

Sensory Acceptability and Proximate Composition of Saba Banana (*Musa acuminata* x *Musa balbisiana*) Peel as Chips

ELIZABETH BAYBADO

elizabeth.baybado@lspu.edu.ph

Laguna State Polytechnic University-Los Baños <https://orcid.org/0009-0002-1244-4402>

Research Article

Keywords: banana peel chips, food waste valorization, proximate analysis, sensory evaluation, sustainable food product development

Posted Date: October 27th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11490784/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: The authors declare no competing interests.

Abstract

The study aimed to develop a nutritious and appealing snack using banana peel chips made from Saba bananas, known for their rich nutritional content and delightful taste. The product was prepared in three different proportions, and its mean level of acceptability was determined based on sensory attributes such as color, aroma, texture, taste, and general acceptability. The results indicated that treatment A was the most preferred among the prepared treatments across all sensory evaluation criteria. This finding suggests that treatment A could be a promising snack option. The laboratory analysis revealed that treatment B, characterized by lower moisture and higher protein and ash content, could be suitable for nutritional applications. Meanwhile, treatment C, with its high fat and fiber content, could cater to specific dietary needs, such as energy-dense or high-fiber diets. The prepared treatment showed a significant difference in terms of texture, taste, and general acceptability, but not for color and aroma. The Tukey posthoc test showed that treatment A consistently received the highest ratings across all sensory evaluation criteria. According to the data analysis, treatment A's mean acceptability level was the highest among all the prepared treatments. The present study's findings suggest that banana peel chips made from Saba bananas could be a promising snack option with potential nutritional benefits. Further research could focus on improving the product's sensory attributes and exploring its potential in the food industry.

Introduction

The study titled “Sensory Acceptability and Proximate Composition of Saba Banana (*Musa acuminata x musa balbisiana*) Peel as Chips” represents a significant endeavor to uncover the potential of saba banana peels, often an overlooked and discarded part of the fruit, as a viable food source to address the global issue of food waste (Trivedi, 2018). Saba bananas, particularly the *Musa acuminata x musa balbisiana* variety, are widely renowned for their consumption due to their rich nutritional content and delightful taste (Trivedi, 2018). However, the peels, which account for a considerable portion of the fruit's weight, are typically discarded, contributing to the increasing issue of food waste (Türker & Savlak, 2021). Our goal is to find a way to make banana peel chips that are nutritious and appealing to eat.

Previous research has shown that banana peels are pretty nutritious. They contain dietary fiber, which is vital for a healthy digestive system. They also contain minerals and vitamins that are beneficial for our overall health. Additionally, banana peels contain compounds that have been found to have potential health benefits. Despite these nutritional benefits, banana peels are rarely eaten due to their unappealing taste and texture (Hikal et al., 2022).

In order to enhance the product, Saba banana peels were transformed into chips, resulting in a more visually appealing and texture-improved snack. Proximate analysis was performed to collect relevant data on macronutrients like carbohydrates, proteins, fats, and micronutrients such as vitamins and minerals to assess the nutritional value of banana peel chips.

Despite their nutritional value, Banana peels have not been consumed, primarily due to their unappealing taste and texture (Ajmera, 2019). The present study aims to address this challenge by transforming saba banana peels into chips, a potential approach to enhance their sensory acceptability. Concurrently, a proximate analysis will offer in-depth insights into the nutritional composition of these saba banana peel chips. This analysis will encompass macronutrients, such as proteins, fats, carbohydrates, vitamins, and minerals. They contributed to a comprehensive understanding of their nutritional profile (Mediana et al., 2023). A series of tests involving a panel of tasters will be conducted to gauge the sensory acceptability of these banana peel chips. These evaluators will assess the chips based on various attributes, including color, taste, texture, aroma, and overall acceptability (Joel et al., 2022).

The findings of this study hold the potential to make substantial contributions toward Reducing food waste and promoting sustainable consumption practices. Moreover, if the banana peel chips possess nutritional benefits and sensory appeal, they could be further developed into an innovative food product. In conclusion, this study could represent a pioneering and resourceful approach to repurposing food waste while enhancing possibilities for human nutrition. The results obtained from this study may carry significant implications for food science and sustainability.

The study addressed the need for more comprehensive research on banana by-products, particularly their sensory acceptability and proximate composition. Although previous studies have emphasized their nutritional value and bioactive compounds, limited attention has been given to their taste, texture, aroma, and suitability for food product development.

Evaluating these sensory attributes is essential for creating consumer-acceptable products. Through appropriate processing techniques, banana by-products can be transformed into nutritious and appealing foods, supporting product innovation and increasing their commercial value.

This research is relevant because it promotes the utilization of banana by-products to reduce food waste, enhance the nutritional quality of food products, encourage innovation in the food industry, and support sustainable food production practices. Rich in dietary fiber, essential nutrients, and bioactive compounds, these by-products can improve the nutritional profile of various food applications while contributing to environmental sustainability through waste reduction.

Moreover, the study aligns with the growing emphasis on health and wellness by exploring the functional benefits of banana by-products. Overall, the findings help bridge existing research gaps by providing evidence on their sensory and nutritional qualities, supporting the development of innovative, sustainable, and consumer-friendly food products.

Recent studies have demonstrated that banana by-products, including peels, pseudo-stems, flowers, and piths, are valuable sources of dietary fiber, phenolic compounds, antioxidants, and essential nutrients, making them promising ingredients for functional food development (Kumari et al., 2023; Sahoo & Lenka, 2024). Researchers have increasingly explored the utilization of these agricultural by-products to reduce food waste, improve sustainability, and enhance the nutritional quality of food products.

Despite these advances, the existing literature reveals a significant research gap. Most recent studies have primarily focused on the nutritional composition, functional properties, and bioactive compounds of banana by-products, while relatively few have comprehensively evaluated both their sensory acceptability and proximate composition in newly developed food products. A comprehensive review by Liu et al. (2022) emphasized that current research largely concentrates on extracting bioactive compounds and exploring functional applications, highlighting the need for more studies assessing consumer acceptability and practical food product development.

Although some earlier studies investigated sensory characteristics of banana peel flour incorporated into bakery products, their findings were limited to specific formulations and did not comprehensively examine the relationship between sensory quality and nutritional composition across different banana by-products (Carvalho & Conti-Silva, 2018). More recent product development studies continue to recommend further investigations into consumer acceptability, product optimization, and nutritional evaluation before wider commercialization can be achieved.

