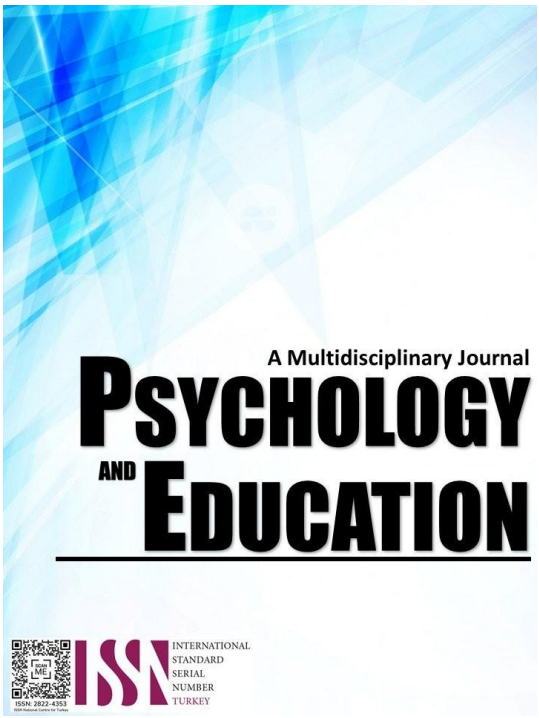
DEVELOPMENT AND CONSUMER ACCEPTABILITY FOR MALUNGGAY (MORINGA OLEIFERA) AND BANANA BLOSSOM (MUSA ACUMINATA) - BASED SNACK CRACKERS: TECHNO-GUIDE APPROACH



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Research Article

Development and Consumer Acceptability for Malunggay (Moringa Oleifera) and Banana Blossom (Musa Acuminata) - Based Snack Crackers: Techno-Guide Approach

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Abstract

This study, entitled Development and Consumer Acceptability of Malunggay (Moringa oleifera) and Banana Blossom (Musa acuminata) Snack Crackers – Techno Guide, is anchored on national and institutional frameworks that promote innovation, food security, and public health. It supports the objectives of the Philippine Innovation Act (Republic Act No. 11293), which underscores innovation as a catalyst for sustainable national development, and is consistent with the Philippine Constitution's recognition of science and technology as essential drivers of progress. Furthermore, the study aligns with the Joint NEDA–DOST–DTI Administrative Order No. 01, Series of 2020, which emphasizes innovation-led strategies in addressing economic growth and food security concerns. The utilization of locally available and underutilized agricultural resources, such as malunggay and banana blossom, promotes inclusive innovation, supports small-scale food enterprises, and contributes to sustainable economic and social development. The theoretical foundation of the study is drawn from Allen's Theory of Food (2012), which conceptualizes food as an outcome of interconnected social, economic, and environmental systems. The development of vegetable-based snack crackers using malunggay and banana blossom reflects sustainable food innovation by maximizing the nutritional potential of accessible, affordable, and culturally relevant crops. This approach contributes to improved nutrition, reduced food waste, and strengthened community-based food systems. In addition, the Theory of Planned Behavior (Ajzen, 1991), further refined through the Reasoned Action Approach (Fishbein & Ajzen, 2020), provides a framework for examining consumer acceptability. The theory explains how attitudes toward health and sensory attributes, perceived social norms from family and school communities, and perceived behavioral control related to product availability and affordability influence students' intentions to consume vegetable-based snack products. This study is further aligned with DepEd Order No. 13, s. 2017, which mandates the provision of nutritious and health-promoting food options in schools to address malnutrition and obesity among learners. The development of malunggay and banana blossom snack crackers supports this directive by offering a nutritious alternative to commercially processed snacks. Moreover, the study complements the objectives of the Gulayan sa Paaralan Program by encouraging the use of school-grown vegetables in value-added food production. Integrating these nutrient-dense crops into snack products reinforces the connection between agriculture, nutrition, and education, while addressing the Double Burden of Malnutrition identified by the World Health Organization. Overall, the study contributes to the promotion of healthy eating habits, food security, and sustainable nutrition interventions within the school setting.

