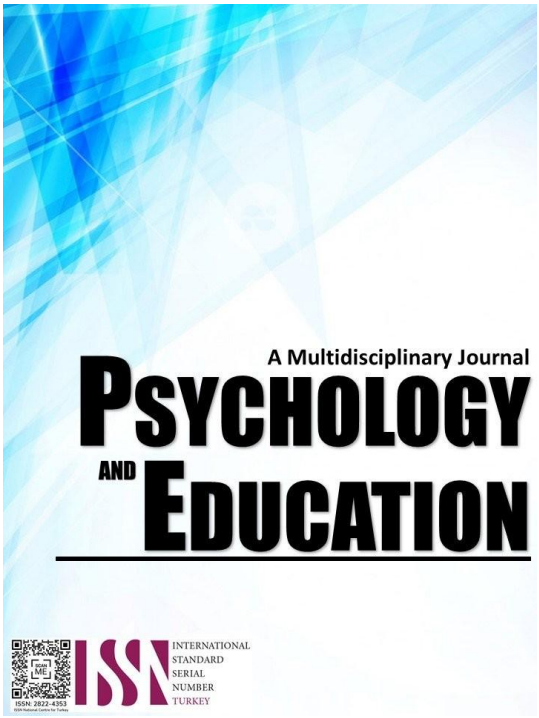
SENSORY ACCEPTABILITY OF FRUIT-ENRICHED FLAVORED BIBINGKA: TECHNO-GUIDE



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Research Article

Sensory Acceptability of Fruit-Enriched Flavored Bibingka: Techno-Guide

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Abstract

This study assessed the sensory acceptability of the five bibingka variants (T0–T4) enriched with locally available fruits: a non-enriched control (T0), mango (T1), dragon fruit (T2), orange (T3), and banana (T4). A total of 100 consumer panelists participated in the sensory evaluation, rating each variant based on taste, color, aroma, mouthfeel, and overall acceptability using standardized scales. Results from one-way Analysis of Variance (ANOVA) revealed significant differences among treatments ($p < 0.05$) for all sensory attributes except color, indicating that fruit type significantly influenced consumer perception. Among the variants, banana-enriched bibingka (T4) obtained the highest ratings for taste (8.6 ± 0.67), aroma (8.7 ± 0.63), mouthfeel (8.6 ± 0.72), and overall acceptability (8.7 ± 0.52), while orange-enriched bibingka (T3) achieved the highest score for color (8.4 ± 0.68), underscoring the importance of visual appeal. Multiple Linear Regression analysis further indicated that taste and aroma were significant predictors ($p < 0.05$) of overall acceptability, jointly explaining 84.3% of the variance, highlighting the dominant role of flavor and aromatic quality in shaping consumer preference. Economic evaluation using Return on Investment (ROI) demonstrated strong commercial potential, with banana-enriched bibingka (T4) yielding the highest ROI (81.19%), followed by mango (T1) at 74.83%, dragon fruit (T2) at 70.39%, orange (T3) at 64.77%, and the control (T0) at 57.84%. Overall, the findings indicate that fruit enrichment, particularly with banana and mango, not only enhances sensory acceptability but also improves profitability. Furthermore, the utilization of locally sourced fruits supports sustainable agriculture, reduces postharvest waste, and strengthens linkages between local farmers and food entrepreneurs, thereby contributing to community-based economic development and food innovation.

Keywords: *fruit-enriched bibingka, sensory evaluation, consumer acceptability, food innovation, bibingka*

Introduction

Rice remains a staple across Asia and serves as a foundational ingredient in a wide range of traditional foods, including rice cakes. In the Philippines, these products are commonly referred to as kakanin, with bibingka recognized as one of the most popular and culturally significant varieties. Traditionally prepared using rice flour, coconut milk, and sugar, bibingka is closely associated with Filipino rituals, festivities, and communal gatherings, reflecting its enduring cultural value.

In recent years, however, shifts in consumer behavior toward healthier and more functional foods have influenced the development of traditional food products. Increasing health consciousness has led to a growing demand for foods that are not only culturally familiar but also nutritionally enhanced. While bibingka is generally perceived as a low-fat and versatile food, its conventional formulation may lack essential nutrients such as dietary fiber, vitamins, and minerals. As a result, there is a need to improve its nutritional profile without compromising its sensory appeal.

One promising approach is incorporating fruit-based ingredients into traditional recipes. Fruit enrichment has been widely recognized as a strategy to enhance both the nutritional value and sensory characteristics of food products, contributing natural sweetness, flavor complexity, and visual appeal. This aligns with the concept of food innovation, which emphasizes the development of healthier and more sustainable products using locally available resources (Rabadán et al., 2021). Recent studies further suggest that consumers are more likely to accept modified traditional foods when they retain cultural familiarity while offering added functional benefits (Lao et al., 2022; Cariño et al., 2025).

Despite these advancements, there remains a clear empirical gap in the Philippine context. Specifically, there is limited research examining the sensory acceptability and consumer preference for bibingka enriched with locally sourced fruits, such as banana, mango, orange, and dragon fruit. Existing studies on enriched bakery and rice-based products often focus on nutritional enhancement or general acceptability but provide insufficient evidence on how specific fruit variations influence key sensory attributes, taste, aroma, texture, color, and overall consumer acceptance in community-based settings.

Addressing this gap is essential for both product development and local economic sustainability. In areas such as Barangay Mantalongon, Barili, Cebu, where fruit production is abundant, surplus harvests often result in postharvest losses due to limited value-adding opportunities. The development of fruit-enriched bibingka presents a practical innovation that not only enhances product quality but also creates new market opportunities for local farmers and small-scale food entrepreneurs.

Thus, this study aims to evaluate the sensory acceptability of bibingka enriched with selected locally available fruits and to determine their potential for commercialization. By integrating sensory evaluation with economic analysis, the research provides evidence-based insights that support food innovation, promote sustainable use of local resources, and contribute to the preservation and modernization of Filipino culinary heritage.