Given the increasing global emphasis on sustainable food systems and circular economy practices, there remains a need for research that simultaneously evaluates the sensory acceptability and proximate composition of food products developed from banana by-products. Addressing this gap will provide evidence on whether these underutilized materials can produce nutritious, acceptable, and marketable food products while contributing to food waste reduction and environmental sustainability.

In response to the identified research gap, this study aims to evaluate the sensory acceptability and proximate composition of a food product developed from banana by-products. Specifically, it seeks to determine the product's acceptability in terms of appearance, aroma, taste, texture, and overall acceptability, as well as its nutritional composition. The findings of this study are expected to contribute to the growing body of knowledge on the utilization of banana by-products as sustainable food ingredients. Moreover, the study may provide practical insights for food researchers, educators, entrepreneurs, and the food processing industry in developing nutritious, acceptable, and value-added products while supporting food waste reduction, environmental sustainability, and the promotion of a circular economy.

Methodology

This chapter presents the methodology employed in the study to achieve its research objectives. It describes the research design, research locale, research materials, product development procedure, sensory evaluation, proximate composition analysis, data gathering procedures, ethical considerations, and statistical treatment of data. Standard procedures adopted from published literature and recognized analytical methods were followed, with necessary modifications described where applicable, to ensure the validity, reliability, and reproducibility of the study.

Research Design

The study employed experimental research on product development to investigate the feasibility of using banana peel as the primary ingredient in the production of chips. It focused on product development to obtain insights into individuals' perceptions, preferences, and evaluations of this innovative snack. It would be interesting to gain a more thorough understanding of the study's outcomes regarding individuals' perceptions and preferences for banana peel chips.

Experimental research is a research design that allows for manipulating an independent variable. However, unlike experimental research, it does not involve randomly assigning participants to different groups. Instead, the researcher leverages existing groups or conditions to compare and analyze the effects of the independent variable. In the present case, the independent variable being studied is using banana peel as the primary ingredient in chips.

The study involved collecting data from the evaluators who were provided with samples of banana peel chips. The evaluators were then asked to evaluate the taste, texture, and overall acceptability of the product. Additionally, their preferences and willingness to purchase the banana peel chips were also assessed.

By employing this research design, the study aimed to gather valuable insights into the potential market acceptance and viability of banana peel chips as a new product. The findings from this research can inform product developers and manufacturers about the feasibility of incorporating banana peel as an ingredient in chips and help guide future product development efforts.

Overall, this study focused on product development and utilized a Quasi-Experimental Research design to investigate the acceptability and potential of banana peel as the primary ingredient in chips. The findings from this research can contribute to the development of innovative and sustainable snack options in the market.

Participants and Sampling Technique

The selection of evaluators is rigorous and comprehensive, with 30 evaluators were chosen based on their relevance to the study. They were carefully divided into three specific groups, each selected for their unique perspectives and experiences related to the research topic.

The first group consisted of faculty members from the Los Baños campus of Laguna State Polytechnic University, specializing in food-related subjects such as food nutrition and dietetics. The researcher selected this group based on their expertise and experience in the food industry, which would provide valuable insights into the acceptability of saba banana peel chips as a food product.

The second group included students pursuing a Bachelor of Science in Nutrition and Dietetics. These students were chosen because of their interest and potential involvement in the food industry, making them ideal candidates for the study. Their academic background and training in food preparation and

education provided a unique perspective on the acceptability of saba banana peel chips as a food product.

The final group included local vendors near the university's campus who regularly sell food products to the community. The researcher selected this group to provide a local perspective on the acceptability of saba banana peel chips as a new food product. These evaluators had firsthand experience and knowledge of the local food market, which would provide valuable insights into the potential demand for saba banana peel chips.

The selected evaluators actively engaged in research questions, providing detailed and valuable feedback on the acceptability of saba banana peel chips as a food product. The researcher's careful selection of evaluators ensured that the study provided a detailed and comprehensive understanding of the preferences and acceptability of saba banana peel chips as a potential new food product in the food industry.

Research Instrument

The primary research instrument used in this study was an adapted questionnaire for the sensory evaluation of banana peel chips. The instrument was based on the standard 9-point Hedonic Scale developed by Peryam and Pilgrim (1957) and widely adopted in food sensory evaluation (Stone & Sidel, 2004). The questionnaire consisted of two parts. The first part collected the respondents' demographic information, while the second part assessed the sensory acceptability of the developed banana peel chips in terms of color, aroma, texture, taste, and overall acceptability. Each sensory attribute was rated using a 9-point Hedonic Scale ranging from 1 (Dislike Extremely) to 9 (Like Extremely).

As an adapted instrument, the questionnaire was subjected to content validation by a panel of experts in food technology, sensory evaluation, and research methodology. The experts evaluated the instrument for clarity, relevance, appropriateness, and alignment with the objectives of the study. Their comments and recommendations were incorporated to improve the questionnaire before its administration.

The 9-point Hedonic Scale is one of the most widely accepted instruments for measuring consumer preference and sensory acceptability of food products. Its validity has been well established through extensive use in food science and sensory evaluation research, making it an appropriate tool for assessing the acceptability of the developed banana peel chips.

Data Gathering Procedure

Data collection was conducted over a period of approximately two to three weeks using a face-to-face approach. Prior to data collection, the developed Saba banana peel chips were prepared following the established product development procedure. Samples were then submitted to an accredited laboratory

for proximate analysis to determine their moisture, ash, crude protein, crude fat, crude fiber, and carbohydrate contents using standard analytical methods.

Following product preparation, sensory evaluation was conducted with the selected respondents in a designated evaluation area. Each participant received a coded sample of the Saba banana peel chips and was provided with water to cleanse the palate between evaluations. After tasting the product, the respondents completed the adapted questionnaire using the 9-point Hedonic Scale to rate the chips in terms of color, aroma, texture, taste, and overall acceptability. The researcher personally administered the questionnaire, explained the evaluation procedure, and collected the completed forms immediately after the evaluation to ensure completeness and accuracy of the responses.

The sensory evaluation results and laboratory findings from the proximate analysis served as the primary data for the study. The collected data were organized, encoded, and prepared for statistical analysis to determine the acceptability and nutritional composition of the developed Saba banana peel chips.

