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Development and evaluation of food products incorporated with Carabao Mango (*Mangifera indica var. carabao*) pulp powder

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Abstract

The study focused on the development and evaluation of Carabao mango pulp powder and its applications in food formulations. The study detailed the physical and nutritional characteristics of the developed powder, conducted evaluations of the resulting food items for both sensory appeal and nutritional content, and determined their shelf life and cost-effectiveness. The findings revealed that the powder retained crucial pulp qualities and remained stable during six months of room temperature storage, with a yield of 20%. The substantial reduction in volume while preserving essential nutrients offered practical logistical benefits. The powder could be efficiently rehydrated and easily integrated into various food formulations. Products developed using the powder demonstrated nutritional quality comparable to similar market offerings and garnered high sensory acceptance. Incorporating the powder enhanced the sensory attributes of the products, as evidenced by experiments. Most items exhibited stability over an extended storage period, and cost estimates indicated competitive pricing in the market.

Keywords: Mango, Proximate composition, Sensory properties, Sensory shelf-life estimation, Mango processing, Mango powder

1. Introduction

The perennial challenge faced by the Philippine mango industry revolves around losses incurred through inadequate post-harvest handling, subpar storage technologies, and surplus production (Caparino et al., 2012; Caparino, 2012). According to reports, local mango farmers experienced losses as high as 33% in 2016, primarily attributed to post-harvest diseases and collection inefficiencies (Mopera, 2016). This challenge is particularly pronounced in the production of Carabao mangoes (*Mangifera indica var. Carabao*), which represent a significant

portion of the country's exports (Rodeo, 2016) and are the most widely produced variety (Bureau of Agricultural Statistics, 2009). The susceptibility of Carabao mangoes to spoilage, especially during peak seasons, results in inevitable losses (Caparino, 2012; Uzada, 1991). This perishability characteristic has led to untapped markets for Carabao mangoes (Uzada, 1991).

Inefficient post-harvest practices and the high volume of mango production have the potential to result in significant wastage of agricultural yield. This scenario not only poses local challenges but also raises concerns about global food security, with far-reaching socio-economic implications. According to data from the Food and Agricultural Organization (FAO) regarding food loss, approximately one-third of global food production (equivalent to 1.3 billion metric tons) is lost annually, with fruits and vegetables contributing the largest share of about half a billion tons (Salemdeeb et al., 2017; Gustavsson et al., 2011). This alarming statistic has prompted food governing bodies worldwide to urge the agricultural and food processing sectors to minimize losses through improvements in processing techniques and product development.

Transforming the edible part of mango, its pulp, into a more stable form provides an opportunity to tackle production losses. For example, dehydrating the fruit can extend its shelf life and rescue subpar products that might otherwise be discarded as rejects. The conversion of mango pulp into dried forms is not a novel concept. There were previous successful attempts to convert it into composite flour (Nur Aziah et al., 2012; Djantou et al., 2011; Nur Aziah et al., 2011), dried cuts, flakes, and powder (Caparino et al., 2012; Caparino, 2012), the last-mentioned being the most flexible form. A stable powder form with minimal caking, minimal color darkening, and more excellent storage stability at room temperature can be achieved by any conventional drying technique using grinding additives, the most common is maltodextrin (Mendoza, 2009; Mahendran, 2008). In terms of nutritional quality, mango powder, a concentrated form of fruit pulp, has been known to have a greater concentration of nutritional elements per unit weight than the same amount of fresh mango pulp. Hence, such a form offers practical advantages in food processing and product development as only small amounts of the powder can provide a significant amount of nutrition (Mendoza, 2009). Such is very important as most consumers shift their consumption to healthy products (Bariuan et al., 2020). Moreover, converting foods into any dehydrated form can significantly decrease transportation costs compared to their raw forms (Ratti, 2001).

Converting excess production and rejected local Carabao mangoes into a dehydrated state for use as a functional ingredient in the creation of food compositions holds considerable benefits from environmental, economic, and scientific perspectives. Initiatives aimed at reducing food losses through innovative approaches contribute significantly to enhancing food security and promoting environmental sustainability (Shafiee-Jood & Cai, 2016). Additionally, the global demand for dried food products has been on the rise, reaching an estimated market value of approximately $12.7 billion in 2016, with Asia representing the largest segment of this market. Among the many dehydrated food product forms, the most in-demand were food powders due to their vast applications (Barbosa-Canovas et al., 2005). Furthermore, given the global popularity of processed Carabao mango products (Siddiq et al., 2017; Tiyayon & Paull, 2017; Caparino, 2012), endeavors to create innovative storage techniques and products derived from the fruit present alternative revenue streams for local mango cultivators. This, in turn, has the potential to significantly contribute to the growth of the mango industry (Siddiq et al., 2017; Tiyayon & Paull,

2017). Finally, there is a scarcity of literature reporting on the creation of pulp powder from the Carabao variety and the formulation of food compositions incorporating mango pulp powder.