Research Questions

This study aimed to develop a fruit-enriched bibingka using selected fruit purees, namely: banana, mango, orange, and dragon fruit, and to evaluate its sensory acceptability in comparison with the standardized bibingka recipe. The research will be conducted at Cebu Technological University–Barili Campus and Brgy. Mantalongon, Barili, Cebu, during the school year 2025–2026. Specifically, it sought to answer the following questions:

1. What are the formulations used in preparing the rice cake or bibingka in terms of:
    1.1 t0- standard bibingka recipe (control group);
    1.2 t1- mango puree (100g) + standard ingredients;
    1.3 t2- dragon fruit puree (100g) + standard ingredients;
    1.4 t3- orange puree (100g) + standard ingredients; and
    1.5 t4- banana puree (100g) + standard ingredients?
2. What is the sensory quality of each treatment (T1-T5) in terms of:
    2.1 color;
    2.2 aroma;
    2.3 taste;
    2.4 texture; and
    2.5 overall acceptability?
3. Is there a significant difference in the sensory attributes of bibingka across the five treatments?
4. What is the production cost of the most acceptable fruit-enriched bibingka?
5. Based on the results of the study, what techno-guide can be recommended for future product development and commercialization?

Literature Review

Functional Enrichment of Bakery and Rice-Based Products

The incorporation of functional ingredients into traditional bakery and rice-based products has gained increasing attention as a strategy to enhance nutritional value while maintaining consumer acceptability. Functional enrichment using fruit-based ingredients—such as purees, powders, and by-products—has been shown to improve the content of dietary fiber, vitamins, antioxidants, and natural sugars, contributing to healthier food alternatives (Rabadán et al., 2021; Wen et al., 2018).

Recent studies highlight that fruit incorporation can positively influence both nutritional and sensory attributes when applied at optimal levels. For instance, Hsu (2023) demonstrated that banana-based enrichment in rice cakes improved moisture retention, texture, and overall palatability due to its natural sugar composition and binding properties. Similarly, Tahir et al. (2019) reported that citrus-based ingredients, such as orange puree, enhanced both the visual appeal and aroma profile of bakery products. However, excessive incorporation of functional ingredients may alter product structure, affecting texture and taste balance (Singh & Giri, 2020).

These findings emphasize that while functional enrichment offers clear nutritional benefits, careful formulation is necessary to maintain desirable sensory qualities. This principle directly informs the present study, which standardizes ingredient proportions to isolate the effect of fruit type on bibingka acceptability.

Sensory Evaluation and Consumer Acceptability Methods

Sensory evaluation remains a fundamental approach in assessing consumer acceptance of food innovations. The use of structured tools such as the 9-point hedonic scale is widely recognized for measuring preferences across key attributes, including taste, aroma, color, texture, and overall acceptability (Stone & Sidel, 2004; Liu et al., 2022).

Recent research underscores the importance of sensory attributes, particularly taste and aroma, as primary drivers of consumer preference. Liu et al. (2022) found that while functional enrichment may alter product texture, overall acceptability remains high when flavor attributes are preserved. Additionally, Jaeger et al. (2018) emphasized that visual appearance plays a complementary role, influencing initial consumer perception and purchase intent.

Advancements in sensory research also highlight the value of combining descriptive and hedonic evaluations to capture both intensity and preference dimensions of food quality. This dual approach strengthens the reliability of consumer acceptability studies and allows for more comprehensive analysis of product performance. Accordingly, the present study adopts both hedonic and descriptive sensory evaluation methods, aligning with established practices in food product development and ensuring robust assessment of fruit-enriched bibingka.

Innovations in Rice Cakes and Traditional Food Products

Innovation in traditional rice-based products, including rice cakes, has increasingly focused on enhancing nutritional value and market appeal through ingredient modification. Studies on Asian rice cakes, such as Korean tteok and other glutinous rice products, show that

fruit-based enrichment can improve both sensory qualities and functional properties (Choi et al., 2021; Lee et al., 2018).

In the Philippine context, research on modified kakanin products demonstrates growing consumer interest in enriched traditional foods. For example, recent studies on squash- and malunggay-enriched rice cakes indicate that incorporating locally available ingredients can enhance both nutritional content and consumer acceptance, provided that sensory qualities remain favorable (Cariño et al., 2025; Focbit et al., 2025). These findings suggest that consumers are receptive to innovation in traditional foods when cultural familiarity is preserved.

Furthermore, studies on banana and fruit-enriched baked products consistently report improvements in sweetness, texture, and overall acceptability, supporting their use as natural flavor enhancers and functional ingredients (Hsu, 2023). This body of research provides a strong foundation for exploring fruit-enriched bibingka as a viable product innovation.

Research Gap and Relevance to the Present Study

Despite the growing body of research on functional food development and traditional product innovation, there remains a notable gap in empirical studies focusing specifically on fruit-enriched bibingka in the Philippine setting. The existing literature primarily addresses general bakery products or other rice-based foods, with limited attention to how locally sourced fruits, such as banana, mango, orange, and dragon fruit, impact the sensory acceptability of bibingka.

Moreover, few studies integrate sensory evaluation with economic analysis, particularly in community-based contexts where local agricultural resources play a critical role. This limits the applicability of existing findings for small-scale food entrepreneurs and local producers.

The present study addresses these gaps by systematically evaluating the sensory acceptability of fruit-enriched bibingka using standardized methods; comparing multiple locally available fruit variants to determine consumer preference; and assessing commercial viability through cost and ROI analysis, linking product innovation with local economic sustainability.

By bridging these gaps, the study contributes to the advancement of food innovation in traditional Filipino products while supporting sustainable utilization of local agricultural resources.

Methodology

Research Design

This study employed a quantitative research approach integrating both experimental and descriptive designs to comprehensively evaluate the sensory acceptability and market potential of fruit-enriched bibingka.

The experimental component involved systematically manipulating bibingka formulations by incorporating different fruit purees: T0 (control), T1 (mango), T2 (dragon fruit), T3 (orange), and T4 (banana). A standardized base recipe was used across all treatments to ensure consistency, with the type of fruit puree serving as the only independent variable. This design enabled a controlled comparison of how fruit variations influence sensory attributes such as taste, aroma, color, and mouthfeel.