Keywords: *malunggay, banana blossom, snack crackers, sensory evaluation, techno guide*

Introduction

Agriculture remains a fundamental pillar of food security and economic stability worldwide, with farmers serving as key contributors to sustainable development. In the Philippines, agriculture continues to sustain the livelihoods of millions, particularly in rural areas, despite ongoing challenges such as climate change, unstable market prices, and limited access to modern technologies. Among the country's locally abundant yet underutilized crops are malunggay (Moringa oleifera) and banana blossom (Musa acuminata), both recognized for their exceptional nutritional and health-promoting properties.

This study seeks to develop nutritious, affordable, and locally sourced vegetable-based snack crackers using malunggay and banana blossom as primary ingredients. These crops are rich in essential vitamins, minerals, antioxidants, and dietary fiber that contribute to improved health outcomes, particularly for children and older people. Malunggay, often referred to as the "miracle tree," offers significant amounts of vitamins A, C, and E, calcium, iron, and potassium—nutrients vital for immunity and growth. Similarly, banana blossom provides fiber, iron, and amino acids that aid digestion and prevent iron deficiency anemia, a common nutritional concern in the country.

By integrating these functional ingredients into a familiar snack format, the study aims to enhance consumer acceptability and encourage healthier eating habits. Moreover, sourcing raw materials from local farmers in Barangay Cagay, Barili, Cebu supports agricultural sustainability, reduces food waste, and promotes rural economic development through value-added production.

Ultimately, this initiative contributes to public health improvement and community empowerment by transforming locally available crops into innovative, health-oriented food products. The study culminates in the creation of both malunggay and banana blossom-based snack crackers and a techno-guide, serving as practical tools for food innovation, livelihood enhancement, and nutritional advancement within the community.

Research Questions

This study focused on the development and evaluation of vegetable-based snack crackers enriched with malunggay (Moringa oleifera) and banana blossom (Musa acuminata) as nutritious and locally sourced food products. Conducted at Cagay National High School and Cebu Technological University – Barili Campus during the 2025–2026 academic year, the research aimed to determine the most acceptable formulation among four variations containing different proportions of these ingredients. Through product formulation and sensory evaluation, the study sought to assess the crackers' sensory qualities, cost efficiency, and potential for local commercialization.

1. What are the snack cracker formulations based on the following treatment combinations:
   1.1 12 g of malunggay + 108 g banana blossom + standard ingredients;
   1.2 24 g of malunggay + 96 g banana blossom + standard ingredients;
   1.3 36 g of malunggay + 84 g banana blossom + standard ingredients; and
   1.4 48 g of malunggay + 72 g banana blossom + standard ingredients?
2. Based on the evaluation of trained panelists, how do the snack crackers perform in terms of the following sensory quality attributes:
   2.1 color;
   2.2 aroma;
   2.3 taste;
   2.4 mouthfeel; and
   2.5 general/overall acceptability?
3. What are the mean acceptability scores of the four treatments using the 9-point Hedonic Scale for the following attributes:
   3.1 color;
   3.2 aroma;
   3.3 taste;
   3.4 mouthfeel; and
   3.5 general/overall acceptability?
4. Is there a significant difference in the sensory attributes among the four formulations?
5. What is the projected production cost for the most preferred treatment formulation?
6. Based on the findings, what techno-guide can be developed to support the preparation and potential commercialization of the snack crackers?

Literature Review

It emphasizes that this study builds upon existing Filipino food innovations, particularly the traditional fish kropek, a popular snack known for its crispy texture, savory flavor, and high consumer acceptance. As described by Mama's Guide Recipes (2020), the kropek-making process involves blending fish with cassava or tapioca starch, steaming, drying, and deep-frying methods that ensure desirable texture and extended shelf life. This traditional process serves as a foundational model for developing a plant-based alternative using malunggay (Moringa oleifera) and banana blossom (Musa acuminata).

