Descriptive Analysis of the Physicochemical, Microbial, and Functional Properties of Peel N' Crunch from Banana (Musa Acuminata X Balbisiana) Peels

Samantha I. Gumban[1*], Jeffrey C. Serencio[2], Maedel Joy V. Escote, PhD[3]

College of Arts and Sciences, Assumption College of Nabunturan, Davao de Oro, Philippines

***Corresponding Author**

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ABSTRACT

The increasing generation of food waste has intensified the need to address this issue through innovative product development that promotes sustainability and food security. This study evaluated the feasibility of developing Peel N' Crunch, a functional snack product made from banana (*Musa acuminata x balbisiana)* peels, through the assessment of its physicochemical, microbial, nutritional, sensory properties. Laboratory analysis were conducted to determine the moisture content, pH level, microbial presence, and nutritional composition, while sensory evaluation was performed using a 4-point Likert scale among 100 consumers from Poblacion, Nabunturan, Davao de Oro. Results showed that the product had a low moisture content (3.46&% ±0.05) and a slightly acidic pH (5.45), indicating good shelf stability and suitability for low-moisture snack foods. Microbial analysis revealed mold, yeast, and *Escherichia coli* levels are within the acceptable safety limits, confirming the product safety under proper manufacturing conditions. Sensory evaluation results indicated positive consumer acceptance, with overall ratings "Satisfied" to "Very Satisfied" for appearance, aroma, taste, and texture. Nutritional analysis further showed a moderate energy and fat content with controlled sodium levels. Overall, the findings demonstrate that the Peel N' Crunch is a safe, acceptable, and a promising sustainable snack product that supports food waste valorization and functional food development.

Keywords: Plant Biology, Food Waste Innovation, Economic Botany, Physicochemical, Microbial, Functional Properties, Nutritional Facts, Banana Peels, Experimental Study.

INTRODUCTION

Banana peels constitute a very significant portion of the fruit waste despite their recognized nutritional and functional potential. In many major banana producing regions their accumulation greatly contributes to the environmental concerns due to the rapid spoilage and the improper disposal (Zaini et al., 2022). However, banana peels are also rich in dietary fiber, phenolic compounds, and very essential nutrients which make them very suitable for use as functional food ingredients (Dom et al., 2024a).

The banana peels often regarded as agricultural waste, represent as untapped resource with significant potential for sustainable innovation. The valorization of banana peels focuses on transforming this abundant by-products, and agricultural input. The production of bananas exceeds 114 million metric tons annually, with the peel comprising one-third of the fruit's total weight and typically discarded as agricultural waste in the food industry. However, banana peels are found to be a rich source of bioactive compounds, most likely antioxidant that offers many health benefits (Putra et al., 2022)

Recent studies have demonstrated the feasibility of incorporating the banana peels into the value added food products which include snack formulations, where they enhance the nutritional quality and the functional

properties (Dargantes et al., 2023). Despite these developments, there is still very limited research that has provided a comprehensive evaluation of the banana peel based products in terms of physicochemical characteristics, microbial safety, and the sensory acceptability, particularly for the chip type snacks intended for direct consumption (Tan et al., 2024).

In the Philippines, where banana production is very extensive, the banana peel waste presents both an environmental challenge and an opportunity for food innovation. Peel N' Crunch, a snack product derived from the Musa acuminata × balbisiana (saba) peels, was developed as a sustainable alternative to conventional chips (Gumban & Serencio, 2024). However, its quality, safety, and the consumer acceptability have not yet been systematically evaluated. This further highlights the need for the empirical validation in order to support its potential for much wider application and possible commercialization.

Therefore, this study aimed to assess Peel N' Crunch in terms of its physicochemical properties, microbial safety, functional/nutritional composition, and its sensory acceptability. Specifically, it evaluated the moisture content, pH level, microbiological presence, nutritional characteristics, and the consumer perception based on the appearance, aroma, taste, and the texture. The findings provide baseline evidence on the viability of the banana peel chips as a sustainable functional snack product.