The preparation and sensory evaluation of samples were conducted under controlled conditions to enhance reliability and replicability. Bibingka samples were prepared using uniform procedures, ingredients, and cooking conditions (e.g., standardized temperature and baking time). Sensory evaluation was conducted in a designated testing area with controlled environmental conditions, including consistent lighting, minimal noise, and neutral surroundings. Samples were coded and presented in randomized order to minimize bias, and panelists were instructed to cleanse their palate between samples to reduce sensory fatigue.

The descriptive component focused on profiling respondents' perceptions and acceptability ratings of the bibingka samples. Data were collected using a 9-point hedonic scale to measure overall acceptability and a 5-point Likert scale for descriptive sensory attributes. In addition, respondent profiles (e.g., group classification as trained or untrained panelists) were considered to contextualize consumer preferences.

Descriptive statistics, including means and standard deviations, were used to summarize sensory ratings. This component aimed to capture consumer preferences as they naturally occur, without influencing respondents' evaluations beyond the controlled presentation of samples.

While the experimental design manipulated product formulation, the descriptive design captured consumer responses to these variations, enabling a comprehensive assessment of both product performance and user perception. This integration ensures that differences in sensory attributes are objectively measured while also reflecting real-world consumer acceptance.

To determine significant differences among treatments, one-way Analysis of Variance (ANOVA) was employed for each sensory attribute. When significant differences were identified ($p < 0.05$), Tukey's Honest Significant Difference (HSD) test was used for post hoc comparisons.

Furthermore, Multiple Linear Regression (MLR) analysis was conducted to identify which sensory attributes significantly predict

overall acceptability. These statistical methods provide robust evidence for evaluating treatment performance and consumer preference patterns.

The most acceptable bibingka variant was determined based on the highest mean scores in overall acceptability and key sensory attributes; statistical significance of differences compared to other treatments ($p < 0.05$); and consistency across multiple sensory parameters (taste, aroma, and mouthfeel).

In addition to sensory evaluation, the study incorporated an economic analysis to assess the commercial viability of each treatment. Production costs, selling price, revenue, and net income were computed for each variant. Return on Investment (ROI) was calculated and used as a key indicator of profitability.

The integration of sensory and economic data allowed for a multi-criteria evaluation, wherein the most recommended product formulation was not only highly acceptable to consumers but also economically feasible. This approach supports the development of a techno-guide for small-scale food entrepreneurs, linking product innovation with practical business application.

Respondents

The study involved a total of 100 panelists, all of whom participated in the sensory evaluation of the five bibingka treatments. The respondents were purposively selected and divided into two groups: trained panelists ($n = 10$) and untrained panelists ($n = 90$) to ensure a balanced evaluation that integrates both expert assessment and general consumer perception.

The trained panelists consisted of Bachelor of Science in Food Technology students from Cebu Technological University–Barili Campus. The selection of 10 trained panelists is consistent with established practices in sensory evaluation, where a smaller group of trained individuals is sufficient for detecting subtle differences in sensory attributes due to their calibration and familiarity with evaluation procedures (Stone & Sidel, 2004). These panelists provided more consistent and analytically reliable assessments of specific sensory characteristics.

The untrained panelists ($n = 90$) included 20 graduate students from Cebu Technological University–Barili Campus and 70 community members from Barangay Mantalongon, Barili, Cebu. This larger group was intended to represent general consumer preferences and capture the product's real-world acceptability. The inclusion of community members enhances the ecological validity of the study, particularly in assessing potential market acceptance at the local level.

All 100 respondents evaluated all five bibingka samples, ensuring uniform data collection and allowing for direct comparison across treatments. This sample size is considered adequate for sensory evaluation studies and provides sufficient statistical power to detect significant differences in inferential analyses such as ANOVA and regression, as supported by similar food acceptability studies (Liu et al., 2022).

A purposive sampling technique was employed to select respondents who are likely bibingka consumers and capable of providing relevant evaluations. To mitigate potential sampling bias, participants were selected from both academic and community settings, ensuring diversity in age, educational background, and consumer experience. This approach enhances the representativeness of the findings while maintaining relevance to the study context.

It is acknowledged that differences in background, food exposure, and sensory sensitivity among respondents may introduce variability in perception. However, such variability reflects real consumer conditions and is therefore valuable in assessing overall acceptability. To further contextualize the results, basic demographic data (e.g., age, sex, educational background, and familiarity with bibingka) were collected and may be used to analyze variations in preferences across respondent groups.

Instrument

The primary instrument used in this study was a structured sensory evaluation questionnaire designed to assess the acceptability and sensory characteristics of fruit-enriched bibingka. The instrument consisted of two main parts: (1) a 9-point hedonic scale to measure overall acceptability and (2) a 5-point descriptive Likert scale to evaluate specific sensory attributes.

The 9-point hedonic scale (1 = Dislike Extremely to 9 = Like Extremely) was utilized to assess respondents' level of liking in terms of taste, color, aroma, mouthfeel, and overall acceptability. This scale is widely recognized in sensory evaluation research for its reliability in capturing consumer preference and has been extensively used in food product development studies (Stone & Sidel, 2004).

Complementing this, a 5-point Likert scale (1 = Very Weak to 5 = Very Strong) was used to evaluate specific descriptive attributes, including sweetness, fruit flavor intensity, aroma strength, and aftertaste. These attributes were carefully selected based on established sensory evaluation frameworks and prior studies on enriched bakery and rice-based products, where flavor intensity, sweetness, and aftertaste are critical determinants of consumer acceptance (Liu et al., 2022). The inclusion of these descriptors enabled more detailed profiling of product characteristics beyond general liking.

The development of the instrument followed a multi-step validation process to ensure content validity and reliability. Initially, the questionnaire was drafted based on existing literature and standard sensory evaluation protocols. It was then subjected to expert review by professionals in food technology and sensory evaluation to assess the clarity, relevance, and appropriateness of the items. Revisions

were made based on their feedback.