The adaptation of this method integrates nutritional and environmental considerations, as malunggay is rich in vitamins A, calcium, and iron (Barrios et al., 2021), while banana blossoms contain high levels of dietary fiber, antioxidants, and phytochemicals (Santiago et al., 2020). Together, these ingredients offer a nutrient-dense and sustainable substitute for conventional snack products.

Furthermore, literature underscores the significance of consumer acceptability rooted in familiar taste, texture, and cultural relevance. By modifying a traditional kropek recipe into a vegetable-based formulation, the study aligns with modern consumer demands for healthier snack options while maintaining a connection to Filipino culinary heritage. This innovation also complements national programs promoting nutrition, food fortification, and sustainable food systems.

Overall, the prior art of fish kropek provides structural and procedural guidance for this study. It demonstrates how traditional food technologies can be creatively adapted to develop nutritious, affordable, and culturally relevant snack alternatives—contributing to dietary diversity, public health, and local agricultural sustainability.

Methodology

Research Design

This study adopted a Completely Randomized Design (CRD) to evaluate the sensory attributes—color, flavor, aroma, texture, and overall acceptability—of malunggay (Moringa oleifera) and banana blossom (Musa acuminata) snack crackers formulated under four treatments (T1–T4). A CRD is considered appropriate when experimental units are relatively homogeneous and when treatments can be assigned randomly, allowing differences in responses to be attributed primarily to treatment effects rather than extraneous variables (Montgomery, 2017). This design is commonly used in food product development and sensory evaluation studies where multiple formulations are compared under control conditions (Lawless & Heymann, 2010).

The use of CRD in this investigation enables the random presentation of cracker samples to panelists, thereby minimizing order effects and personal bias during sensory evaluation. According to Meilgaard, Civille, and Carr (2016), randomization is essential in sensory studies to ensure the reliability and validity of consumer response data, particularly when assessing variations in formulation. The four treatments in this study represent different proportions of malunggay leaves and banana blossom, allowing for a systematic comparison of sensory outcomes resulting from ingredient modification.

The study followed an iterative product development approach, beginning with a pretrial formulation. Initial results indicated excessive bitterness, necessitating adjustments in ingredient proportions to improve palatability and consumer acceptability. Such iterative refinement is a recognized practice in food innovation research, where preliminary trials inform subsequent experimental treatments to optimize both nutritional value and sensory quality (Grunert, 2013; Lawless & Heymann, 2010). The revised formulations were designed to balance the sensory contributions of malunggay and banana blossom while maintaining feasibility for small-scale production and potential scalability.

To measure consumer acceptability, the study employs the 9-point Hedonic Scale, a standardized sensory evaluation tool developed by Peryam and Pilgrim (1957). The scale remains one of the most widely used instruments in food science research due to its sensitivity and effectiveness in capturing degrees of liking across sensory attributes such as appearance, aroma, taste, texture, and overall acceptability (Stone & Sidel, 2004; Meilgaard et al., 2016). The application of the hedonic scale is particularly appropriate for studies involving untrained or semi-trained panelists, as it reflects genuine consumer preferences rather than expert judgments.

Data obtained from the hedonic evaluation will be analyzed using descriptive statistics and appropriate inferential methods consistent with CRD, such as analysis of variance (ANOVA), to determine significant differences among treatment means. Descriptive and comparative analyses are standard analytical approaches in sensory and consumer studies, providing meaningful interpretation of acceptance levels and supporting evidence-based conclusions for product development (Montgomery, 2017; Lawless & Heymann, 2010). The findings of this sensory evaluation will serve as the empirical basis for the development of a utility model for the proposed snack crackers.

Overall, the integration of CRD, iterative formulation, and validated sensory evaluation tools establishes a methodologically sound framework consistent with established practices in food product research and strengthens the reliability and rigor of the study's findings.

