Sustainable Biscuit Development Using Banana Peel and Jackfruit Seed Flours: Sensory Evaluation and Selected Nutritional Characteristics

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ABSTRACT

This study developed a biscuit incorporating banana peel flour and jackfruit seed flour and evaluated its sensory quality, acceptability, and selected nutritional characteristics. A descriptive product-evaluation design was employed with 120 purposively selected participants, comprising 40 expert bakers from bakeries in Metro Manila and 80 consumers from Manila. Data were collected using a structured questionnaire and summarized through weighted means. Assessments by the two groups were compared descriptively. Laboratory analyses determined the biscuit's crude fiber, moisture, and protein contents. The findings showed favorable sensory evaluations. Texture received the highest composite sensory-quality rating, whereas taste obtained the highest composite acceptability rating. Consumers gave a higher overall acceptability rating than expert bakers, with the difference presented as a descriptive comparison. Laboratory analysis characterized three selected compositional parameters: crude fiber, moisture, and protein. The results demonstrate the feasibility of incorporating banana peel flour and jackfruit seed flour into the formulation evaluated in this study. Further investigations involving multiple substitution levels, a conventional control, replicated production batches, a broader nutritional profile, and microbiological and shelf-life assessments can extend these initial findings.

Keywords*:* banana peel flour; jackfruit seed flour; sustainable food development; biscuit formulation; sensory evaluation; consumer acceptability; nutritional analysis

INTRODUCTION

The valorization of agricultural by-products is an important area of food product development, particularly in efforts to reduce food waste and identify alternative ingredients for value-added products. Banana peels and jackfruit seeds, commonly discarded during food preparation and processing, have attracted research interest because of their potential applications in food formulations. Recent reviews have examined the use of banana peel in baked products and its potential contribution to product properties (Ismail et al., 2024; Wang et al., 2026). Research on jackfruit seed flour has also documented its applications in bakery and extrusion products, while noting that incorporation levels can influence composition, texture, and color (Mohammed et al., 2024). These findings provide a basis for investigating the use of both materials in biscuit development.

Biscuits provide a practical format for evaluating alternative flour ingredients because their quality can be assessed through sensory attributes such as appearance, aroma, texture, and taste. Incorporating nontraditional flours may change the physical and sensory characteristics of the finished product, making formulation and consumer evaluation important components of product development. Sayem et al. (2024) examined the use of fruit and vegetable by-products in biscuits and reported that ingredient selection and substitution levels influenced product properties and sensory responses. Viana et al. (2026) investigated the nutritional, technological, and sensory properties of savory biscuits formulated with green banana pulp and peel flours. Goh et al. (2024) also explored biscuit formulations containing jackfruit seed flour blended with okara flour. Collectively, these studies demonstrate the importance of evaluating product quality and consumer response when developing baked products from underutilized materials.

Sensory evaluation helps characterize product attributes and determine how assessors respond to a finished food product. Recent reviews emphasize selecting sensory methods that suit the research objectives and product characteristics being assessed (Rodrigues et al., 2024). For alternative-flour biscuits, systematic evaluation of appearance, aroma, texture, and taste can identify product strengths and attributes that may require refinement. Assessments from food professionals and consumers may provide complementary perspectives, Favorable sensory ratings provide an important basis for product development, while nutritional composition, potential health effects, shelf-life stability, and commercial feasibility can be examined through dedicated analyses.

The present study examined a biscuit incorporating banana peel flour and jackfruit seed flour. It evaluated the specific formulation through sensory-quality assessment, consumer acceptability, a descriptive comparison of expert-baker and consumer ratings, and laboratory analysis of selected compositional characteristics. Rather than presuming that the ingredients improve nutritional quality, the study documents the sensory responses and available laboratory results for the developed biscuit.

Specifically, the study aimed to: (1) assess the sensory quality of the developed biscuit in terms of appearance or color, aroma, texture, and taste; (2) determine its level of acceptability; (3) compare evaluations provided by expert bakers and consumers; and (4) describe the laboratory-determined crude fiber, moisture, and protein contents of the biscuit.

