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Development and Organoleptic Assessment of Indian Mango Crackers

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ABSTRACT

The Indian mango (*Mangifera indica L. var. Katchamita*) is a productive but largely neglected cultivar in the Philippines. This variety of mango is often ignored or underestimated because of its sharp taste and limited use in processing. This research aimed to develop and assess Indian mango-based crackers with two experimental formulations (Variant 1213: mango puree; Variant 4050: mango essence) compared to a commercial control (Variant 8448). Microbiological analysis showed that all the variants conformed to Department of Health, Food and Drug Administration, and Codex Alimentarius requirements. There were 66 respondents who performed the sensory evaluation, revealing significant differences in taste, texture, aroma, appearance, and overall acceptability ($p < 0.001$). The commercial control was better in all respects than the prototype variants; however, Variant 1213 showed moderate acceptability but required refinement in crispness and oil absorption. Preliminary market survey results showed that most consumers were in favor of buying processed Indian mango products, with jams, chips/crackers, and pickles being the most acceptable ones. The results indicate that Indian mango may be a springboard for value-added innovations and rural enterprise development as long as product formulations are optimized and wider consumer acceptance is achieved.

Keywords: *Indian mango, Katchamita, food product development, sensory evaluation, value addition*

Introduction

The mango sector in the Philippines has always been considered a major contributor to the agricultural production that provides a livelihood to the farmers and, at the same time, contributes substantially to both local consumption and export revenues. Mangoes come third after pineapple and banana as the country's most important fruit crops. In fact, mangoes still serve as one of the icons of Philippine agriculture. It is primarily the Carabao mango that is known internationally as the Manila Super Mango and is the most popular in the market, owing to its sweetness and high level of consumer preference. However, other varieties like Pico and Katchamita (Indian mango), which are also high-yielding and pest-resistant, are rarely used.

The Katchamita mango has small fruits that are oval in shape; its skin is a smooth green that turns to yellow-green, and the flesh, which is a deep yellow, has a sub-acid flavor. While it is the Carabao mango that is popular in the market, Katchamita trees do bear fruit regularly as compared to Carabao trees, and they also require less input to produce, which means that they can be a better choice for farmers who have small farms. There is limited consumer preference for the sub-acid taste of Katchamita mango, so most of the time, the ripe Katchamita mangoes are thrown away or sold at very low prices. This situation leads to the wastage of the mangoes and, at the same time, there is a loss of opportunity to add value. Therefore, it is a challenge to find ways of processing Katchamita mangoes that would not only give the flavors that people love but also make the products marketable.

Across the world, mango by-products have been acknowledged not only for their nutritional value but also for their functional properties in food. For instance, Choi et al. (2020) have demonstrated the use of mango seed flour as an ingredient in baked products. Pazzini et al. (2021) have done a comprehensive review of the use of mango by-products in various applications of the food industry. Medina-Rendon et al. (2021, 2023) have carried out studies based on the extrusion of mango peel and kernel flours, where the challenges of getting good sensory properties have been highlighted. Petikirige et al. (2022) have carried out a comparative study on drying techniques for tropical fruits while relating the choice of the process to the sensory outcomes of dried fruits.

On the other hand, Li and Dai (2023) have examined the influence of drying and maturity on volatile properties, whereas Lin et al. (2023) have done an optimization of drying methods for mango slices. Ayustaningwarno et al. (2020) have investigated the vacuum-fried mango chips and identified two critical factors, i.e., crispness and oil control, for producing high-quality mango chips. Local research, such as the work of Balasote et al. on mango chips in 2022, affirms that consumers are willing to try unconventional mango products.

In addition, a number of studies have been carried out recently that focus on sustainability and consumer-initiated innovation. For example, Domene-Vallero et al. (2026) emphasized the sustainable processing of mango by-products, while Adjei et al. (2026) looked at consumer-led product development for indigenous fruits. Similarly, Moreno-Rojo et al. (2024) explored the potential of mango peel flour in bread making, and Ja'afar et al. (2026) and Zomegni et al. (2026) found mango kernel flour to be useful in flatbread and biscuits. These studies together bring out the potential of mango by-products in various food applications and will be a good starting point for researchers.

This paper attempted to fill the void in knowledge by creating new food products from ripe Katchamita mangoes, standardizing cracker recipes, and carrying out sensory analysis to determine the consumer acceptance level. By situating the research within the broader context of sustainable agriculture and rural enterprise development, this

work contributes to reducing waste, diversifying product lines, and empowering farmers through innovation.

Methods

Research Design

This study employed an experimental product development design, focusing on the formulation and evaluation of mango-based crackers. While six prototypes were initially conceptualized, such as dried mango, crackers/chips, yoghurt, powdered juice, pickles, and fruit leather, procurement constraints limited full evaluation to the cracker variants. The research thus concentrated on crackers as the primary product innovation.