To further strengthen validity, cognitive interviews were conducted with a small group of respondents to ensure that the questions and scale descriptors were clearly understood and interpreted consistently. Following this, a pilot test was carried out with a subset of participants who were not included in the final sample. The pilot test aimed to evaluate the instrument's reliability, targeting a Cronbach's alpha of at least 0.85 to indicate high internal consistency.

The sensory evaluation questionnaire was administered in printed (paper-based) format during the actual testing sessions to ensure ease of use and minimize technical distractions. The evaluation was conducted in a controlled sensory environment, with standardized conditions such as adequate lighting, minimal noise, and neutral surroundings to reduce external influences on perception.

Each respondent received coded samples presented in randomized order and completed the evaluation form individually. Clear instructions were provided to ensure consistent use of the scales, and respondents were asked to cleanse their palate between samples to maintain accuracy in their evaluations.

Procedure

The data collection process was systematically designed to obtain accurate and reliable information on consumer perceptions of fruit-enriched bibingka. It consisted of several stages to ensure methodological rigor, validity, consistency, and adherence to ethical and research standards.

Prior to conducting the study, formal approval was obtained from the Campus Director of Cebu Technological University–Barili Campus. In addition, the study protocol was submitted to the institution's Institutional Review Board (IRB) for ethical review and clearance. All participants were provided with an informed consent form outlining the purpose of the study, procedures, potential risks and benefits, confidentiality of responses, and voluntary participation. Written consent was secured prior to participation.

A pilot test of the sensory evaluation instrument was conducted with a small group of respondents to assess clarity, reliability, and appropriateness. The instrument consisted of two parts: (1) a 9-point Hedonic Scale to evaluate color, aroma, taste, texture, and overall acceptability based on Peryam (1992), as adapted by Ambrad et al. (2018); and (2) a 5-point Likert Scale to assess specific sensory characteristics. Internal consistency was evaluated using Cronbach's alpha, with a target reliability coefficient of 0.85 or higher.

Following validation of the instrument, the preparation of bibingka samples commenced. The study included five treatments: T0 (control), T1 (mango), T2 (dragon fruit), T3 (orange), and T4 (banana). A standardized base recipe was used across all treatments, with variation limited to the addition of fruit puree. Each formulation consisted of 500 grams of rice flour, 1¼ cups of white sugar, 2 cups of coconut milk, 2 cups of water, 1 tablespoon of yeast, ½ teaspoon of salt, and 100 grams of fruit puree for enriched samples.

The preparation followed traditional methods. Dry ingredients were mixed, followed by the gradual addition of liquids until a smooth batter was formed. The batter was fermented for 30–60 minutes. Fruit puree was incorporated into the respective treatments, while the control remained plain. Llanera molds lined with softened banana leaves were filled three-fourths full. Baking was conducted in a preheated oven at 165–180°C and monitored using a digital infrared thermometer. Samples were baked, cooled, coded, and prepared for evaluation.

Strict Good Manufacturing Practices (GMP) were observed, including sanitation of equipment and workspace, use of food-grade materials, and adherence to proper hygiene protocols.

The sensory evaluation was conducted in a controlled indoor environment with consistent lighting, minimal noise, and adequate ventilation. Panelists were seated in a shared but well-spaced area to minimize interaction and bias.

All panelists evaluated all five treatments, allowing for within-subject comparison. Prior to evaluation, respondents underwent a brief orientation and calibration session to standardize understanding of the scales.

Samples were assigned random three-digit codes and were served using a randomized complete block design (RCBD). The serving order was randomized for each participant using a pre-generated sequence to minimize order bias.

Panelists were instructed on proper evaluation procedures. Each respondent evaluated all samples using both scales. Between samples, panelists cleansed their palate with water and observed a 3–5-minute rest interval to reduce sensory fatigue.

Completed evaluation forms were collected, checked for completeness, encoded, and organized for analysis. Statistical tools such as mean, Analysis of Variance (ANOVA), and t-tests were applied to determine significant differences among treatments. This systematic procedure ensured the collection of valid, reliable, and unbiased data.

Data Analysis

Quantitative data on the sensory attributes of the five bibingka treatments were collected, coded, organized, and tabulated. Sensory characteristics—including color, aroma, taste, texture, and overall acceptability- were summarized using descriptive statistics, particularly mean and standard deviation.

To determine statistically significant differences among treatments, a one-way Analysis of Variance (ANOVA) was conducted at a 0.05 level of significance ($p < 0.05$). Prior to ANOVA, its assumptions were tested. Normality of data distribution was assessed using the Shapiro–Wilk test, while homogeneity of variances was evaluated using Levene's Test.

When assumptions were violated, appropriate alternative tests were applied, including Welch's ANOVA or nonparametric tests such as the Kruskal–Wallis test. When significant differences were identified, post hoc analysis using Tukey's Honest Significant Difference (HSD) test was performed to determine pairwise differences among treatments.

To further examine relationships among sensory attributes, Principal Component Analysis (PCA) was conducted, where applicable, to identify clustering patterns and attribute contributions to overall acceptability. All statistical analyses were performed using RStudio, utilizing packages such as dplyr, ggplot2, stats, agricolae, and car.

Data integrity was ensured through screening procedures. Incomplete questionnaires were excluded, while minor missing values were addressed using mean substitution within acceptable limits.

Ethical Considerations

This study strictly adhered to established ethical principles to protect the rights, dignity, and welfare of all participants throughout the research process. Prior to data collection, the research protocol was formally reviewed and approved by the Ethics Committee of Cebu Technological University–Barili Campus.

All participants were provided with a detailed informed consent form that clearly outlined the purpose of the study, the procedures involved, potential risks and benefits, and measures to ensure confidentiality. Participation was entirely voluntary, and respondents were informed of their right to withdraw at any point without penalty or disadvantage. Written consent was obtained prior to participation.

Confidentiality and anonymity were strictly maintained. No personally identifiable information was disclosed in any report or publication. All collected data were securely stored and were accessed only by the research team. Data were presented in aggregate form to ensure that individual responses could not be traced back to specific participants.

To ensure participant safety, the sensory evaluation was conducted in a controlled and hygienic environment in accordance with established food safety standards. All bibingka samples were prepared using fresh and safe ingredients under strict sanitary conditions. Participants were asked to disclose any known food allergies or dietary restrictions before participating.