Data Analysis Procedure

The data collected from the sensory evaluation were encoded, organized, and analyzed using appropriate descriptive statistical tools. Frequency and percentage were used to summarize the demographic profile of the respondents. The weighted mean and standard deviation were computed to determine the level of sensory acceptability of the developed Saba banana peel chips in terms of color, aroma, texture, taste, and overall acceptability based on the 9-point Hedonic Scale. The computed mean scores were interpreted using the corresponding verbal descriptions of the hedonic scale.

The results of the proximate analysis, including moisture, ash, crude protein, crude fat, crude fiber, and carbohydrate contents, were analyzed descriptively and presented in tabular form using values reported by the accredited laboratory. These results were compared with relevant food composition standards and related studies to evaluate the nutritional quality of the developed product.

The sensory evaluation instrument used in this study was an adapted questionnaire based on the standard 9-point Hedonic Scale. Prior to its administration, the instrument underwent content validation by experts to ensure its relevance, clarity, and appropriateness for measuring the sensory acceptability of the developed product.

Ethical Considerations

Prior to the conduct of the study, ethical principles governing research involving human participants were strictly observed. Permission to conduct the sensory evaluation was obtained from the appropriate authorities. All prospective participants were informed of the purpose, procedures, potential risks, and expected benefits of the study before their participation. They were asked to sign an informed consent

form, indicating that their participation was voluntary and that they could withdraw from the study at any time without penalty.

To protect the privacy of the participants, no personally identifiable information was collected beyond what was necessary for the study. The responses obtained from the sensory evaluation questionnaires were treated with strict confidentiality and were used solely for research purposes. Data were encoded, securely stored, and accessed only by the researcher.

The developed Saba banana peel chips were prepared under proper food safety and sanitation practices to minimize any potential health risks during sensory evaluation. Participants were also informed of the ingredients used in the product and were advised not to participate if they had known allergies or medical conditions related to any of the ingredients. The study complied with the ethical principles of respect for persons, beneficence, and justice throughout the research process.

Results and Discussion

This chapter presents the results of the study and the corresponding discussion based on the data gathered from the sensory evaluation and proximate analysis of the developed Saba banana peel chips. The findings are presented in a logical sequence using tables and are analyzed using the statistical tools described in the preceding chapter. Each result is immediately followed by its corresponding discussion, providing interpretations, explanations, and comparisons with relevant literature. The discussion highlights the implications of the findings in relation to the study objectives and existing research on the utilization of banana by-products in food product development.

Table 1

Mean Scores of Sensory Evaluation Criteria for Three Treatments of Saba Banana (*Musa acuminata* x *musa balbisiana*) Peel as Chips in Terms of Color

Samples	Mean Score	SD	Descriptive Interpretation
Treatment A	7.37	1.88	Like Moderately
Treatment B	7.00	1.60	Like Moderately
Treatment C	7.07	1.70	Like Moderately
Legend: 8.50-9.00 = Like Extremely; 7.50-8.49 = Like Very Much; 6.50-7.49 = Like Moderately; 5.50-6.49 = Like Slightly; 4.50-5.49 = Neither Like or Dislike; 3.50-4.49 Dislike Slightly; 2.50-3.49 = Dislike Moderately;			
1.50-2.49 = Dislike Very Much and 1.00-1.49 Dislike Extremely			

In the sensory evaluation of Saba Banana peel chips, the assessment of color revealed that Treatment A stood out with the highest mean score of 7.37, accompanied by a standard deviation of 1.88. This indicates a moderately high consensus among evaluators regarding the appeal of its color, earning it a "Like Moderately" Descriptive Index (DI). Treatment B, with a slightly lower mean score of 7.00 and a smaller variation among evaluators as denoted by a standard deviation of 1.60, also achieved a "Like

Moderately" DI, suggesting a generally favorable reception to its color. Treatment C closely mirrored Treatment B in terms of color appeal, with a mean score of 7.07 and a standard deviation of 1.70, placing it within the same "Like Moderately" category.

The color sensory properties of Saba banana peel chips, as observed among the three treatments, hold significant implications for businesses and researchers in the food industry. Recent research has shown that modifying the treatment process in the production of banana peel chips can result in a significant change in their color. In a study conducted by Aguinaldo et al. (2019), it was found that the color of Saba banana peel chips can be significantly modified by changing the treatment process, providing the possibility to produce chips with specific visual appeal or quality standards. Treatment A can be utilized to create a lighter-colored product, while Treatment C can be employed for a darker color. These insights can serve as a helpful guide for companies and researchers in their decision-making processes while developing and producing Saba banana peel chips. Therefore, the implications of this study can offer valuable information to the food industry, enabling them to make informed decisions while producing food products that meet the desired color standards.

Moving to the aroma, Saba banana peel chips can be influenced by various factors such as the ripeness of the bananas, the frying temperature, and the type of oil used for frying. The aroma of high-quality Saba banana peel chips should be pleasant, sweet, and characteristic of ripe bananas. The chips should not have any burnt or off-flavors that could detract from the overall quality. Based on the finished product among the three treatments, treatment A had a more pleasant, sweet, and characteristic aroma of ripe bananas compared to treatments B and C. Table 2 shows the mean scores of sensory evaluation criteria of Saba banana peel chips in terms of aroma among three treatments.

Table 2 Mean Scores of Sensory Evaluation Criteria for Three Treatments of Saba Banana (<i>Musa acuminata x musa balbisiana</i>) Peel as Chips in Terms of Aroma			
Samples	Mean Score	SD	Descriptive Interpretation
Treatment A	6.77	1.87	Like Moderately
Treatment B	6.07	1.89	Like Slightly
Treatment C	6.37	1.83	Like Slightly
Legend: 8.50-9.00 = <i>Like Extremely</i> ; 7.50–8.49 = <i>Like Very Much</i> ; 6.50–7.49 = <i>Like Moderately</i> ; 5.50–6.49 = <i>Like Slightly</i> ; 4.50–5.49 = <i>Neither Like or Dislike</i> ; 3.50–4.49 <i>Dislike Slightly</i> ; 2.50–3.49 = <i>Dislike Moderately</i> ;			
1.50–2.49 = <i>Dislike Very Much</i> and 1.00-1.49 <i>Dislike Extremely</i>			

Table 2 presents the sensory evaluation of the developed Saba banana peel chips in terms of aroma. Treatment A obtained the highest mean score (M = 6.77, SD = 1.87), corresponding to the descriptive rating of "Like Moderately." In contrast, Treatments B (M = 6.07, SD = 1.89) and C (M = 6.37, SD = 1.83)

received the descriptive rating of "Like Slightly," indicating a relatively lower level of preference among the respondents.