METHODOLOGY

Research Design and Participants

The study employed a descriptive product-evaluation design to assess the sensory quality, acceptability, and selected nutritional characteristics of a biscuit formulated using banana peel flour and jackfruit seed flour. The participants comprised 120 purposively selected individuals: 40 expert bakers from bakeries in Metro Manila and 80 consumers from Manila. Expert bakers provided professional assessments, while consumers evaluated the product's sensory attributes and overall acceptability. The study focused on a single formulation and employed a descriptive product evaluation approach. This design provides an initial profile of the tested biscuit based on the assessments of the participating expert bakers and consumers. Future comparative trials incorporating a conventional biscuit control and several substitution levels can determine how different flour proportions influence sensory and compositional outcomes. The findings are presented as product-specific results within the context of the participating groups.

Product Formulation

The evaluated formulation contained 15 g of banana peel flour and 15 g of jackfruit seed flour, giving a combined 30 g of alternative flours in a 225 g flour blend. All-purpose flour accounted for the remaining 195 g. The ingredients and quantities used are presented in Table 1. This formulation represents the product evaluated in the present study. Its performance may be further examined through comparative trials involving alternative flour ratios and a conventional biscuit formulation.

Table 1. Ingredients and Quantities Used in the Biscuit Formulation

Ingredient	Quantity	Unit
Banana peel flour	15	g
Jackfruit seed flour	15	g
All-purpose flour	195	g
Sugar	40	g
Margarine	40	g
Egg	1	piece
Langka extract	1	teaspoon
Milk	30	mL
Baking powder	1	teaspoon

Preparation of Alternative Flours

Banana peel flour was prepared from 150 g of fresh banana peels. The peels were washed under running water, cut into uniform pieces, and oven-dried at 60°C for 6–8 hours until brittle. The dried material was ground using a mechanical blender and sieved to obtain fine flour.

Jackfruit seed flour was prepared from 150 g of seeds. The seeds were washed and boiled for 20–30 minutes, after which the outer skin and seed coat were removed. The seeds were sliced into thin pieces, oven-dried at 60°C for 6–8 hours, ground, and sieved. The resulting flour was stored in an airtight container. These processing steps are comparable to published methods for preparing banana-peel powder and jackfruit seed flour for food applications (Pomasa et al., 2025; Sreejaya et al., 2024).

Biscuit Preparation

The oven was preheated to 170°C. Banana peel flour, jackfruit seed flour, all-purpose flour, and baking powder were sifted and mixed. In a separate bowl, 40 g of margarine was creamed with 40 g of sugar until smooth, followed by the addition of one egg and one teaspoon of langka extract. The dry ingredients were gradually incorporated into the wet mixture, and 30 mL of milk was added incrementally to achieve the desired dough consistency. The dough was rested for 10–15 minutes, rolled out evenly, and cut into uniform shapes. The pieces were placed on a baking tray and baked at 170°C for 15–20 minutes or until golden brown. The biscuits were cooled to room temperature on a wire rack and stored in airtight containers before sensory evaluation.

Sensory Evaluation and Statistical Analysis

Sensory quality and acceptability were evaluated using a structured questionnaire covering appearance or color, aroma, texture, and taste. Weighted means were calculated to summarize participants' assessments. Ratings from expert bakers and consumers were compared descriptively. Composite means were calculated by weighting the reported group means according to their respective sample sizes (40 expert bakers and 80 consumers). The available dataset presents group-level means. Accordingly, the analysis focuses on descriptive comparisons of the expert-baker and consumer assessments. Participant-level responses and within-group variability would be required for inferential testing and effect-size estimation; these analyses may be incorporated in future studies when the underlying data are available.

Laboratory Analysis

The selected nutritional characteristics of the developed biscuit were analyzed by SentroTek sa Pagsusuri, Pagsasanay, Pangangasiwa Pang-Agham at Teknolohiya Corp. (SentroTek, 2026). Crude fiber was measured using an ANKOM Fiber Analyzer, moisture content was determined through gravimetric analysis, and protein content was measured using the Kjeldahl method. Protein was reported using the nitrogen conversion factor N × 6.25. The laboratory values are presented as reported in the available test results. For fuller analytical transparency, the final report may be supplemented with the number of independent production batches and analytical replicates, method standards, measurement basis, and available uncertainty and quality-control information.

RESULTS AND DISCUSSION

Sensory Quality of the Developed Biscuit

Table 2 summarizes sensory-quality ratings from 40 expert bakers and 80 consumers. The composite weighted means are estimates calculated from the reported subgroup means and sample sizes; because the subgroup means are rounded, the composite values are approximate.