Raw Materials

Ripe Katchamita mangoes were harvested from local sources. Fruits were washed, peeled, and deseeded to obtain clean pulp. The pulp was run through a blender and stored under refrigeration to maintain freshness and prevent microbial contamination until use.

Product Formulation

Through trial and error, two cracker variants were developed: Variant 1213 was formulated with cassava starch (65%), ripe Indian mango puree (30%), salt, water, and spices (5%); while Variant 4050 was formulated with cassava starch (95%), mango essence, salt, water, and spices (5%).

Exact ingredient proportions were standardized to ensure replicability. To form a working dough, the mixture (cassava starch, Indian mango puree, salt, white pepper) was blended with clean water (250-300 mL) in gradual intervals until a slightly runny dough was formed. The dough was then divided into 8 parts (3/4 cup per part) on the autoclavable plastic (6x10 in.), thinned to form a sheet-like form (5 mm), and steamed for seven minutes. Steamed dough sheets were dehydrated at 70 °C for 120 minutes to achieve ~12% final moisture content, cut into 0.5 x 1.5-inch chips before frying at 100-120 °C for 5-10 seconds. The commercial control (Variant 8448) was included for comparison.

Microbial Analysis

Microbial testing was done by submission of food samples to the Department of Science and Technology – Regional Standards and Testing Laboratory. Parameters included in the tests were Escherichia coli, total coliforms, aerobic plate count, and yeast/molds. All results conformed to Department of Health, Food and Drug Administration, and Codex Alimentarius standards, confirming product safety.

Sensory Evaluation

A total of 66 respondents, consisting of students and employees aged 20 to 43 years, participated in the sensory evaluation. The nine-point hedonic scale, which is the standard (9 = extremely like, 1 = extremely dislike), served as the means for measuring taste, texture, aroma, appearance, and overall acceptability. Bias-free decisions were ensured by the single-blind method. The statistical methods applied were descriptive statistics, one-way ANOVA, and Tukey's HSD post-hoc tests.

Ethical Considerations

Informed consent was obtained from all the participants. Confidentiality was maintained, and procedures adhered to the Declaration of Helsinki and national research ethics policies.

Results and Discussion

Microbial Safety

All cracker samples tested negative for microbial contamination, confirming compliance with food safety standards. This finding established the baseline safety of the products and allowed sensory evaluation to proceed.

Generally, all results were below the detection limits of the applied test methods (<3.0 MPN/g for coliforms and <10 CFU/g for aerobic plate count and yeast/molds), and therefore comply with the microbiological standards for processed food products set by the Department of Health (DOH), Food and Drug Administration (FDA), and Codex Alimentarius.

Table 1. Comparative Report of Indian Mango Crackers vs. Common Acceptable Limit

Microbial Parameter	Common Acceptable Limit (per gram)	Sample Result
Escherichia coli	Not detectable / <3 MPN/g	<3.0 MPN/g
Total Coliforms	<100 MPN/g	<3.0 MPN/g
Aerobic Plate Count	$<10^5$ CFU/g	<10 CFU/g
Yeast and Molds	$<10^3$ CFU/g	<10 CFU/g

Demographic Profile of the Respondents

A total of 66 panelists participated in the sensory evaluation, comprising students and employees of Isabela State University as well as individuals from nearby communities. The ages of the panelists ranged from 20 to 43 years, with respondents aged 20–22 years comprising the largest proportion of the sample. Females made up the majority of the panel (~75%), with males accounting for only ~25%. While most participants were from Cabagan, Tumauini, Delfin Albano, and Sta. Maria, only a few came from San Pablo, Quirino, and Cagayan (Province).

Based on their self-ratings of moods, most people's emotions were somewhere between neutral and happy, with only a smaller fraction being hungry, pleased, or frustrated. This kind of panel composition is favorable as it reduces the possibility of bias arising from being in a negative mood.

Also, it is worthwhile mentioning that the sensory evaluation was a single-blind trial: the panelists did not know what or which product formulation they were tasting. This step was taken to ensure that judgments were based on sensory perception alone and not on expectations derived from product knowledge.