In the event of any adverse reactions (e.g., allergic reactions or discomfort), appropriate measures were implemented immediately, including discontinuing participation, providing first aid, and referring for medical assistance when necessary. Participants experiencing discomfort were allowed to withdraw without any obligation to complete the evaluation.

Any potential conflicts of interest were fully disclosed, and the study was conducted with honesty, integrity, and transparency. No form of coercion or undue influence was used in recruiting participants. By upholding these ethical standards, the study ensured participants' respect while generating valid and reliable insights into the consumer acceptability of fruit-enriched bibingka.

Results and Discussion

This section presents a detailed examination of the data collected from sensory evaluations of five bibingka treatments, including four fruit-enriched variants and one standard recipe. The primary objective was to assess consumer acceptability in terms of sensory attributes such as color, aroma, taste, texture, and overall appeal. By systematically analyzing these attributes, the study sought to identify which formulations resonated most with consumer preferences and to understand the factors influencing acceptance.

Using both descriptive and inferential statistical methods, including Analysis of Variance (ANOVA) and Multiple Linear Regression (MLR), the data were analyzed to determine significant differences among treatments and to explore the relationship between sensory characteristics and overall acceptability. This comprehensive approach enabled an in-depth understanding of how modifications to traditional bibingka recipes, through the addition of locally sourced fruit purees, affected consumer perceptions.

Furthermore, this section interpreted the findings in the context of current consumer trends toward health-conscious eating and cultural food innovation. Insights gained informed recommendations for product development and potential commercialization strategies that aligned with both cultural preservation and modern nutritional demands.

Formulations of Fruit-Enriched Bibingka Treatments

The study utilized a standardized base recipe across all treatments (T0–T4), ensuring that differences in sensory outcomes were primarily attributed to the type of fruit puree incorporated. By maintaining uniformity in ingredients and preparation methods, the experiment effectively isolated the influence of mango, dragon fruit, orange, and banana purees on the sensory characteristics of bibingka.

This controlled formulation strengthened the internal validity of the study by minimizing confounding variables. It ensured that

observed differences in consumer acceptability were directly linked to fruit enrichment rather than inconsistencies in preparation, thereby providing reliable insights for product development. This approach aligns with food product development principles emphasizing standardization in experimental formulations to isolate treatment effects (Belitz et al., 2019; Singh & Giri, 2020).

Table 1. *Bibingka formulations with fruit puree enrichments*

Treatment	*Fruit Puree (100 g)*	*Description*
T0	None	Standard bibingka (control)
T1	Mango	Mango-enriched bibingka
T2	Dragon fruit	Dragon fruit-enriched bibingka
T3	Orange	Orange-enriched bibingka
T4	Banana	Banana fruit-enriched bibingka

Product Description and Acceptability

The descriptive sensory evaluation assessed the intensity of aroma, color, mouthfeel, and taste across the five bibingka treatments (T0–T4). The mean scores, standard deviations, and Tukey's HSD groupings are presented in Table 2 with corresponding visual comparisons for each attribute (Figures 4, 6, 8, 10). Results of the one-way ANOVA revealed significant differences ($p < 0.05$) among treatments for all sensory attributes except color. Post-hoc analysis using Tukey's HSD further identified specific differences between treatment pairs, where treatments sharing the same superscript letter were not significantly different at $p < 0.05$.

In terms of consumer acceptability, the five treatments were evaluated by 100 respondents using a 9-point hedonic scale, where higher scores indicate greater preference (Stone & Sidel, 2004). These results provide insights into both the descriptive sensory characteristics and consumer perception of the fruit-enriched bibingka formulations compared to the standard recipe.

Color

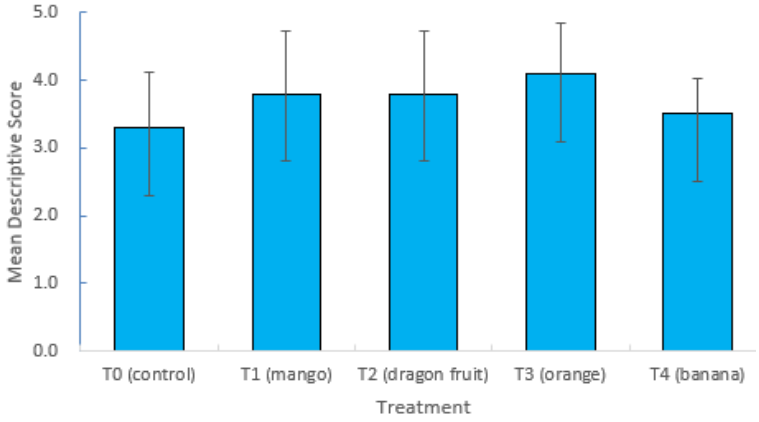

Figure 1. *Mean descriptive color scores of bibingka treatments (T0–T4)*

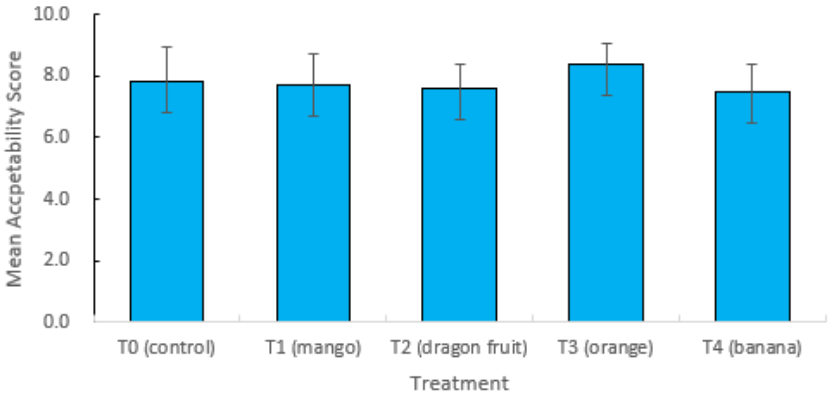

Figure 2. *Mean acceptability color scores of bibingka treatments (T0–T4)*

Descriptive analysis showed no significant differences in color among treatments ($p = 0.2213$), suggesting that fruit puree incorporation did not produce noticeable visual variation during evaluation. However, consumer acceptability revealed that orange-enriched bibingka (T3) received the highest color rating, while banana (T4) obtained the lowest.