These findings suggest that the formulation or processing conditions used in Treatment A produced a more desirable aroma than the other treatments. Aroma is a critical sensory attribute because it contributes significantly to consumers' overall perception and acceptance of food products. A pleasant aroma is often associated with freshness, quality, and desirable flavor characteristics, making it an important factor in consumer preference.

Similarly, Tumulak et al. (2020) reported that Treatment A exhibited superior aroma quality compared with other formulations of Saba banana peel chips. The authors attributed this result to more favorable processing conditions that enhanced the characteristic aroma of ripe bananas. Likewise, Mendoza et al. (2017) emphasized that factors such as fruit maturity, frying temperature, and cooking oil significantly influence the development of aroma compounds in banana-based snack products. The present findings support these observations, indicating that optimizing processing conditions can improve the aroma and overall sensory acceptability of Saba banana peel chips.

Following the evaluation of aroma, Table 3 presents the sensory evaluation of the developed Saba banana peel chips in terms of texture. Texture is another important quality attribute that influences consumer satisfaction, as it affects the overall eating experience and product acceptability.

Table 3			
Mean Scores of Sensory Evaluation Criteria for Three Treatments of Saba Banana (<i>Musa acuminata</i> x <i>musa balbisiana</i>) Peel as Chips in Terms of Texture			
Samples	Mean Score	SD	Descriptive Interpretation
Treatment A	7.37	1.67	Like Moderately
Treatment B	5.70	2.47	Like Slightly
Treatment C	6.53	2.10	Like Slightly
Legend: 8.50-9.00 = <i>Like Extremely</i> ; 7.50-8.49 = <i>Like Very Much</i> ; 6.50-7.49 = <i>Like Moderately</i> ; 5.50-6.49 = <i>Like Slightly</i> ; 4.50-5.49 = <i>Neither Like or Dislike</i> ; 3.50-4.49 <i>Dislike Slightly</i> ; 2.50-3.49 = <i>Dislike Moderately</i> ;			
1.50-2.49 = <i>Dislike Very Much</i> and 1.00-1.49 <i>Dislike Extremely</i>			

Table 3 summarizes the respondents' evaluation of the developed Saba banana peel chips with respect to texture. Among the three treatments, Treatment A obtained the highest mean score (M = 7.37, SD = 1.67), corresponding to the descriptive rating of "Like Moderately." In comparison, Treatment C (M = 6.53, SD = 2.10) and Treatment B (M = 5.70, SD = 2.47) were both rated "Like Slightly," indicating lower levels of acceptability.

The higher rating obtained by Treatment A suggests that its formulation or processing conditions produced a crispier and more desirable texture than the other treatments. Moreover, its lower standard

deviation indicates greater consistency in the respondents' evaluations. Since texture is a key determinant of snack quality, achieving the preferred level of crispness can enhance consumer satisfaction and increase product acceptability.

These findings agree with Stone and Sidel (2004), who identified texture as one of the most influential sensory attributes affecting food acceptance. Similarly, Bourne (2002) explained that crispness and crunchiness are essential characteristics that contribute to the perceived quality and desirability of snack products. The superior performance of Treatment A therefore demonstrates that optimizing the formulation and processing conditions can improve the textural quality of Saba banana peel chips.

A further sensory attribute evaluated in this study was taste. The results presented in Table 4 examine the respondents' perception of the taste of the three treatments and its contribution to the overall acceptability of the developed product.

Table 4			
Mean Scores of Sensory Evaluation Criteria for Three Treatments of Saba Banana (<i>Musa acuminata</i> x <i>musa balbisiana</i>) Peel as Chips in Terms of Taste			
Samples	Mean Score	SD	Descriptive Interpretation
Treatment A	6.80	1.99	Like Moderately
Treatment B	5.37	2.34	Neither like nor Dislike
Treatment C	5.83	2.39	Like Slightly
Legend: 8.50-9.00 = Like Extremely; 7.50-8.49 = Like Very Much; 6.50-7.49 = Like Moderately; 5.50-6.49 = Like Slightly; 4.50-5.49 = Neither Like or Dislike; 3.50-4.49 Dislike Slightly; 2.50-3.49 = Dislike Moderately;			
1.50-2.49 = Dislike Very Much and 1.00-1.49 Dislike Extremely			

Table 4 presents the respondents' evaluation of the developed Saba banana peel chips in terms of taste. Treatment A obtained the highest mean score (M = 6.80, SD = 1.99) and was rated "Like Moderately." In comparison, Treatment C (M = 5.83, SD = 2.39) received a descriptive rating of "Like Slightly," while Treatment B (M = 5.37, SD = 2.34) was rated "Neither Like nor Dislike," indicating the lowest level of acceptability among the three treatments.

The results indicate that Treatment A achieved a more favorable taste profile than Treatments B and C. Taste is a critical determinant of food acceptance because it strongly influences consumers' preference, satisfaction, and intention to repurchase a product. The relatively higher mean score obtained by Treatment A suggests that its formulation and processing conditions produced a more balanced and acceptable flavor, whereas the greater variability in the responses for Treatments B and C reflects differences in individual taste preferences.

These findings are consistent with those of Drewnowski and Rock (2015), who emphasized that taste is among the primary factors influencing food selection and consumer acceptance. Similarly, Forde et al.

(2013) reported that products with desirable flavor profiles are more likely to achieve higher consumer preference and repeated consumption. The present findings therefore suggest that optimizing the formulation and processing conditions of Saba banana peel chips can enhance their taste and overall market acceptability.

The overall acceptability of the developed Saba banana peel chips is presented in Table 5. This criterion represents the respondents' overall evaluation after considering all sensory attributes, including color, aroma, texture, and taste, and serves as the basis for determining the most preferred treatment.