Table 2. Sensory-Quality Assessments of the Developed Biscuit

Sensory attribute	Expert bakers WM	Consumers WM	Composite WM	Interpretation
Taste	4.30	4.44	4.39	Excellent
Texture	4.50	4.42	4.45	Excellent
Color/appearance	4.10	4.38	4.29	Excellent
Aroma	4.22	4.54	4.43	Excellent
Overall	**4.28**	**4.45**	**4.39**	**Excellent**

Composite means provide representative weighted estimates based on subgroup means and sample sizes.

The biscuit received favorable sensory evaluations, with an approximate overall composite weighted mean of 4.39, interpreted as Excellent. Texture received the highest composite rating (WM = 4.45), followed by aroma (WM = 4.43), taste (WM = 4.39), and color or appearance (WM = 4.29). This pattern highlights texture as a relative strength and identifies color or appearance as an attribute for further refinement. Consumers rated taste (4.44), color or appearance (4.38), and aroma (4.54) more favorably than expert bakers (4.30, 4.10, and 4.22, respectively). Expert bakers gave a higher texture rating (4.50) than consumers (4.42).

These observations are consistent with research showing that the use and proportion of alternative flours can influence biscuit characteristics and sensory responses. Viana et al. (2026) found that sensory and textural properties varied among biscuit formulations containing green banana pulp and peel flours. Jariyah et al. (2024) demonstrated the value of structured sensory profiling for describing the sensory attributes of biscuits made with non-wheat flours. Although the products and formulations differ from those examined in the present study, these studies support further testing of ingredient ratios and processing conditions.

Comparison of Expert-Baker and Consumer Assessments

Table 3 presents the descriptive comparison of overall acceptability ratings. Expert bakers recorded a mean of 4.28, while consumers obtained a higher mean of 4.51, reflecting a difference of 0.23 points in favor of consumers. These results show that both groups provided favorable assessments of the developed biscuit, with consumers giving a slightly higher overall acceptability rating. The findings provide a basis for further comparative analysis using participant-level data.

Table 3. Descriptive Comparison of Overall Acceptability Ratings by Respondent Group

Respondent group	n	Overall acceptability WM
Expert bakers	40	4.28
Consumers	80	4.51
Mean difference (consumers − expert bakers)	**—**	**0.23**

The higher mean among consumers indicates that they provided a more favorable overall evaluation of the developed biscuit than the expert bakers, with a difference of 0.23 points. This result highlights the positive reception of the product among both respondent groups, particularly among consumers. Similarly, Oh et al. (2024) found that consumer acceptance varied according to sensory-test conditions and preparation methods in their study of home-meal replacement foods. Although their products differed from the biscuit examined in the present study, their findings emphasize the value of standardized evaluation procedures in assessing consumer preferences. In this regard, the observed difference provides useful descriptive insight into how the two respondent groups assessed the developed biscuit.

Acceptability of the Developed Biscuit

Table 4 presents the acceptability ratings reported for the developed biscuit. The approximate overall sample-size-weighted composite mean was 4.43, interpreted as Highly Acceptable.

Table 4. Acceptability Ratings of the Developed Biscuit

Acceptability attribute	Expert bakers WM	Consumers WM	Composite WM	Interpretation
Taste	4.40	4.62	4.55	Highly Acceptable
Texture	4.40	4.50	4.47	Highly Acceptable
Color/appearance	4.20	4.42	4.35	Highly Acceptable
Aroma	4.10	4.50	4.37	Highly Acceptable
Overall	**4.28**	**4.51**	**4.43**	**Highly Acceptable**

Note. Composite means are weighted estimates reflecting subgroup means and sample sizes.

Taste received the highest composite acceptability rating (WM = 4.55), followed by texture (WM = 4.47), aroma (WM = 4.37), and color or appearance (WM = 4.35). Consumers rated taste at 4.62, compared with 4.40 among expert bakers. For the overall assessment, consumers recorded a mean of 4.51 and expert bakers recorded 4.28. These results indicate favorable evaluations among both participating groups.