Although instrumental or descriptive evaluation indicated minimal variation, consumer perception differed, highlighting that visual appeal remains a critical factor influencing purchasing decisions. Bright and vibrant colors, such as those from orange puree, enhance

attractiveness even when differences are subtle.

This finding supports studies indicating that visual appearance strongly influences food preference and acceptability, particularly in baked products (Jaeger et al., 2018; Lawless & Heymann, 2010).

Aroma

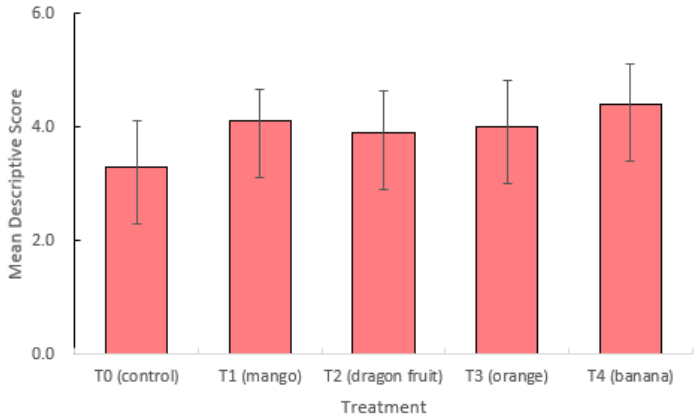

Figure 3. *Mean descriptive aroma scores of bibingka treatments (T0–T4)*

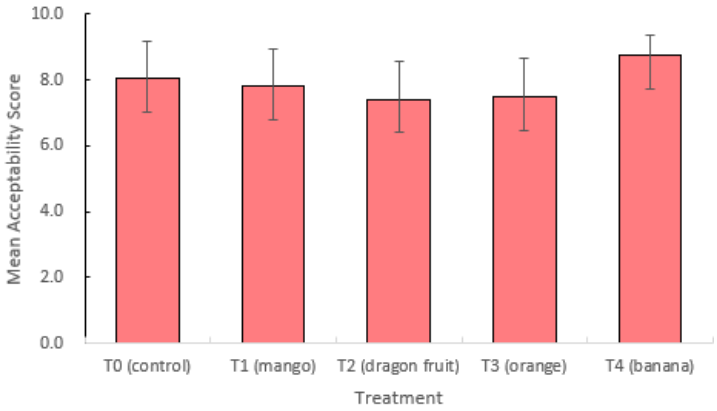

Figure 4. *Mean acceptability aroma scores of bibingka treatments (T0–T4)*

Aroma differed significantly across treatments, with banana-enriched bibingka (T4) exhibiting the highest intensity and acceptability ratings. Dragon fruit (T2) showed the lowest aroma perception, while mango and orange fell within moderate ranges. The strong aromatic compounds in bananas enhanced sensory appeal, indicating that aroma plays a crucial role in shaping consumer preference. Products with pronounced and pleasant aroma profiles are more likely to be favored in the market. This result is consistent with literature highlighting the importance of volatile compounds in influencing aroma perception and overall food acceptance (Belitz et al., 2019; Meilgaard et al., 2016).

Taste

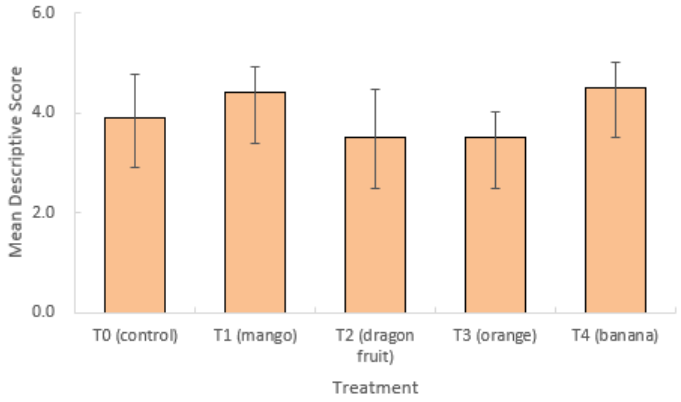

Figure 5. *Mean descriptive taste scores of bibingka treatments (T0–T4)*

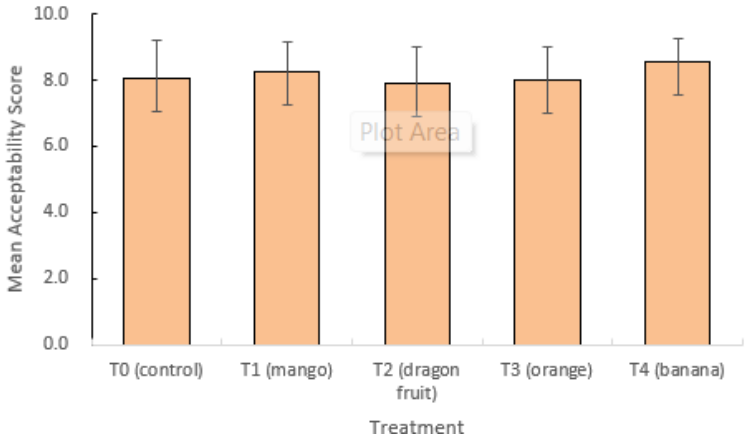

Figure 6. *Mean acceptability taste scores of bibingka treatments (T0–T4)*

Significant differences in taste were observed ($p < 0.05$), with banana (T4) achieving the highest ratings and dragon fruit (T2) the lowest. Mango and control samples performed moderately, while orange showed relatively lower acceptability due to its acidic profile.

Taste emerged as a primary determinant of consumer acceptance. Sweet and familiar flavor profiles, such as banana, enhance palatability, while overly acidic or mild flavors may reduce preference. This aligns with studies indicating that sweetness and flavor congruence significantly affect consumer liking in bakery products (Lawless & Heymann, 2010; Meilgaard et al., 2016).