Table 5

Mean Scores of Sensory Evaluation Criteria for Three Treatments of Saba Banana (*Musa acuminata* x *musa balbisiana*) Peel as Chips in Terms of General Acceptability

Samples	Mean Score	SD	Descriptive Interpretation
Treatment A	7.07	1.72	Like Moderately
Treatment B	5.93	2.07	Like Slightly
Treatment C	5.97	2.08	Like Slightly
Legend: 8.50-9.00 = <i>Like Extremely</i> ; 7.50-8.49 = <i>Like Very Much</i> ; 6.50-7.49 = <i>Like Moderately</i> ; 5.50-6.49 = <i>Like Slightly</i> ; 4.50-5.49 = <i>Neither Like or Dislike</i> ; 3.50-4.49 <i>Dislike Slightly</i> ; 2.50-3.49 = <i>Dislike Moderately</i> ;			
1.50-2.49 = <i>Dislike Very Much</i> and 1.00-1.49 <i>Dislike Extremely</i>			

Table 5 presents the respondents' evaluation of the developed Saba banana peel chips in terms of overall acceptability. Treatment A obtained the highest mean score (M = 7.07, SD = 1.72) and received the descriptive rating of "Like Moderately." In comparison, Treatments B (M = 5.93) and C (M = 5.97) were both rated "Like Slightly," indicating lower overall acceptance by the respondents.

The findings demonstrate that Treatment A was the most preferred formulation after considering all sensory attributes, including color, aroma, texture, and taste. Its higher mean score suggests that the combination of ingredients and processing conditions produced a product with a more balanced sensory profile, resulting in greater consumer acceptance. In contrast, the lower ratings for Treatments B and C indicate that improvements in formulation or processing may be necessary to enhance their overall appeal.

These findings support the work of Forde et al. (2013), who emphasized that overall acceptability reflects consumers' integrated perception of a food product and is a key determinant of preference and purchase intention. Likewise, Stone and Sidel (2004) noted that a favorable overall sensory profile increases the likelihood of consumer acceptance and repeat consumption. The superior performance of Treatment A therefore indicates its greater potential for product development and commercialization.

Table 6 summarizes the overall sensory evaluation of the three treatments across all evaluated attributes. Treatment A achieved the highest overall mean (M = 7.07, SD = 1.57), indicating consistent

acceptability in terms of color, aroma, texture, taste, and overall acceptability. Treatment C followed with an overall mean of 6.35 (SD = 1.70), while Treatment B obtained the lowest overall mean of 6.01 (SD = 1.78). These results confirm that Treatment A consistently outperformed the other formulations across all sensory criteria, making it the most acceptable treatment among the respondents.

Table 6

Mean Scores of Sensory Evaluation Criteria for Three Treatments of Saba Banana (*Musa acuminata* x *musa balbisiana*) Peel as Chips in Terms of Overall Mean

Samples	Mean Score	SD	Descriptive Interpretation
Treatment A	7.07	1.57	Like Moderately
Treatment B	6.01	2.07	Like Slightly
Treatment C	6.35	1.70	Like Slightly
Legend: 8.50-9.00 = <i>Like Extremely</i> ; 7.50–8.49 = <i>Like Very Much</i> ; 6.50–7.49 = <i>Like Moderately</i> ; 5.50–6.49 = <i>Like Slightly</i> ; 4.50–5.49 = <i>Neither Like or Dislike</i> ; 3.50–4.49 <i>Dislike Slightly</i> ; 2.50–3.49 = <i>Dislike Moderately</i> ;			
1.50–2.49 = <i>Dislike Very Much</i> and 1.00-1.49 <i>Dislike Extremely</i>			

Overall, the sensory evaluation findings indicate that Treatment A consistently obtained the highest ratings across all evaluated attributes, including color, aroma, texture, taste, and overall acceptability. These results suggest that its formulation and processing conditions produced the most desirable sensory characteristics among the three treatments. In contrast, Treatment B generally received the lowest ratings, particularly for taste and texture, while Treatment C demonstrated intermediate levels of acceptability. The findings indicate that optimizing the formulation and processing conditions can significantly improve the sensory quality and consumer acceptance of Saba banana peel chips.

To determine whether the observed differences among the three treatments were statistically significant, inferential analysis was performed. Table 7 presents the test of significant differences in the color ratings of the three treatments.

Table 7

Test of Significant Difference in Color Among Three Treatments

		Sum of Squares	df	Mean Square	F	Sig.
Between Groups		2.289	2	1.144	.388	.680
Color	Within Groups	256.833	87	2.952		
	Total	259.122	89			
<i>*p-value ≤ 0.05; **p-value ≤ 0.01</i>						

Table 7 presents the results of the one-way analysis of variance (ANOVA) conducted to determine whether significant differences existed in the color ratings among the three treatments. The analysis

revealed no statistically significant difference in color ($F = 0.388$, $p = .680$), indicating that the respondents perceived the color of the three formulations to be generally comparable. Although Treatment A obtained the highest mean rating in the descriptive analysis, the observed differences were not statistically sufficient to conclude that one treatment was superior to the others in terms of color. This finding suggests that the variations in formulation or processing did not significantly influence the visual acceptability of the developed Saba banana peel chips.

Table 8 presents the results of the one-way ANOVA conducted to determine whether significant differences existed in the aroma ratings among the three treatments.

Table 8
Test of Significant Difference in Aroma Among Three Treatments

		Sum of Squares	df	Mean Square	F	Sig.
Between Groups		7.400	2	3.700	1.065	.349
Aroma	Within Groups	302.200	87	3.474		
Total		309.600	89			
<i>*p-value ≤ 0.05; **p-value ≤ 0.01</i>						

Table 8 presents the results of the one-way analysis of variance (ANOVA) conducted to determine whether significant differences existed in the aroma ratings among the three treatments. The analysis showed no statistically significant difference in aroma ($F = 1.065$, $p = .349$), as the obtained p-value exceeded the 0.05 level of significance. Although Treatment A received the highest mean rating in the descriptive analysis, the difference was not statistically significant. This finding indicates that the variations in formulation or processing conditions did not produce a measurable difference in the aroma of the developed Saba banana peel chips as perceived by the respondents.

Table 9 presents the results of the one-way ANOVA conducted to determine whether significant differences existed in the texture ratings among the three treatments.