METHODOLOGY

This study employed a quantitative descriptive-experimental research design in order to evaluate the Peel N' Crunch, a snack product developed from the saba banana (*Musa acuminata* × *balbisiana*) peels. The study was conducted in Poblacion, Nabunturan, Davao de Oro, Philippines with the laboratory analyses performed at the Department of Science and Technology (DOST) Regional Standards and Testing Laboratory XI. The research design has enabled the systematic evaluation of the product's quality, safety, and the consumer acceptability.

Product Preparation

Peel N' Crunch was prepared using a cleaned saba banana peels which were sliced, boiled, seasoned, ground, mixed with cornstarch, molded, boiled, cooled, sliced, sun dried, and then fried until crispy. The finished product was packed in a resealable packaging in order to maintain the quality and the freshness. All preparation procedures were conducted under proper sanitation and standard food handling practices in order to further ensure the product safety and consistency.

Physicochemical and Microbial Analysis

Physicochemical analysis was conducted in order to determine the moisture content and the pH level of the product. Moisture content was measured using the gravimetric method while pH was determined using a pH meter.

Microbial analysis was performed to assess the mold count, yeast count, and the *Escherichia coli*. Mold and yeast counts were determined using the pour plate method while the *E. coli* was analyzed using the multiple tube fermentation technique. Nutritional analysis was also conducted to determine the product's basic composition which includes the fat, sodium, carbohydrates, and protein.

Sensory Evaluation

Sensory evaluation was conducted among 100 respondents from Poblacion, Nabunturan, Davao de Oro. Respondents were selected through the use of random sampling and were limited to the individuals aged 18 to 40 years old who were willing to participate and had no known banana allergy.

The evaluation focused on the four sensory attributes: the appearance, aroma, taste, and the texture. A 4-point Likert scale (shown below) was used in order to measure the level of acceptability, ranging from Very

Unsatisfied to Very Satisfied. Each evaluation session has lasted approximately 15–20 minutes per respondent with very clear instructions provided to ensure the consistent understanding and reliable responses.

Rating Scale for Appearance			
Rating Scale	**Range of Mean**	**Description**	**Interpretation**
4	3.50-4.00	Very Satisfied	The respondents are highly satisfied with the appearance, indicating strong approval of its color, texture, and overall visual appeal.
3	2.50-3.49	Satisfied	The respondents are satisfied with the appearance, suggesting that its visual qualities are acceptable with minor areas for improvement.
2	1.50-2.49	Unsatisfied	The respondents are not satisfied with the appearance, indicating noticeable issues in color, texture, or presentation.
1	1.00-1.49	Very Unsatisfied	The respondents are highly dissatisfied with the appearance, reflecting strong disapproval of its overall visual quality and presentation.

Rating Scale for Aroma			
Rating Scale	**Range of Mean**	**Description**	**Interpretation**
4	3.50-4.00	Very Satisfied	The respondents are highly satisfied with the aroma, indicating strong approval of its pleasantness, natural scent, and its contribution to the product's overall appeal.
3	2.50-3.49	Satisfied	The respondents are satisfied with the aroma, suggesting that the smell is acceptable and generally pleasant, with minor improvements needed in intensity or naturalness.
2	1.50-2.49	Unsatisfied	The respondents are not satisfied with the aroma, indicating noticeable issues such as undesirable smell, imbalance, or being too weak or too strong.
1	1.00-1.49	Very Unsatisfied	The respondents are highly dissatisfied with the aroma, reflecting strong disapproval due to unpleasant, overpowering, or unacceptable smell.

Rating Scale for Taste			
Rating Scale	**Range of Mean**	**Description**	**Interpretation**
4	3.50-4.00	Very Satisfied	The respondents are highly satisfied with the taste, indicating strong approval of flavor, balance, and overall palatability.
3	2.50-3.49	Satisfied	The respondents are satisfied with the taste, suggesting acceptable flavor with minor improvements needed in balance or intensity.
2	1.50-2.49	Unsatisfied	The respondents are not satisfied with the taste, indicating issues with flavor, balance, or aftertaste.
1	1.00-1.49	Very Unsatisfied	The respondents are highly dissatisfied with the taste, reflecting strong disapproval of the product's flavor and palatability.