Mouthfeel

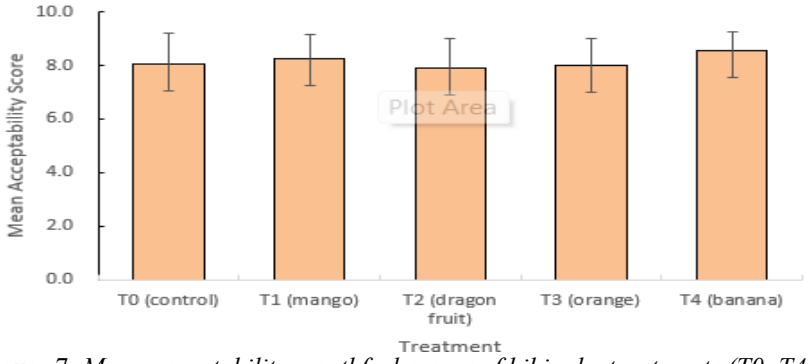

Figure 7. *Mean acceptability mouthfeel scores of bibingka treatments (T0–T4)*

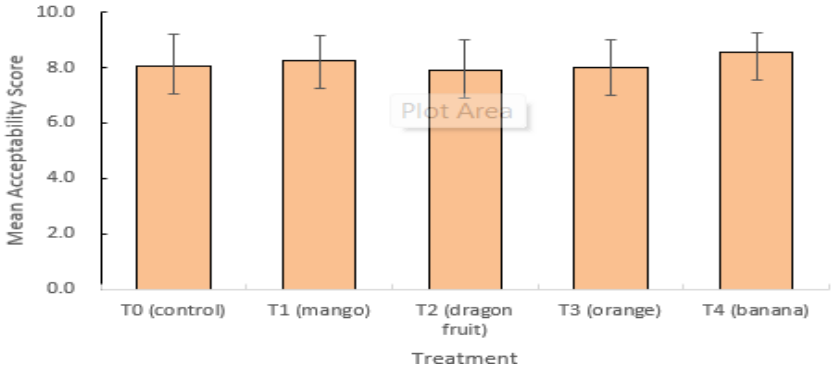

Figure 8. *Mean acceptability mouthfeel scores of bibingka treatments (T0–T4)*

Mouthfeel varied significantly, with banana (T4) and mango (T1) providing the most desirable texture, while dragon fruit (T2) scored lowest due to its fibrous characteristics.

Texture plays a vital role in product acceptability, as smooth and cohesive mouthfeel enhances the eating experience. Selecting fruit purees with favorable physicochemical properties is essential for product optimization. This supports findings that ingredient composition, particularly fiber and pectin content, influences texture and overall sensory quality (Belitz et al., 2019; Singh & Giri, 2020).

Overall Acceptability

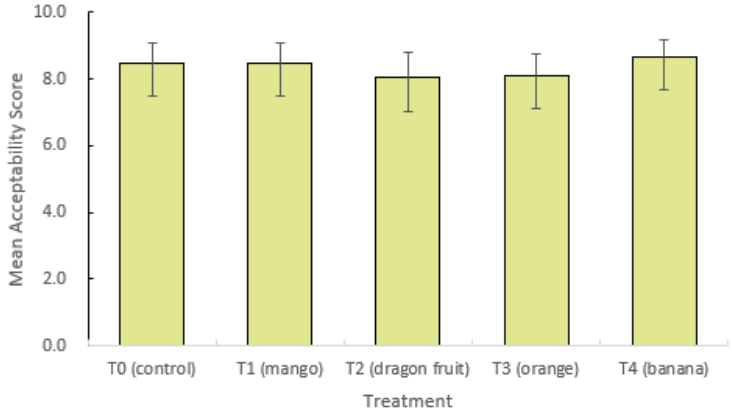

Figure 9. *Mean acceptability scores for Overall Acceptability of bibingka treatments (T0–T4)*

Banana-enriched bibingka (T4) achieved the highest overall acceptability, followed by mango (T1) and the control (T0), while dragon fruit (T2) ranked lowest. The results indicate that combining favorable taste, aroma, and texture leads to higher overall acceptance. Banana emerged as the most suitable fruit for enrichment due to its balanced sensory contributions. This finding is consistent with consumer studies showing that overall liking is a composite response influenced by multiple sensory attributes (Stone & Sidel, 2004).

Anova and Post-Hoc Comparison of Fruit-Enriched Bibingka Across Sensory Attributes

Table 2 presents the results of one-way ANOVA and Tukey's HSD post-hoc comparisons of mean acceptability ratings for five bibingka treatments (T0 – control, T1 – mango, T2 – dragon fruit, T3 – orange, and T4 – banana) across five sensory attributes: taste, color, aroma, mouthfeel, and overall acceptability. The post-hoc groupings indicate which treatments were significantly different at $\alpha = 0.05$, with treatments sharing the same letter considered not significantly different. ANOVA results revealed significant differences ($p < 0.001$) across all sensory attributes. Post-hoc analysis confirmed that banana (T4) consistently ranked highest in taste, aroma, mouthfeel, and overall acceptability, while orange (T3) excelled in color.

The type of fruit puree significantly influences consumer perception, emphasizing the importance of ingredient selection in product development. Banana and orange provide strategic advantages depending on whether flavor or visual appeal is prioritized. These findings support previous research emphasizing the role of ingredient functionality and sensory balance in enhancing consumer acceptance (Lawless & Heymann, 2010; Meilgaard et al., 2016; Singh & Giri, 2020).