Table 2. Demographic Profile of the Respondents for the Sensory Evaluation of Indian Mango Crackers

Demographics	Number of Respondents	Percentage (%)
Sex		
Female	52	78.8
Male	14	21.2
Age		
20–22 years (students)	43	65.2
25–43 years (employees)	23	34.8
Location		
Tumauini	15	22.7
Cabagan	18	27.3
Delfin Albano	9	13.6
Sto. Tomas	5	7.6
Sta. Maria	7	10.6
San Pablo	3	4.5
City of Ilagan	1	1.5
Quirino	1	1.5
Peñablanca (Cagayan)	1	1.5
Unspecified	6	9.2
Mood		
Neutral	20	30.3
Happy	26	39.4
Hungry	7	10.6
Pleased	3	4.5
Overjoyed	2	3.0
Negative (Sad, Frustrated, Angry)	8	12.1

Descriptive Statistics of Sensory Attributes

Table 3 presents the mean sensory scores of the three variants. The commercial control (8448) consistently achieved the highest scores across all attributes, while Variant 1213 showed moderate acceptability, and Variant 4050 was the least preferred.

Additionally, the qualitative feedback confirmed these results. The respondents praised Variant 8448 as “highly recommended” and “very delicious,” while variant 1213 was described as “balanced but oily” and “needs to be crispier.” Variant 4050 earned a sour and unbalanced flavor, “not suitable to the cracker,” and “vegetable-like aroma” were some of the comments. The insights complement the statistical results and highlight the need for formulation adjustment. The fairly good acceptance of Variant 1213, particularly the oiliness and lowered crispness, may also be the reason why Dharmaprema et al. (2026) found that moisture and oil absorption greatly lowered consumer liking in mango-pumpkin crackers. Besides, Ayustaningwarno et al. (2020) found that vacuum-fried mango chips had higher crispness and lower oil uptake than those from conventional frying, which basically emphasized the need for established drying and frying parameters in mango-based snack production.

The sourness and imbalance reported in the case of Variant 4050 are consistent with the results of Kassa and Teferi (2025), who indicated that mango chips at improper drying stages resulted in undesirable acidity and bad texture. In this regard, essence-

based formulations should be very careful with acidity and flavor balancing in order to achieve consumer acceptability.

Table 3. Mean Sensory Scores of Indian Mango Cracker Variants Across Taste, Texture, Aroma, Appearance, and Overall Acceptability

Attribute	Variant 1213	Variant 4050	Variant 8448
Taste	6.7	5.2	8.9
Texture	7.4	5.8	8.8
Aroma	7.3	5.6	8.7
Appearance	7.5	5.9	8.8
Overall Acceptability	7.2	5.5	8.9

Difference Test for Sensory Attributes of Indian Mango Cracker Variants

The sensory analysis clearly showed differences in the three cracker samples. From Table 3, the commercial control (8448) was the highest-rated product in acceptability, and this is consistent with the respondents' comments that the flavor balance and crispness of the control were good; the mean scores for taste (M=8.9), texture (M=8.9), aroma (M=8.7), and appearance (M=8.8) show that the control was highly preferred. Compared to this, the taste and texture scores of variant 1213, which was made using Indian mango puree, were not very high, as some panelists found the product too oily and not very crisp and less liked overall, despite a few panelists reporting flavor balance.

Lastly, Variant 4050 obtained the lowest scores amongst the three products and is described as sour, hard, and with off-flavors. The taste (M=5.2), texture (M=5.8), and aroma (M=5.6) mean scores of Variant 4050 were very low. Overall acceptability followed a similar trend, with the control (M=8.9) being the clear favorite, Variant 1213 (M=7.2) showing moderate potential, and Variant 4050 (M=5.5) being the least acceptable.

Table 4. One-Way ANOVA Results for Sensory Attributes of Indian Mango Cracker Variants

Attribute	f-value	p-value	Interpretation
Taste	38.12	< .001	Significant difference
Texture	22.45	< .001	Significant difference
Aroma	18.67	< .001	Significant difference
Appearance	16.89	< .001	Significant difference
Overall Acceptability	27.03	< .001	Significant difference

ANOVA results (Table 3) confirmed statistically significant differences across all sensory attributes ($p < .001$). Tukey's HSD (Table 4) further revealed that the control significantly outperformed both prototypes, while Variants 1213 and 4050 were often statistically similar.

The significant differences in aroma between the variants go hand-in-hand with the findings made by Li et al. (2023), who revealed that maturity status and infrared drying are two major factors governing the volatile compounds in mango. Such results stress the necessity to choose the right raw material maturity and drying method so as to enhance aroma profiles.

Concerning the appearance, particularly oiliness, presents a reflection of the overall problem of sustainable drying. Lin et al. (2023) pointed out that drying kinetics and energy efficiency are the main factors in product quality, including oil absorption and crispness. Petikirige et al. (2022) conducted further studies on the impact of the various drying methods on sensory attributes of tropical fruits, and their findings suggest that better drying protocols can improve not only the visual but also the textural qualities of Indian mango crackers. Local relevance gets more backing from Balasote et al. (2022), who learned that Indian mango chips were largely acceptable to consumers; thus, when formulation problems are taken into consideration, processed Katchamita mango products still find the Philippine market.