Rating Scale for Texture			
Rating Scale	**Range of Mean**	**Description**	**Interpretation**
4	3.50-4.00	Very Satisfied	The respondents are highly satisfied with the texture, indicating strong approval of crispness, consistency, and mouthfeel.
3	2.50-3.49	Satisfied	The respondents are satisfied with the texture, suggesting acceptable consistency and mouthfeel with minor improvements needed.
2	1.50-2.49	Unsatisfied	The respondents are not satisfied with the texture, indicating issues with crispness, consistency, or mouthfeel.
1	1.00-1.49	Very Unsatisfied	The respondents are highly dissatisfied with the texture, reflecting strong disapproval due to poor or unpleasant mouthfeel and inconsistency.

Research Subject

This study involved approximately 100 respondents residing around Poblacion, Nabunturan, Davao de Oro, who were selected through random sampling. This sampling method provides an equal chance of selection to ensure representation of the community's perspective and experiences and to minimize bias (Noor et al., 2022).

Respondent involvement takes only 15-20 minutes, depending on how long they take to answer. The qualified respondent was between 18 and 40 years old and willing to participate, ensuring that the data gathered came from the active and productive age group (Raurich & Seegmuller, 2020). At the same time, the unqualified respondents are those with banana allergies, unwilling, and anyone below the minimum age requirement. Respondents can also withdraw from the study at any time for personal reasons or if they develop any discomfort or allergic reaction during product testing.

Statistical Treatment of Data

Mean. This was used to compute the mean from the sensory evaluation gathered from the respondents. The mean served as the primary statistical tool to determine participants' overall evaluation of the Peel N' Crunch product (Mishra et al., 2019).

Ethical Considerations

Participants were informed about the purpose, procedures, risks, and the benefits of the study and informed consent was also obtained prior to the participation. Participation was voluntary and respondents were allowed to withdraw at any time. Confidentiality and the anonymity of all participants were strictly maintained. All the data collected were used solely for academic purposes and handled in accordance with the ethical research standards.

RESULTS AND DISCUSSION

This section presents and interprets the findings of the study on the physicochemical properties, microbial safety, nutritional composition, and the sensory acceptability of Peel N’ Crunch. The results are organized according to the study objectives and supported by the laboratory analysis and consumer evaluation data.

Table 1. Physicochemical Properties of Peel N’ Crunch

Parameter	Result	Measurement Uncertainty	Acceptable Limit/Standard
Moisture content	3.46%	±0.05	<5% for low-moisture foods
pH level	5.45	—	4.5–6.5

The physicochemical results have indicated that Peel N’ Crunch possesses very favorable characteristics for a chip type snack product. The moisture content (3.46%) is well below the threshold for the low moisture foods which is very essential in maintaining the crispness and limiting the microbial growth. This suggests that the processing methods, particularly the drying and frying were effective in reducing the water content and enhancing the product stability (Codex Alimentarius Commission, 2015). Low moisture conditions are widely recognized as a very critical factor in extending the shelf life and preserving the quality of the snack products.

The pH level of 5.45 reflects a slightly acidic condition that falls within the acceptable range for the food products. This acidity may contribute to the flavor development while also influencing the microbial activity as many microorganisms have reduced growth rates in the mildly acidic environments. When combined with the low moisture content, the pH level has further supported the product’s stability (Kumar, 2025). These findings indicate that Peel N’ Crunch meets the essential physicochemical standards for the safe and shelf stable snack foods.

Microbial Properties of Peel N' Crunch

Table 2. Microbial Analysis of Peel N' Crunch

Parameter	Result	Acceptable Limit/ Standard
Mold Count (Pour Plate Method)	180 CFU/g	<1,000 CFU/g (FDA, 2012; DOH, 2004)
Yeast Count	<100 Est. CFU/g	<1,000 CFU/g FDA, 2012; DOH, 2004))
Escherichia coli, MPN (MultipleTube Fermentation Technique)	<3.0 MPN/g	<3 MPN/g

*CFU- Colony Forming Unit MPN- Most Probable Number

The microbial analysis has demonstrated that the Peel N' Crunch is within the acceptable safety limits for the ready-to-eat products. The mold and yeast counts were substantially lower than the allowable threshold which indicates the effective control of the fungal contamination during the processing. This suggests that the combined effects of boiling, drying, frying, and packaging have contributed to reducing the microbial presence.