Related studies likewise show that the acceptability of baked products containing alternative flours depends on ingredient selection and substitution level. Malik et al. (2025) reported that biscuits made with a composite raw-banana and Acacia nilotica seed flour blend were most acceptable at the lower substitution level examined, while higher levels reduced acceptability partly because of darker color, coarser texture, and bitterness. Tamil Mulakkan et al. (2025) also reported variation in sensory scores among cookies formulated with jackfruit seed flour. These studies provide context for the present findings and support further optimization of the formulation. The acceptability ratings provide a sensory basis for continued product evaluation. Nutritional quality, potential health effects, shelf-life stability, and commercial feasibility can be examined through dedicated analyses.

Laboratory Analysis of Selected Nutritional Characteristics

Table 5 presents the laboratory results for the selected nutritional parameters.

Table 5. Laboratory Results for Selected Nutritional Parameters

Parameter	Reported result	Analytical method
Crude fiber	0.78% w/w	ANKOM Fiber Analyzer
Moisture	6.4 g/100 g	Gravimetry
Protein (N × 6.25)	12.4 g/100 g	Kjeldahl method

These results provide an initial compositional profile of the product based on the selected nutritional parameters. In a related study, Goh et al. (2024) reported protein values ranging from 9.16 to 20.81 g/100 g, moisture values from 3.98 to 6.95%, and crude fiber values from 0.35 to 5.97% across biscuit formulations incorporating jackfruit seed flour and okara flour. The values obtained in the present study fall within the ranges reported by these researchers, providing a useful point of reference for discussing the compositional characteristics of biscuits developed with alternative flour ingredients. It is also important to recognize that crude fiber represents a specific fraction of dietary components and is analytically distinct from total dietary fiber. Further nutritional analyses covering total dietary fiber, fat, ash, carbohydrates, energy, and selected micronutrients could expand the existing findings and establish a more comprehensive nutritional profile of the developed biscuit.

CONCLUSION

1. The biscuit formulated using banana peel flour and jackfruit seed flour received favorable sensory-quality and acceptability evaluations from the participating expert bakers and consumers. The findings indicate that the developed product demonstrated desirable characteristics in terms of texture, taste,

appearance, and aroma, reflecting its positive reception among the respondents. Both groups provided favorable assessments, highlighting the potential of the formulation as an alternative biscuit product.

2. Laboratory analysis further characterized the biscuit in terms of selected nutritional components, particularly protein, moisture, and crude fiber. These findings contribute to understanding the compositional characteristics of the developed product and provide an initial basis for describing its nutritional profile.

3. Overall, the findings demonstrate the potential of banana peel flour and jackfruit seed flour as alternative ingredients in biscuit development. The favorable sensory evaluations, together with the laboratory findings, establish a basis for recognizing the developed biscuit as a promising product formulation that utilizes alternative flour ingredients.

RECOMMENDATIONS

1. Future researchers should conduct controlled formulation trials using different substitution levels of banana peel flour and jackfruit seed flour, with a conventional biscuit formulation serving as the control. The substitution percentages should be clearly defined in relation to the total flour blend or the individual alternative flour ingredients. Independent production batches should also be prepared to assess formulation consistency and product quality.

2. Subsequent studies should adopt standardized sensory evaluation procedures by clearly specifying the sensory scale, verbal descriptions, serving conditions, sample coding, presentation sequence, testing environment, palate-cleansing procedures, and assessor instructions. Sensory quality and overall acceptability should be clearly defined and treated as separate constructs when both are assessed. Ethical clearance, informed consent, ingredient disclosure, allergy screening, and participant-safety measures should likewise be incorporated into the research protocol.

3. Future investigations should expand the laboratory characterization of the developed biscuit by examining total dietary fiber, fat, ash, carbohydrates, energy, and selected micronutrients. Crude fiber and total dietary fiber should be determined and reported separately. Researchers should also document the analytical methods and standards used, the number of independent production batches and laboratory replicates, the basis of reported measurements, and relevant quality-control procedures to support the reliability and reproducibility of the results.

4. Microbiological testing and shelf-life evaluation should be conducted under specified packaging and storage conditions to determine the product's microbiological quality, storage stability, and suitability for potential distribution. These assessments should be completed before making claims regarding product safety and shelf-life.

5. Following formulation refinement and product safety assessment, further studies may investigate consumer purchase intention, packaging preferences, production costs, and small-scale manufacturing feasibility. These investigations may provide additional information on the product's market potential and practical application in food product development.

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