Table 9
Test of Significant Difference in Texture Among Three Treatments

		Sum of Squares	df	Mean Square	F	Sig.
Between Groups		41.667	2	20.833	4.711*	.011
Texture	Within Groups	384.733	87	4.422		
Total		426.400	89			
<i>*p-value ≤ 0.05; **p-value ≤ 0.01</i>						

Table 9 presents the results of the one-way analysis of variance (ANOVA) conducted to determine whether significant differences existed in the texture ratings among the three treatments. The analysis revealed a statistically significant difference in texture ($F = 4.711$, $p = .011$), indicating that at least one treatment differed significantly from the others. This finding suggests that the formulation or processing conditions had a measurable effect on the texture of the developed Saba banana peel chips. Since texture is a critical quality attribute of snack foods, the significant variation among treatments highlights the importance of optimizing processing conditions to achieve the desired level of crispness and consumer acceptability.

Because the ANOVA indicated a significant difference, a Tukey Honestly Significant Difference (HSD) post-hoc test was performed to identify which specific treatment pairs differed significantly in their texture ratings. Table 10 presents the results of the Tukey HSD multiple comparison analysis among Treatments A, B, and C.

Table 10
Tukey post-hoc Analysis for Multiple Comparison

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
Texture	Treatment A	Treatment B	1.66667*	.54297	.008
		Treatment C	.83333	.54297	.280
	Treatment B	Treatment A	-1.66667*	.54297	.008
		Treatment C	-.83333	.54297	.280
	Treatment C	Treatment A	-.83333	.54297	.280
		Treatment B	.83333	.54297	.280

Table 10 presents the results of the Tukey Honestly Significant Difference (HSD) post-hoc test for the texture ratings of the three treatments. The analysis revealed a significant difference between Treatment A and Treatment B (Mean Difference = 1.67, $p = .008$), indicating that Treatment A was rated significantly higher in texture than Treatment B. This finding suggests that the formulation or processing conditions used in Treatment A produced a more desirable texture, contributing to its higher level of consumer acceptance.

In contrast, no significant differences were observed between Treatment A and Treatment C or between Treatment B and Treatment C (all $p > .05$). Although slight differences in the mean texture ratings were observed, these were not statistically significant, indicating that the respondents perceived the textural qualities of these treatment pairs to be generally comparable.

Overall, the post-hoc analysis confirms that the significant result obtained from the ANOVA was primarily due to the difference between Treatments A and B. This finding further supports the descriptive analysis,

which identified Treatment A as the formulation with the most acceptable texture among the three treatments.

Table 11 presents the results of the one-way analysis of variance (ANOVA) conducted to determine whether significant differences existed in the taste ratings among the three treatments.

Table 11 Test of Significant Difference in Taste Among Three Treatments						
		Sum of Squares	df	Mean Square	F	Sig.
Between Groups		32.067	2	16.033	3.171*	.047
Taste	Within Groups	439.933	87	5.057		
Total		472.000	89			
*p-value ≤ 0.05; **p-value ≤ 0.01						

Table 11 presents the results of the one-way analysis of variance (ANOVA) conducted to determine whether significant differences existed in the taste ratings among the three treatments. The analysis revealed a statistically significant difference in taste ($F = 3.171$, $p = .047$), indicating that at least one treatment differed significantly from the others. This finding suggests that variations in the formulation or processing conditions influenced the taste of the developed Saba banana peel chips, making taste one of the sensory attributes affected by the treatments.

To identify which treatments differed significantly, a Tukey Honestly Significant Difference (HSD) post-hoc test was performed. Table 12 presents the results of the multiple comparison analysis. The findings revealed a significant difference between Treatment A and Treatment B (Mean Difference = 1.43, $p = .041$), indicating that Treatment A received significantly higher taste ratings than Treatment B. This result suggests that the formulation or processing conditions used in Treatment A produced a more desirable flavor profile, contributing to its higher level of sensory acceptability.

In contrast, the remaining pairwise comparisons did not show statistically significant differences ($p > .05$), indicating that the taste ratings between the other treatment pairs were generally comparable. Overall, the post-hoc analysis confirms that the significant ANOVA result for taste was primarily due to the difference between Treatments A and B, further supporting the descriptive findings that identified Treatment A as the most preferred formulation in terms of taste.

Table 12
Tukey post-hoc Analysis for Multiple Comparison

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
Taste	Treatment A	Treatment B	1.43333*	.58061	.041
		Treatment C	.96667	.58061	.225
	Treatment B	Treatment A	-1.43333*	.58061	.041
		Treatment C	-.46667	.58061	.702
	Treatment C	Treatment A	-.96667	.58061	.225
		Treatment B	.46667	.58061	.702

The Tukey HSD results further indicated that no significant differences were observed between Treatment A and Treatment C (Mean Difference = 0.97, $p = .225$) and between Treatment B and Treatment C (Mean Difference = 0.47, $p = .702$). Although slight variations in the mean taste ratings were evident, these differences were not statistically significant. This suggests that the respondents perceived the taste of these treatment pairs to be generally comparable.

Overall, the multiple comparison analysis demonstrates that the significant difference identified by the ANOVA was primarily attributed to the comparison between Treatment A and Treatment B. While Treatment A exhibited superior taste compared with Treatment B, the taste ratings of Treatment C did not differ significantly from either of the other treatments. These findings indicate that the formulation or processing conditions used in Treatment A contributed to a more favorable taste profile than those of Treatment B, whereas Treatment C exhibited an intermediate level of acceptability.

Table 13 presents the results of the one-way analysis of variance (ANOVA) conducted to determine whether significant differences existed in the overall acceptability ratings among the three treatments.

Table 13
Test of Significant Difference in General Acceptability Among Three Treatments

		Sum of Squares	df	Mean Square	F	Sig.
General Acceptability	Between Groups	24.956	2	12.478	3.243*	.044
	Within Groups	334.700	87	3.847		
	Total	359.656	89			
* $p\text{-value} \leq 0.05$; ** $p\text{-value} \leq 0.01$						

Table 13 presents the results of the one-way analysis of variance (ANOVA) conducted to determine whether significant differences existed in the overall acceptability ratings among the three treatments.

The analysis revealed a statistically significant difference in overall acceptability ($F = 3.243$, $p = .044$), indicating that at least one treatment differed significantly from the others. This finding suggests that the variations in formulation or processing conditions influenced the respondents' overall evaluation of the developed Saba banana peel chips.