Respondents

A total of 110 panelists participated in the sensory evaluation of the developed malunggay (Moringa oleifera) and banana blossom (Musa acuminata) snack crackers during the 2025–2026 school year. The panel consisted of 100 untrained panelists, including high school students, parents, and local vendors from Cagay National High School and residents of Barangay Cagay, representing the target consumer population, and 10 trained panelists, comprising Food Technology students from Cebu Technological University – Barili Campus, who provided expert assessment of specific sensory attributes.

Untrained panelists were included to provide consumer-based evaluations of general acceptability, while trained panelists were responsible for evaluating color, aroma, taste, and mouthfeel using their expertise in food assessment. Panelists were selected using purposive sampling. A Survey Questionnaire for Taster Selection was administered to identify participants who were willing, available during the testing period, free of allergies to vegetable-based ingredients, and interested in participating in the sensory evaluation.

Before the evaluation, all panelists attended two orientation sessions. The first session introduced the research background, objectives, and the importance of their participation. The second session explained the sensory evaluation process, including proper use of the hedonic rating scale for assessing color, aroma, taste, mouthfeel, and overall acceptability. This preparation ensured that panelists were informed and capable of providing reliable evaluations.

Instrument

The study utilized a standardized sensory evaluation form based on the 9-point Hedonic Scale by Peryam and Pilgrim (1992) to measure consumer acceptability of the developed malunggay and banana blossom snack crackers. A 5-point Likert scale was also applied to assess specific sensory attributes such as color, aroma, taste, and mouthfeel. The questionnaire consisted of two parts: Part I gathered panelist information and consent, while Part II guided the evaluation of product samples. Clear written and oral instructions were provided to ensure consistent understanding and accurate data collection. This instrument effectively captured both trained and untrained panelists' perceptions, ensuring reliable analysis of product quality and acceptability.

Procedure

Technological University – Barili Campus was observed, including obtaining formal approval from the Campus Director and concerned authorities. Upon approval, relevant literature and recipes were reviewed to support the formulation of a nutritious vegetable-based cracker using malunggay (Moringa oleifera) and banana blossom (Musa acuminata). The experimental design employed four (4) treatments with varying proportions of the main ingredients. Each formulation was prepared following standardized procedures and evaluated through sensory testing by 110 panelists using the 9-Point Hedonic Scale. The results were analyzed using weighted mean and ANOVA to determine the most acceptable formulation in terms of color, aroma, taste, texture, and overall acceptability.

Data Analysis

Following the sensory evaluation, the data were analyzed using appropriate statistical techniques. The weighted mean was calculated to determine the overall acceptability of each treatment based on the panelists' responses. Analysis of variance (ANOVA) was performed to assess whether significant differences existed among the four treatments. This statistical procedure identified variations in the sensory attributes—such as color, aroma, taste, texture, and overall acceptability—across the different formulations of the malunggay and banana blossom snack crackers.

Ethical Considerations

The study strictly adhered to ethical research standards to ensure the rights, dignity, and welfare of all participants. Informed consent was obtained from both trained and untrained panelists after a full explanation of the study's purpose and procedures, emphasizing voluntary participation and confidentiality of responses. Sensory evaluations were conducted using standardized and non-invasive methods under controlled, hygienic conditions to ensure reliability and fairness. All ingredients were responsibly sourced and free from chemical additives, following food safety and sanitation protocols. The research also upheld cultural and environmental ethics by promoting the use of locally available, nutritious, and sustainable ingredients such as malunggay and banana blossom, aligning with the study's goal of supporting health, education, and local agriculture.