Table 2. *ANOVA and Post-Hoc Results for Sensory Attributes*

Attribute	*F-value*	*p-value*	*Significant?*	*Mean ± SD*	*Post-Hoc Grouping (Tukey HSD)*
Taste	7.29	0.0001	Highly Significant	T0: 8.2 ± 0.93 T1: 7.9 ± 1.11 T2: 8.0 ± 1.01 T3: 8.6 ± 0.67 T4: 8.1 ± 1.14	T3 (a) > T0, T2, T4 (ab) > T1 (b)
Color	14.56	<0.0001	Highly Significant	T0: 7.7 ± 0.99 T1: 7.6 ± 0.79 T2: 8.4 ± 0.68 T3: 7.5 ± 0.88 T4: 7.8 ± 1.12	T2 (a) > T4, T0 (ab) > T1, T3 (b)
Aroma	25.54	<0.0001	Highly Significant	T0: 7.8 ± 1.14 T1: 7.4 ± 1.14 T2: 7.5 ± 1.16 T3: 8.7 ± 0.63 T4: 8.0 ± 1.13	T3 (a) > T4, T2 (ab) > T0, T1 (b)
Mouthfeel	8.46	<0.0001	Highly Significant	T0: 8.4 ± 0.85 T1: 8.0 ± 1.01 T2: 8.0 ± 0.98 T3: 8.6 ± 0.72 T4: 8.4 ± 0.94	T3, T0, T4 (a) > T1, T2 (b)
Overall Acceptability	19.03	<0.0001	Highly Significant	T0: 8.5 ± 0.59 T1: 8.0 ± 0.74 T2: 8.1 ± 0.64 T3: 8.7 ± 0.52 T4: 8.5 ± 0.58	T3 (a) > T0, T4 (ab) > T2 > T1 (b)

Cost Analysis of the Most Preferred Fruit-Enriched Bibingka

Table 3 presents the cost structure for both standard and fruit-enriched bibingka formulations. The base recipe (control, T0) had a total production cost of ₱101.38 per batch. The addition of fruit puree increased total costs proportionally to the fruit's market price, with orange puree (T3) yielding the highest total cost at ₱121.38 and banana puree (T4) the lowest among fruit-enriched versions at ₱110.38.

Table 3. *Cost and Return Analysis for Standard and Fruit-Enriched Rice Cakes*

Treatment	*Base Cost (₱)*	*Fruit Cost (₱)*	*Total Cost (₱)*	*Selling Price (₱/pc)*	*Revenue (₱)*	*Net Income (₱)*	*ROI (%)*
T0 – Control	101.38	0	101.38	8	160	58.62	57.84
T1 – Mango	101.38	13	114.38	10	200	85.62	74.83
T2 – Dragon fruit	101.38	16	117.38	10	200	82.62	70.39
T3 – Orange	101.38	20	121.38	10	200	78.62	64.77
T4 – Banana	101.38	9	110.38	10	200	89.62	81.19

Note. ROI = (Net Income ÷ Total Cost) × 100. All revenues are calculated assuming 20 pieces per batch.

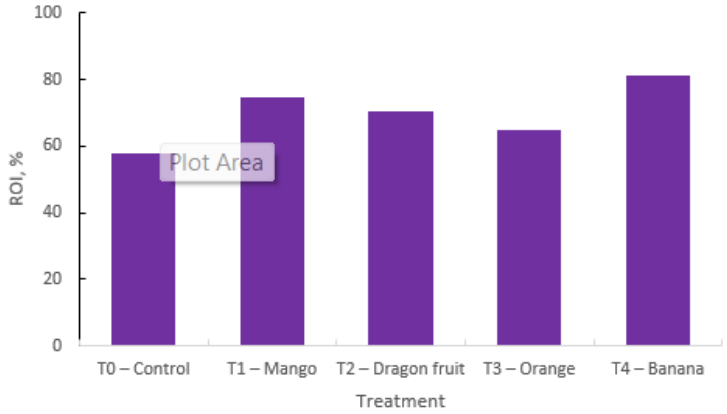

Figure 10. *ROI bar graph by treatment, with T4 having the highest ROI and T0 the lowest*

Cost analysis showed that fruit enrichment increased production costs; however, it also improved profitability. Banana-enriched bibingka (T4) achieved the highest ROI (81.19%), while the control had the lowest.

Despite additional costs, fruit enrichment—particularly with banana—offers strong commercial potential due to its balance of affordability and high consumer acceptability. This supports its viability for small-scale food enterprises. This aligns with studies on value-added food products, which highlight that cost-efficiency combined with high consumer acceptance drives market success (Belitz et al., 2019; Singh & Giri, 2020).

Conclusions

This study demonstrated that fruit enrichment significantly influenced the sensory acceptability and market potential of bibingka. Among the five treatments, banana-enriched bibingka (T4) consistently achieved the highest ratings in taste, aroma, mouthfeel, and overall acceptability, while orange-enriched bibingka (T3) was most preferred in terms of color. Statistical analysis confirmed that most sensory attributes differed significantly across treatments ($p < 0.05$), with taste and aroma emerging as the strongest predictors of overall acceptability. In addition to sensory performance, economic evaluation revealed that fruit-enriched variants, particularly banana and mango, offered greater profitability, with banana yielding the highest Return on Investment (ROI). These findings indicate that fruit enrichment not only enhances product quality but also strengthens commercial viability. Overall, the study highlights that integrating locally sourced fruits into traditional bibingka is an effective strategy for food innovation, cultural preservation, and economic development. It further emphasizes the importance of aligning product development with consumer preferences, particularly flavor and aroma, to ensure market success.

In line with these conclusions, the following recommendations are proposed:

Food developers and practitioners are encouraged to focus on banana and mango variants for product improvement and commercialization, given their superior sensory and economic performance. Refinement of formulations, particularly in optimizing fruit puree proportions, is recommended to enhance quality further. Entrepreneurs and small-scale producers should consider commercializing fruit-enriched bibingka, supported by the development of a standardized techno-guide to ensure consistency and cost efficiency. Local government units and agricultural stakeholders are urged to promote the use of locally grown fruits in value-added products to reduce postharvest losses and improve farmer income. Strengthening farm-to-market linkages will further support sustainable local economies. Consumer awareness initiatives should be implemented to highlight the nutritional benefits and cultural significance of fruit-enriched bibingka, particularly among health-conscious markets. Future research should explore additional fruit variants, conduct nutritional and shelf-life analysis, and examine consumer preferences across diverse populations to expand the

applicability of findings. Lastly, institutions such as Cebu Technological University and relevant agencies are encouraged to support innovation in traditional foods through research, extension, and policy initiatives.

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