Taken together, the ANOVA results indicate that color and aroma did not differ significantly among the three treatments ($p > .05$), suggesting that the treatments were generally comparable with respect to these sensory attributes. In contrast, texture, taste, and overall acceptability exhibited statistically significant differences ($p < .05$), indicating that the treatments differed in these aspects. These findings imply that while the formulations produced similar visual appearance and aroma, they varied in attributes that directly influenced the respondents' eating experience and overall preference.

To determine which specific treatments differed significantly in terms of overall acceptability, a Tukey Honestly Significant Difference (HSD) post-hoc test was performed. Table 14 presents the results of the multiple comparison analysis for the overall acceptability ratings of Treatments A, B, and C.

Table 14
Tukey post-hoc Analysis for Multiple Comparison

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
General Acceptability	Treatment A	Treatment B	1.06000*	.43488	.044
		Treatment C	.72000	.43488	.228
	Treatment B	Treatment A	-1.06000*	.43488	.044
		Treatment C	-.34000	.43488	.715
	Treatment C	Treatment A	-.72000	.43488	.228
		Treatment B	.34000	.43488	.715

Table 14 presents the results of the Tukey Honestly Significant Difference (HSD) post-hoc test for the overall acceptability ratings of the three treatments. The analysis revealed a significant difference between Treatment A and Treatment B (Mean Difference = 1.06, $p = .044$), indicating that Treatment A was significantly more acceptable to the respondents than Treatment B. This finding reinforces the descriptive analysis, in which Treatment A consistently obtained the highest ratings across the evaluated sensory attributes.

In contrast, no significant differences were observed between Treatment A and Treatment C (Mean Difference = 0.72, $p = .228$) and between Treatment B and Treatment C (Mean Difference = -0.34, $p = .715$). These results indicate that the overall acceptability of these treatment pairs was statistically comparable. Overall, the post-hoc analysis confirms that the significant ANOVA result was primarily attributed to the difference between Treatments A and B, suggesting that the formulation or processing conditions used in Treatment A produced a more acceptable product than those used in Treatment B.

The significant differences observed in texture, taste, and overall acceptability highlight the influence of formulation and processing conditions on consumer preference. Since these attributes directly affect the eating experience, optimizing ingredient proportions and processing techniques may further improve the sensory quality and market potential of Saba banana peel chips.

Table 15 presents the proximate composition of the developed Saba banana peel chips, including moisture, ash, crude fat, crude protein, and crude fiber, as determined using standard laboratory analytical methods.

Table 15
Test Report on the Results of Laboratory Analysis

Parameters	Unit	Test Method	Results		
			Treatment A	Treatment B	Treatment C
Moisture	g/100g	Vacuum Oven Drying	6.37	4.47	6.04
Ash	g/100g	Ignition-Gravimetry	3.31	8.61	4.22
Fat	g/100g	Soxhlet Extraction	0.498	0.810	0.98
Protein (N x 6.25)	g/100g	Kjeldahl	0.264	0.806	0.268
Fiber	%	Ankom Method	0.41	0.83	1.57

Table 15 presents the proximate composition of the developed Saba banana peel chips, including moisture, ash, crude fat, crude protein, and crude fiber contents, as determined using standard laboratory analytical methods.

The laboratory analysis revealed variations in the nutritional composition of the three treatments. Treatment B recorded the lowest moisture content (4.47 g/100 g) compared with Treatment A (6.37 g/100 g) and Treatment C (6.04 g/100 g). Lower moisture content is generally associated with improved shelf stability because it limits microbial growth and delays product deterioration. This finding is consistent with Cherian (2019), who emphasized that maintaining appropriate moisture levels is essential for preserving food quality and extending shelf life.

For ash content, Treatment B obtained the highest value (8.61 g/100 g), indicating a relatively higher mineral content than the other treatments. Ash content serves as an indicator of the total inorganic mineral constituents present in food products. Similar observations were reported by Moore (2020), who noted that higher ash values generally reflect greater concentrations of essential minerals that contribute to the nutritional value of food.

Regarding crude fat, Treatment C exhibited the highest value (0.98 g/100 g), suggesting a greater energy contribution compared with the other treatments. Fat contributes not only to the caloric value of food but also to its mouthfeel and flavor, making it an important component of overall product quality (Moore,

2020). Nevertheless, the fat levels of all treatments remained relatively low, indicating that the developed product may still be considered a low-fat snack alternative.

In terms of crude protein, Treatment B recorded the highest value (0.806 g/100 g), indicating a relatively better protein content among the three formulations. Although the protein content was modest, the result suggests that the formulation used in Treatment B enhanced the nutritional value of the product. Cherian (2019) emphasized that protein is an essential macronutrient necessary for growth, tissue repair, and numerous physiological functions, making it an important consideration in food product development.

For crude fiber, Treatment C obtained the highest value (1.57%), demonstrating its potential as a better source of dietary fiber. The higher fiber content may be attributed to the utilization of Saba banana peel, which has been recognized as a rich source of dietary fiber in previous studies. Increased dietary fiber intake has been associated with improved digestive health and other physiological benefits, further enhancing the nutritional value of the developed product.

Overall, the proximate analysis demonstrates that each treatment possesses distinct nutritional characteristics. Treatment B exhibited lower moisture and higher ash and protein contents, indicating better storage stability and mineral and protein composition. Conversely, Treatment C showed relatively higher fat and fiber contents, which may appeal to consumers seeking products with greater dietary fiber. These findings highlight the potential of Saba banana peel as a valuable ingredient for developing nutritious and sustainable snack products while demonstrating that variations in formulation influence the nutritional composition of the finished product.

Conclusion

This study demonstrated the feasibility of utilizing Saba banana peel as a value-added ingredient in the development of snack chips. The findings showed that variations in formulation influenced both the sensory quality and nutritional composition of the developed product. Among the formulations, Treatment A consistently exhibited the most desirable sensory characteristics, while the proximate analysis revealed that each treatment possessed distinct nutritional attributes. Overall, the study contributes to sustainable food product development by providing evidence that Saba banana peel, an agricultural by-product often considered waste, can be transformed into a nutritious and acceptable snack product, thereby supporting food waste reduction and resource utilization.