Against this backdrop, the Commission on Higher Education (CHED) initiated a research project focused on the sustainability of mango production in Bataan province, recognized as one of the burgeoning areas for mango cultivation in the Philippines. The project was funded under the commission's Discovery-Applied Research and Extension for Trans/Inter-disciplinary Opportunities Research Grant (DARETO) program. The present study was a part of the project. It attempted to develop and evaluate Carabao mango pulp powder and five food compositions based on the material. Specifically, the study was able to detail the basic attributes and nutritional quality of the developed mango pulp powder; conduct sensory and nutritional evaluations of five food products based on the innovation; and estimate the shelf-life and profitable costing of the new product developments. The rationale was to convert the unavoidable production losses of Carabao mangoes into a stable product with an extended shelf life, easier storage, and versatility for the creation of valuable food compositions. This aimed to assist local mango cultivators in generating income from surplus produce that might otherwise go to waste, thereby contributing to the sustainable mango farming practices advocated by the CHED-DARETO project.

2. Materials and methods

2.1 Materials

The present study had the following materials used: Carabao mangoes obtained as excess produce/production losses by mango cultivators under an ongoing Bataan mango production sustainability project funded by CHED-DARETO; food-grade maltodextrin as grinding additive; and product development ingredients (refer to product development portion).

The acquired mango fruits were kept at room temperature (25°C) and relative humidity (80-85%) until all had the desired ripeness levels (Levels 5 [Ripe] and Level 6 [Overripe]) for processing. Ripe to overripe mangoes were chosen for processing. At these levels, the mango fruits are prone to quality deterioration due to mishandling and can most likely become production losses. The mango ripeness levels were ascertained according to the Philippine National Standards for Fresh Fruits using a color and physical observation table for Carabao mango peel and flesh: Level 1, Green (peel: completely light green; pulp: yellowish-white or light-yellow green); Level 2, Breaker (peel: traces of yellow; pulp: white to yellowish-white); Level 3, Turning (peel: more green than yellow; pulp: more yellow than white); Level 4, Semi-ripe (peel: more yellow than green; pulp: yellow); Level 5, Ripe (peel: 80-100% yellow; pulp: yellow); and Level 6, Overripe (peel: yellow; pulp: yellow).

2.2 Mango pulp powder processing

Processing the Carabao mango pulp into powder necessitated a combination of both manual and mechanical methods. After thoroughly washing, sanitizing with chlorinated water

(200 ppm), and air-drying the whole fruits, the pulps were extracted by peeling the fruits and then manually detaching the pulps from the stones with knives. The obtained pulps were stored immediately in previously sanitized polyethylene (PET) containers, and they were placed in the refrigerator to delay spoilage until further processing.

The collected pulps were dried into brittle strips using an agricultural drier at 70°C for 14 hours. The dried pulp strips were cooled for 2 hours and then were turned into a coarse powder using a high-speed electric blender. The resulting coarse powder was again subjected to drying, this time at 60°C for 7 hours. After being cooled for 2 hours, the dried coarse powder was mixed with the grinding additive (5% maltodextrin to the total weight of the dried coarse powder) and then was grounded into fine powder until most can be sieved with a mesh size of 200 (75 μm diameter). The obtained final powder was stored in previously sanitized and air-tight PET containers until quality inspection and usage to develop five mango-based food compositions.

2.3 Product developments

In the present study, five mango-based food compositions were developed: Mangonitas, Mango Bar, Mango Polvoron, Mango Pastimallows, and Mango Tart. These formulations utilized commercially available raw ingredients, with the incorporation of the developed mango pulp powder as quality enhancers at varying amounts and processing stages.

For Mango Polvoron, a mixture of rehydrated mango pulp powder, sugar, and butter was cooked under low heat for 5 minutes. The resulting blend was combined with mango pulp powder, toasted cake flour, powdered milk, and sugar until thoroughly mixed. The mixtures were shaped using polvoron molders, cooled, and sealed in aluminum foil.

To create the Mango Tart shell, margarine was combined with a mixture of all-purpose flour, mango pulp powder, and sugar until well-blended. Water was sprinkled to form dough balls, which were then flattened and fitted into tart molders. The shells were pre-baked for 18 minutes. For the filling, condensed milk, egg yolk, and rehydrated mango pulp powder were cooked for 5 minutes. The fillings were spread into the shells, topped with meringue made by gradually adding powdered sugar to egg whites, and baked again for 8 minutes. The products were cooled and sealed in polypropylene (PP) plastics.

In preparing Mango Bar, a mixture of butter and brown sugar was cooked, cooled for 30 minutes, and combined with an egg. Dry ingredients (all-purpose flour, baking powder, salt, walnuts, rehydrated mango pulp powder) were gradually incorporated until well-blended. The resulting batter was poured into a bar molder and baked until achieving the desired texture. The cooled mango bars were packed and sealed in aluminum foil bags.

For Mango Pastimallows, pastillas were made by gradually combining powdered milk, mango pulp powder, and condensed milk. These pastillas were used as coatings for pre-made marshmallows, which were then manually molded into desired shapes and rolled in a mixture of sugar, mango pulp powder, and cornstarch before being packed in plastic food bags.