The *Escherichia coli* result which falls within the acceptable limits further indicates the absence of the significant contamination and reflects the proper sanitation and handling practices during the production. As *E. coli* is commonly used as an indicator organism for hygiene, its low level has supported the reliability of the production process. These results confirm that the product is microbiologically safe and very suitable for consumption when the proper food handling and the storage practices are maintained carefully (FDA, 2022).

Nutritional Composition of Peel N' Crunch

Table 3. Nutritional Composition of Peel N' Crunch

Parameter	Result	Measurement Uncertainty
Moisture	3.43%	±0.06
Protein	0.91 %	±0.02
Total Fat	26.85%	±0.3
Ash	2.19%	±0.01
Sodium	614mg/100g	±11

The nutritional analysis indicates that the Peel N' Crunch is a low-moisture energy dense snack product. The low moisture content has supported the product's crisp texture and its shelf stability which reinforces the findings of the physicochemical analysis. The protein content is also relatively low which is typical for the plant based snack products that are not specifically formulated for high protein intake.

The total fat content is also relatively high, likely due to the frying process and plays a very significant role in enhancing the flavor, texture, and the overall palatability. While the fat contributes positively to the sensory quality, it also suggests that the consumption should be moderated. The ash content further reflects the presence of the mineral components that are derived from the raw materials while the sodium level contributes to the flavor but still highlights the importance of balanced consumption (Wang et al., 2020). Overall, the nutritional profile aligns with the typical snack foods while still demonstrating the potential of the banana peel waste as a functional ingredient.

Sensory Acceptability of Peel N' Crunch

Table 4. Sensory Acceptability of Peel N' Crunch

Sensory Attribute	Mean	Interpretation
Appearance	3.49	Satisfied
Taste	3.59	Very Satisfied

Aroma	3.55	Very Satisfied
Texture	3.65	Very Satisfied
Grand Mean	**3.57**	**Very Satisfied**

The sensory evaluation results indicate that the Peel N' Crunch was generally well accepted by the consumers with an overall rating of "Very Satisfied." Among the evaluated attributes, texture received the highest score which greatly suggested that the crispness and the mouthfeel were the most influential factors in the consumer acceptance (Kamei et al., 2023). This is particularly important for the chip type snacks where the texture is the primary determinant of the eating satisfaction and perceived quality.

Taste and aroma also received high ratings which indicated that the flavor formulation was very effective in enhancing the product's appeal. These attributes contribute significantly to the overall acceptability as they directly influence the consumer preference and the likelihood of repeat consumption (Popova & Miteva, 2025). Appearance, although slightly lower than the other attributes, also remained within the acceptable range which suggests that the improvements in the visual presentation such as the color uniformity may further enhance the product appeal (Silva et al., 2025) .

Overall, the sensory findings demonstrate that the Peel N' Crunch meets the consumer expectations in terms of the quality and acceptability. The combination of the favorable texture, taste, and aroma has suggests the strong market potential for the product as a sustainable snack alternative.

CONCLUSION

This study aimed to perform a descriptive analysis of the physicochemical, microbial, and functional properties of Peel N' Crunch from banana (*Musa acuminata x balbisiana)* peels, demonstrating acceptable results suitable for a ready-to-eat snack product. The low moisture content and slightly acidic pH support the product's stability. At the same time, the microbiological analysis confirms that mold, yeast, and E. coli levels are within safe limits, ensuring that the product is safe for consumption when stored under proper conditions. These findings answer the research questions related to product safety and quality, showing that the manufacturing process effectively controls microbial growth and maintains product integrity. Based on the sensory evaluation results, consumers were generally satisfied with the product's appearance, aroma, taste, and texture. The taste and texture, in particular, were the most influential factors driving the overall consumers' acceptance. This addresses the research questions regarding consumers' preferences and acceptability, indicating that Peel N' Crunch meets the sensory expectations of its target consumers.

The nutritional analysis revealed that the product provides moderate energy and fat while maintaining low sodium content per serving, suggesting that it can serve as a comparatively healthier snack alternative to conventional chips. Overall, the study confirms that the Peel N' Crunch is safe, appealing, and nutritionally suitable for its target market. The research process also enabled the researchers to appreciate the importance of integrating sensory, microbiological, and nutritional analyses to evaluate food products, thereby providing a comprehensive picture of product quality.

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