Table 5. Tukey's HSD Post-Hoc Test Results for Pairwise Comparisons of Indian Mango Cracker Variants

Attribute	Significant Pairwise Differences	Interpretation
Taste	8448 vs 1213; 8448 vs 4050; 1213 vs 4050	All pairs differ significantly
Texture	8448 vs 1213; 8448 vs 4050	Control better; 1213 ≈ 4050
Aroma	8448 vs 1213; 8448 vs 4050	Control better; 1213 ≈ 4050
Appearance	8448 vs 1213; 8448 vs 4050	Control better; 1213 ≈ 4050
Overall Acceptability	8448 vs 1213; 8448 vs 4050; 1213 vs 4050	All pairs differ significantly

Besides local ones, more extensive references also confirm the versatility of mango by-products in the food sector. Pazzini et al. (2021) presented mango by-products in the food industry applications for nutrition and functional potential. Medina-Rendon et al. (2021, 2023) studied extrusion of mango peel and kernel flours, showing that incorporation of mango by-products is one way to enhance fiber content, but it also calls for sensory re-adjustment. Moreno-Rojo et al. (2024) found that mango peel flour was an enhancement for bread quality, whereas Ja'afar et al. (2026) and Zomegni et al. (2026) attested to the usefulness of mango kernel flour in making flatbread and biscuits. Collectively, the researchers pave the way for a degree of mango-based new product generation; however, they stress the need to keep performing detailed physicochemical characterization.

The ultimate role that sustainability and consumer-driven innovation play in this sector is highlighted by Domene-Vallero et al. (2026), who focused on the sustainable processing of mango by-products, while Adjei et al. (2026) made consumer product development for indigenous fruits a more dominant theme. In light of these two, Indian mango crackers, after proper tuning, could be both a source of rural enterprise and a sustainable food system.

Preliminary Market Survey

The preliminary market survey, though limited (N=5), indicated consumer openness to processed Indian mango products. Respondents suggested jams, chips, and pickles as preferred formats. Price and quality were identified as key purchasing factors. While the small sample size limits generalizability, the findings highlight potential market opportunities.

Conclusion and Future Works

This study demonstrated that Indian mango (Katchamita) can be transformed into safe and acceptable food products, specifically crackers. However, current formulations require refinement to achieve higher consumer acceptability. Variant 1213 showed moderate potential, while Variant 4050 was the least preferred. Claims of commercial viability remain premature without further optimization.

This study has several limitations that should be considered when interpreting the findings. First, the use of a commercially available product as the control introduced potential confounding variables, as differences in formulation, processing methods, and ingredient composition may have influenced the comparative sensory evaluation. Second, the sensory evaluation was conducted with a panel of only 66 respondents, primarily drawn from a single university community, which may limit the generalizability of the findings to broader consumer populations. Finally, the study focused primarily on sensory acceptability and did not include analyses of proximate composition, texture profile, or shelf-life stability. The absence of these evaluations restricts a comprehensive assessment of the product's nutritional quality, physicochemical properties, and storage performance. Collectively, these limitations highlight the need for future investigations employing larger and more diverse consumer panels, standardized control products, and comprehensive laboratory analyses to strengthen the scientific rigor and practical applicability of the developed Indian mango crackers as a product.

Future research may focus on strengthening the technical and market viability of Indian mango crackers. Proximate and physicochemical analyses covering moisture, fat uptake, water activity, and protein content could also provide a stronger scientific basis for refinement. Frying and drying parameters must be optimized to reduce oiliness and improve crispness, while sensory panels could be expanded to include more diverse consumer groups. Shelf-life and packaging stability studies are also needed to establish commercial readiness. Beyond crackers, exploring alternative product lines such as jams, beverages, and pickles may broaden market appeal. Finally, farmer training and extension programs may be integrated to build local capacity in standardized processing and food safety compliance, ensuring that innovation translates into sustainable rural enterprise development.

By addressing these recommendations, future research can unlock the full potential of Indian mango in value-added food innovation, contributing to sustainable agriculture and rural enterprise development.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Artificial Intelligence (AI) Declaration Statement

The authors acknowledge the use of artificial intelligence (AI) tools, specifically Microsoft Copilot, in the refinement of this manuscript. AI assistance was limited to language editing and formatting of sections such as ethical considerations and references in APA 7th edition style. AI assistance was also utilized to hasten the search for related literature for the discussion of results. The intellectual content, research design, data collection, analysis, and interpretation of results were solely conducted by the authors. All outputs generated by AI were critically reviewed, validated, and revised

by the authors to ensure accuracy, originality, and alignment with the study objectives. The use of AI did not replace the scholarly judgment of the researchers, and full responsibility for the content of this paper rests with the authors.