil	25gm	15
	Turmeric	1.6gm	0.16
	Red chilli powder	1.6gm	0.16
		Total	**36.82**
PANCAKE	Banana Pulp	100gm	10
	Wheat flour	50gm	7
	Sugar	20gm	5
		Total	**27**
BACON	Brinjal	100gm	12
	Besan	25gm	7
	Red chilli powder	1.6gm	0.16
	Turmeric	1.6gm	0.16
		Total	**19.32**
		Grand Total	**179.14**

Interpretation: The Table 4.1 indicates that the price estimate has been prepared for control food products and the primary components in every food product has been calculated for 100 grams. The different ingredient in each food product is taken as consistent with the requirementand the price estimate has been calculated for that. The total food price that was spend in the ingredients purchase was (179.14). These costs did not include transportation, rent, local taxes,sales commissions, etc.

Table 4.2. Costing of Treated Products

Product Name	Ingredients	Amount for standard recipe	Purchase prices
CHUTNEY	Banana peel	100gm	10
	Garlic	10gm	5
	Ginger	10gm	3
	Green chilli	10gm	3
		Total	**21**
JAM	Banana Peel	100 gm	10
	Jaggery	12gm	3
	Cardamom	1.6gm	0.16
	Cinnamon	1.6 gm	0.16
		Total	**13.32**
HALWA	Banana Peel	100gm	10
	Coconut milk	50gm	15
	Sugar	10gm	5
	Ghee	20gm	20
		Total	**50**
TIKKI	Banana peel	100gm	10
	Onion	25gm	5
	Oil	12gm	5
	Besan	25gm	3.5
	Green chilli	5gm	3
	Turmeric	1.6gm	0.16
	Red chilli powder	1.6gm	0.16
		Total	**26.82**
PANCAKE	Banana peel	100gm	10
	Wheat flour	50gm	7
	Dates	20gm	10
		Total	**27**
BACON	Brinjal	100gm	10
	Besan	25gm	7
	Red chilli powder	1.6gm	0.16
	Turmeric	1.6gm	0.16
		Total	**17.32**
		Grand Total	**155.46**

Interpretation: The Table 4.2 shows that the cost estimate has been prepared for treated food products and the primary ingredients in each food product has been calculated for 100 grams. The other ingredient in each food product is taken as per the requirement and the price estimate has been calculated for that. The total food cost that was spend in the ingredients purchase was(155.46). These costs did not include transportation, rent, local taxes, sales commissions, etc. The cost of control product was higher than that of the treated product because there is no purchase cost for the banana peel, since high-quality banana peels has been sourced from local

food establishments, juice shops, and markets in Patna. The peel of banana used in this study for making a food product can be consumed by all sections of the society.

Conclusion:

The disposal of agricultural waste from fruits and vegetables poses a critical global issue, considering challenges related to storage, disposal, environmental impact, and potential health risks. Peels, often discarded, represent a substantial portion of fruit waste. Despite their abundance, these by-products have received limited attention in terms of utilization orrecycling, possibly due to the unknown commercial benefits associated with them. Banana peel, a common by-product of banana processing, shares this fate with other agricultural by- products. However, it holds great potential as an alternative ingredient in food processing. In terms of nutritional content, banana peel is notably rich in dietary fiber, promoting healthydigestion.

The results of our study revealed that food products incorporating banana peel exhibit enhanced nutritional value, including dietary fibers, carbohydrates, proteins, fats, vitamins, minerals, calcium, iron, and various bioactive components such as carotenoids, polyphenols, pro-vitamins, essential minerals, as well as antioxidant and antimicrobial activities when compared to products without banana peel. Furthermore, the treated products scored higher in hedonic rating tests and independent t-tests, as determined by one-way analysis of variance (ANOVA) for sensory attributes. This indicates a greater acceptability among panel members compared to control products. The utilization of banana peel in food products offers significant health benefits, particularly for digestive health due to its high fiber content. Incorporating banana peels as a food ingredient can provide an affordable and accessible source of nutrition, especially in regions facing issues of food insecurity and malnutrition. In conclusion, raising public awareness about food waste and the potential use of unconventional yet nutritious ingredients in food product development is crucial.

References:

Alam, J., Akter, S., Afroze, S., Islam, T., and Haque, E.S., (2020). Development Of Fiber and Mineral Enriched Cookies By Utilization Of Banana And Banana Peel Flour, *Journal Of Microbiology Biotechnology And Food Science,* 10, pp. 329-333.

Badilla, S.O., Garcia, K.A., Vazquez, M.J., Sanchez, S.R., Velasco, O.C., Carranza, H.P., and Cruz, N.A., (2022). Potential use of banana peel (Musa cavendish) as ingredient for pasta and bakery products, *Heliyon*, 8, pp.1-9.

Hikal, M., Hussein, A., Bratovcic, A and Kirill, G., (2022). Banana peels: A waste treasure for human being, *Evidence Based Complementary and Alternative Medicine,* 22, pp. 2-9.

Mehazabeen, A., and Srinivasan, G., (2020). Export performance of banana in India – a markov chain analysis, *Plant Archives*, 20, pp. 3836-3838.

Naik, M.G., and Yogish, S.N., (2018). An Economic Analysis of Banana cultivation in India, *Journal of Emerging Technologies and Innovative Research,* 5, pp. 32-39.

Prashanthi, D., and Chaitanya, M., (2020). A Review on Multiple Use of Banana Peel, *International Journal of Scientific Development and Research,* 5, pp. 120-122.

Radzi. M., and Aini, H., (2020). Incorporation of Banana Peel Fiber in Jelly as a Functional Food Precursor, *Pusat Pengajian Technology Industry University Sains Malaysia,* 2, pp. 1-43.

Rana, G.N., and Singh, Y., (2018). Potential use of banana and its byproducts: a review(in press), *International Journal of Current Microbiology and Applied*, 7, pp. 1827- 1831.

Shivaji, C.N., Mhaske, A.R., and Kokate, S.D., (2019). Trade Performance of Banana in India, *International Journal of Research and Review,* 9, pp. 113-122.

Singh, R., Ranvir, S., and Madan, S., (2017). Comparative study of the properties of ripe banana flour, unripe banana flour and cooker banana flour aiming towards effective utilization of these flours, *International Journal Of Current Microbiology And applied Science,* 6, pp. 2003-2015.

Srilakshmi, B., (2018). Food Science *New Age International Publishers,* 7, pp. 300-301.

Taiyeba, N., Gupta, A., and Verma, T., (2020). Utilization of sweet potato peels and potato peels for the department of value-added food products, *International Journal Current microbiology And Applied Science,* 9, pp. 546 to 553.

Wachirasiri, P., Julakarangka, S., and Wanlapa, S., (2008). The Effects of Banana Peel preparations on The Properties of Banana Peel Dietary Fiber Content, *songklankarin Journal of Science and Technology,* 31, pp. 606-611.