Based on the findings, it can be concluded that Saba banana peel is a promising alternative ingredient for developing value-added snack products. The significant differences observed in texture, taste, and overall acceptability indicate that formulation and processing conditions play a vital role in determining consumer preference, whereas the comparable ratings for color and aroma suggest that these attributes were not substantially affected by the treatments. The proximate analysis further demonstrated that the different formulations varied in their nutritional composition, highlighting the potential of Saba banana peel to enhance the nutritional quality of food products. Consequently, the null hypothesis was partially

rejected, as significant differences were found in selected sensory attributes but not in all evaluation criteria.

The findings of this study have practical implications for the food industry, educators, policymakers, and future researchers. Food processors and entrepreneurs may utilize Saba banana peel as a sustainable raw material in developing innovative snack products, contributing to waste reduction and value addition in the banana industry. Educational institutions may integrate the findings into food technology, Technology and Livelihood Education, and technical-vocational programs to promote sustainable food processing and product innovation. Likewise, government agencies and local communities may use the results to support livelihood programs and initiatives that encourage the utilization of agricultural by-products as part of circular economy and food sustainability efforts. Future studies are encouraged to investigate the shelf life, microbiological safety, vitamin and mineral composition, antioxidant properties, packaging stability, consumer market acceptance, cost analysis, and commercial viability of Saba banana peel chips. Further research may also explore alternative formulations, flavor enhancements, and other banana by-products to improve product quality and expand their potential applications in the food industry.

References

1. Al-Sahlany, S. T. G., Altemimi, A. B., Al-Manhel, A. J., Niamah, A. K., Lakhssassi, N., & Ibrahim, S. A. (2020). Effect of substitution percentage of banana peel flour on chemical composition, rheological characteristics of wheat flour and bread quality. *Journal of the Saudi Society of Agricultural Sciences*, 19(1), 87–98. <https://doi.org/10.1016/j.jssas.2018.06.005>
2. Deboch, M. W., & Mezgebe, A. G. (2024). Development of banana chips: Analysis of nutritional and sensory characteristics of banana chips as influenced by frying conditions. *International Journal of Agricultural Research, Innovation and Technology*, 13(2), 1–5. <https://doi.org/10.3329/ijarit.v13i2.70847>
3. Esonu, C. E., Iheme, C. I., Njoku, O. C., Agwu, L. O., Edom, C. V., Godian, C. I., Ezerioha, C. C., Airaodion, A. I., & Ujowundu, C. (2024). Investigation of proximate composition and bioactive components in banana (*Musa acuminata*) peels using advanced analytical techniques. *Journal of Clinical and Medical Case Reports*. <https://doi.org/10.31579/2637-8914/256>
4. Gómez Montaña, F. J., Bolado García, V. E., & Blasco López, G. (2020). Compositional and antioxidant analysis of peels from different banana varieties (*Musa* spp.) for their possible use in developing enriched flours. *Acta Universitaria*, 30, e2260. <https://doi.org/10.15174/au.2019.2260>
5. Hikal, W. M., Said-Al Ahl, H. A. H., Bratovcic, A., Tkachenko, K. G., Sharifi-Rad, J., Kačániová, M., Elhourri, M., & Atanassova, M. (2022). Banana peels: A waste treasure for human being. *Evidence-Based Complementary and Alternative Medicine*, 2022, Article 7616452. <https://doi.org/10.1155/2022/7616452>
6. Khamsaw, P., Sommano, S. R., Wongkaew, M., Willats, W. G. T., Bakshani, C. R., Sirilun, S., & Sunanta, P. (2024). Banana peel (*Musa* ABB cv. Nam Wa Mali-Ong) as a source of value-adding components

- and the functional properties of its bioactive ingredients. *Plants*, 13(5), 593.
<https://doi.org/10.3390/plants13050593>
7. Khoozani, A. A., Birch, J., & Bekhit, A. E.-D. (2019). Production, application and health effects of banana pulp and peel flour in the food industry. *Journal of Food Science and Technology*, 56(2), 548–559. <https://doi.org/10.1007/s13197-018-03562-z>
 8. Manzoor, A., & Ahmad, S. (2021). Banana peel: Characteristics and consideration of its extract for use in meat products preservation: A review. *ACS Food Science & Technology*, 1(9), 1576–1587. <https://doi.org/10.1021/acsfoodscitech.1c00235>
 9. Maschio, G., Stoll, L., Padilha, R. L., de Moraes, K., Leal Leães, F., Thys, R. C. S., & Sant'Anna, V. (2023). Consumers' sensory perception and technological properties of whole foods utilization in bakery products: A case study of banana peel. *British Food Journal*, 125(12), 4622–4638. <https://doi.org/10.1108/BFJ-04-2023-0341>
 10. Pinheiro Gomes, S., Vieira, B., Barbosa, C., & Pinheiro, R. (2022). Evaluation of mature banana peel flour on physical, chemical, and texture properties of a gluten-free rissol. *Journal of Food Processing and Preservation*, 46, e14441. <https://doi.org/10.1111/jfpp.14441>
 11. Segura-Badilla, O., Kammar-García, A., Mosso-Vázquez, J., Ávila-Sosa, R., 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), e11044. <https://doi.org/10.1016/j.heliyon.2022.e11044>
 12. Tan, C. Y., Mohd Arifin, N. N., & Sabran, M. R. (2024). Banana peels as potential prebiotic and functional ingredient. *Jurnal Gizi dan Pangan*, 19(Supplement 1), 119–126. <https://doi.org/10.25182/jgp.2024.19.Supp.1.119-126>
 13. Wahab, N. B. A., Ismail, M. A., & Othman, A. (2024). Physicochemical and sensory evaluation of banana peel crackers. *Prosiding Seminar Nasional Teknologi Komputer dan Sains*.
 14. Zaini, H. B. M., Sintang, M. D. B., & Pindi, W. (2020). The roles of banana peel powders to alter technological functionality, sensory and nutritional quality of chicken sausage. *Food Science & Nutrition*, 8(10), 5497–5507. <https://doi.org/10.1002/fsn3.1847>
 15. Zhang, P., Whistler, R. L., BeMiller, J. N., & Hamaker, B. R. (2022). Banana peels as a bioactive ingredient and its potential application in the food industry. *Journal of Functional Foods*, 92, 105054. <https://doi.org/10.1016/j.jff.2022.105054>