Results and Discussion

This study evaluated four formulations of malunggay (Moringa oleifera) and banana blossom (Musa acuminata) snack crackers to determine the most acceptable product in terms of color, aroma, taste, mouthfeel, and overall acceptability. Sensory evaluation was conducted by trained and untrained panelists using the 9-point Hedonic Scale. Descriptive statistics and two-way ANOVA were applied to analyze the data, while Tukey's HSD test identified significant differences among treatments. Findings revealed the formulation with the highest level of consumer preference, which became the basis for the development of a techno-guide designed to standardize product preparation, promote marketability, and support potential commercialization of the vegetable-based crackers.

Table 1. *Formulations of Malunggay and Banana Blossom Snack Crackers*

Treatment Code	*Malunggay Content (g)*	*Banana Blossom Content (g)*
T1	12 g	108 g
T2	24 g	96 g
T3	36 g	84 g
T4	48 g	72 g

Table 1 presents the four treatment formulations of malunggay and banana blossom snack crackers. The treatments were structured to systematically vary malunggay and banana blossom ratios while keeping other ingredients constant. This allowed the study to assess the effect of ingredient proportions on sensory attributes and consumer acceptability.

Table 2. *Mean descriptive score (±SD) and Tukey groupings for descriptive attributes of malunggay and banana blossom snack crackers by trained panelists*

Treatment	*Descriptive Score*			
	Color	*Aroma*	*Taste*	*Mouthfeel*
T1 (12g + 108g)	3.7 ± 1.57ab	2.8 ± 1.03b	1.7 ± 0.82c	2.3 ± 1.25ab
T2 (24g + 96g)	3.9 ± 1.29a	3.0 ± 0.47b	2.3 ± 1.49bc	2.7 ± 1.25a
T3 (36g + 84g)	2.8 ± 1.32bc	2.7 ± 0.95b	2.6 ± 1.26b	2.2 ± 0.79ab
T4 (48g + 72g)	2.4 ± 1.26c	3.6 ± 1.07a	3.7 ± 1.34a	1.9 ± 0.88b

Means in a column with different superscripts are significantly different at α = 0.05, Tukey's HSD.

This section presents the mean acceptability scores of the four treatment formulations (T1 to T4) across the five sensory attributes: color, aroma, taste, mouthfeel, and overall acceptability. The scores were obtained from untrained (n = 100) panelists using the 9-point Hedonic Scale. Table 10 presents the mean descriptive scores (±SD) and Tukey groupings for the acceptability attributes of malunggay and banana blossom snack crackers. Results revealed that variations in malunggay and banana blossom levels significantly influenced consumer perception across sensory parameters.

Table 3. *Mean descriptive score (±SD) and Tukey groupings for acceptability of malunggay and banana blossom snack crackers by untrained panelists*

Treatment	*Descriptive Score*				
	Color	*Aroma*	*Taste*	*Mouthfeel*	*Overall Acceptability*
T1 (12g + 108g)	8.04 ± 1.15	7.81 ± 1.05	7.95 ± 1.46	7.84 ± 1.41	8.04 ± 1.22
T2 (24g + 96g)	7.35 ± 1.36	6.91 ± 1.30	6.83 ± 1.70	6.65 ± 1.67	6.92 ± 1.43
T3 (36g + 84g)	6.60 ± 1.38	6.42 ± 1.63	6.34 ± 1.63	6.27 ± 1.64	6.32 ± 1.46
T4 (48g + 72g)	6.12 ± 1.97	6.00 ± 1.68	6.03 ± 1.83	5.95 ± 1.75	6.08 ± 1.83

Means in a column with different superscripts are significantly different at α = 0.05, Tukey's HSD.

Table 3 presents the mean acceptability scores for all treatments across sensory attributes and overall acceptability. T1 consistently

received the highest scores, indicating it was the most preferred formulation among panelists. T2 and T3 showed moderate acceptability with no significant differences between them, while T4, with the highest malunggay content, consistently scored lowest, suggesting excessive malunggay negatively affects flavor and overall acceptability.

Table 4. *ANOVA Results on Sensory Attributes of Snack Crackers (Untrained Panelists, n = 100)*

Sensory Attribute	*F-Value*	*P-Value*
Color	33.66	<2e-16 ***
Aroma	33.52	<2e-16 ***
Taste	22.93	1.04e-13 ***
Mouthfeel	27.51	3.52e-16 ***
General Acceptability	33.89	<2e-16 ***

****Highly Significant at p ≤ 0.001*

As indicated in Table 4, the untrained panelists' one-way Analysis of Variance (ANOVA) results for the four treatment formulations (T1–T4) showed statistically significant variations in each of the five sensory qualities.

Each of the F-values is large and associated with a very small p-value ($p < 0.001$), which means that there are highly significant differences among the four treatments (T1, T2, T3, and T4) in terms of color, aroma, taste, mouthfeel, and overall acceptability. The triple asterisks (***) indicate a high level of statistical significance according to standard thresholds (e.g., Meilgaard et al., 2015; Lawless & Heymann, 2010).

This implies that the sensory responses of untrained panelists varied significantly depending on the formulation, affirming that the changes in malunggay and banana blossom concentrations noticeably influenced consumer perceptions across all evaluated attributes.

Table 5. *Summary of Tukey Groupings by Attribute*

Attribute	*Group A (Most Preferred)*	*Group B (Moderate)*	*Group C (Least Preferred)*
Aroma	T1	T2, T3	T4
Color	T1	T2, T3	T4
Taste	T1	T2, T3	T4
Mouthfeel	T1	T2, T3	T4
Overall Acceptability	T1	T2, T3	T4

Tukey's HSD post hoc analysis showed clear distinctions among the four formulations across all sensory attributes evaluated by untrained panelists. Treatment 1 (T1) achieved the highest mean ratings for color, aroma, taste, mouthfeel, and overall acceptability, indicating superior consumer preference. Treatments 2 and 3 (T2 and T3) exhibited moderate acceptance with no significant difference between them, while Treatment 4 (T4), containing the highest proportion of malunggay, consistently scored lowest. These findings suggest that excessive malunggay content can adversely affect sensory qualities, particularly flavor and aroma, aligning with prior research on sensory limits in functional food formulations (Alves et al., 2021; Lawless & Heymann, 2010).

Table 6. *Estimated Production Costs per Batch by Treatment*

Ingredient	*Cost (T1)*	*Cost (T2)*	*Cost (T3)*	*Cost (T4)*
Malunggay (fresh)	₱0.72	₱1.80	₱2.70	₱3.78
Banana Blossom (cooked)	₱1.62	₱1.44	₱1.26	₱1.08
Cassava Flour	₱28.00	₱28.00	₱28.00	₱28.00
Iodized Salt	₱0.40	₱0.40	₱0.40	₱0.40
Garlic Powder	₱8.04	₱8.04	₱8.04	₱8.04
Ground Black Pepper	₱1.61	₱1.61	₱1.61	₱1.61
Water	₱1.25	₱1.25	₱1.25	₱1.25
Oil	₱37.00	₱37.00	₱37.00	₱37.00
Total	₱78.64	₱79.54	₱80.26	₱81.16

Note: All costs are in Philippine pesos and based on standard batch sizes used in the experiment.

Among the four treatments, T1 (12g malunggay + 108g banana blossom) was not only the most sensorially acceptable but also the least expensive to produce at ₱78.64 per batch. The cost gradually increased with higher malunggay content, with T4 (48g malunggay + 72g banana blossom) being the most expensive at ₱81.16. This is due to the incremental use of malunggay, which, despite its low per-gram cost, contributes significantly when used in larger quantities.

These findings suggest that T1 is not only optimal in terms of consumer preference but also cost-efficiency, making it the most viable for potential market scaling or community-level production. This supports earlier works that recommend maximizing the use of locally available and low-cost functional ingredients in snack production (Boateng et al., 2020; Meilgaard et al., 2015).

Based on the results of the acceptability test, production cost analysis, and sensory evaluation, a comprehensive techno-guide was developed to support local producers, community groups, and small-scale entrepreneurs in manufacturing malunggay and banana blossom-based snack crackers. The guide serves as a practical manual outlining the standardized procedure for replicating the most acceptable formulation (T1), ensuring consistent product quality, enhanced nutritional value, cost-effectiveness, and sustainable production practices.

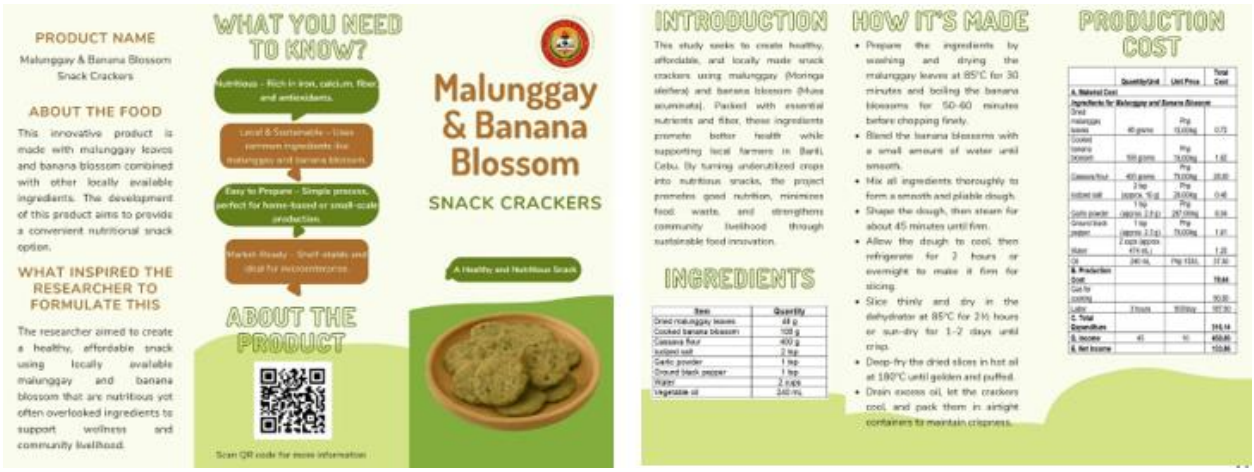

Figure 1. *Product Label of Malunggay and Banana Blossom Snack Crackers*

Conclusions

This study successfully developed a vegetable-based snack cracker incorporating malunggay (Moringa oleifera) and banana blossom (Musa acuminata), with Treatment 1 (12 g malunggay + 108 g banana blossom) identified as the most acceptable formulation based on sensory evaluations conducted by both trained and untrained panelists. Significant differences were observed among the four formulations, particularly in aroma, color, and overall acceptability, indicating that variations in ingredient proportions significantly influenced consumer perception. Multiple linear regression analysis further revealed that color and mouthfeel were significant predictors of overall acceptability, underscoring the importance of visual appeal and textural quality in product development.

Based on these findings, it is recommended that future product development efforts prioritize the optimization of color and mouthfeel to enhance consumer acceptance of vegetable-enriched snack products. Food processors and small-scale entrepreneurs are encouraged to adopt Treatment 1 as the standard formulation due to its superior sensory performance and cost efficiency, making it suitable for community-level production and potential commercialization. To further improve product quality, subsequent studies may explore processing techniques such as blanching, dehydration methods, or flavor enhancement strategies to mitigate the strong sensory impact of higher malunggay concentrations.

In addition, future research should examine the nutritional composition, shelf life, and microbial stability of the developed snack crackers to ensure product safety and market readiness. Expanding consumer testing to include a larger and more diverse demographic group is also recommended to validate broader market acceptability. The techno-guide developed in this study may serve as a practical reference for local producers, schools, and community organizations, supporting sustainable food innovation, livelihood development, and the utilization of locally available agricultural resources.

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