In the case of Mangonitas, crusts were created by combining all-purpose flour, mango pulp powder, cornstarch, and sugar. Corn oil was added, and water was sprinkled to form dough balls, which were then flattened and cut into circles. The filling was prepared by combining and cooking butter, sugar, water, egg yolk, rehydrated mango pulp powder, and cashew nuts for 8

minutes. The crusts were combined with the fillings, resembling empanadas, and baked for 18 minutes. After cooling, the products were packed using grease-proof papers.

Each developed product had a corresponding control product, created using the same procedure and ingredients except for the absence of mango pulp powder.

2.4 Nutritional analysis

In this study, the Carabao mango fresh pulp and pulp powder samples underwent analysis for moisture (Association of Official Analytical Chemists [AOAC] 934.06 [Vacuum Oven]), protein (Block Digestion [Kjeldahl]), fat (Acid Hydrolysis [Soxhlet]), ash (AOAC 940.26), carbohydrates (computed by difference), total sugar (AOAC 923.09), and total dietary fiber (AOAC 991.42) contents utilizing standard methods. The values were expressed in %w/w. Additionally, the energy contents were determined in kcal/100g through calculation. Furthermore, the samples were tested for Vitamin C (mg/kg) and Beta Carotene (μg/kg) using an in-house method for High-Performance Liquid Chromatography at the Standards and Testing Division of the Philippines' Department of Science and Technology. The five product developments underwent testing for moisture, protein, ash, fat, carbohydrates, and total dietary fiber contents using the aforementioned methods. All measurements were conducted in triplicate.

2.5 Home-use sensorial evaluation

The developed products underwent a home-use sensory evaluation using the following parameters: appearance, color, aroma, flavor, texture, and general acceptability. Fifty untrained panelists living in the City of Balanga in Bataan province assessed a serving of each product for the said sensorial parameters using a 7-point hedonic rating scale (1=dislike intensely, 2=dislike moderately, 3=dislike slightly, 4=neither like nor a dislike, 5=like slightly, 6=like moderately and 7=like intensely) where a rating of 5 and above indicate acceptability.

2.6 Real-time sensory shelf-life testing

In this study, real-time shelf-life testing was done on the sensorial qualities of the product developments over a four-week period. This approach, well-suited for foods with a short shelf-life, such as sweets and pastries (relevant to the current product developments), allows for efficient results without involving complex calculations. The purpose of this method is to ensure that product developments meet quality thresholds aligned with consumers' expectations (Hough, 2010).

All examined samples were stored at room temperature under realistic ambiance and light conditions. They underwent testing for the same parameters and rating scale as employed in the home-use sensory evaluation of the present study. However, this time, the evaluations were conducted weekly for a month by a panel of five trained experts.

2.7 Costing estimation

Profitable cost estimates for the product developments were derived by calculating the cost of raw materials per gram and determining the overall costs for each pack of products with a markup ranging from 55% to 145%. This computation took into account utilities, electricity, and labor expenses.

2.8 Statistical analyses

The experiments in this study employed completely randomized designs. All statistical analyses were conducted with IBM SPSS Version 20.0 for Windows. The results were presented as mean±standard deviation. Significance tests for differences utilized One-way Analysis of Variance and Mann-Whitney U Test, both at α=0.05.

3. Results and discussion

3.1 Attributes of the produced Carabao mango pulp powder

The mango pulp powder obtained in the present study had a typical mango pulp aroma and color and with very minimal caking. After six months of storage at room temperature inside an air-tight container, we observed no contamination. Such was attributable to the powder's very low moisture content (Tesfaye, 2017). A more extensive stability analysis did not materialize due to mobility constraints related to the COVID-19 pandemic. It is important to note that the observed shelf-life of six months was far longer than the reported shelf-life for ripe whole mango fruit, 4-8 days at room temperature and 2-3 weeks in cold storage (Asio & Cuaresma, 2016). It was also longer than those reported for ripe mango fresh-cuts, seven days under controlled conditions (Castillo et al., 2015).

Table 1: Nutritional attributes of unprocessed fruit pulp and developed pulp powder from Carabao Mango (*Mangifera indica var. carabao*).

Nutritive Parameter	Unprocessed Fruit Pulp	Developed Pulp Powder
Moisture (%w/w)	80.70±0.06[a]	1.41±0.03[b]
Protein (%w/w)	0.87±0.00[b]	3.27±0.04[a]
Fat (%w/w)	0.19±0.00	0.92±0.02
Ash (%w/w)	0.33±0.00[b]	2.06±0.01[a]
Carbohydrates (%w/w)	18.00±0.02[b]	92.35±0.05[a]
Energy (kcal/100g)	77.12±0.11[b]	390.68±0.02[a]
Total Sugar (%w/w)	14.77±0.15[b]	72.31±0.79[a]
Total Dietary Fiber (%w/w)	45.4±0.00[a]	12.47±0.07[b]
Vitamin C (mg/kg)	133.33±2.28	ND
Beta Carotene(μg/kg)	144.79±9.05[b]	728.15±62.05[a]

- Values were expressed as mean±standard deviation of triplicate analysis
- Values with a different superscript in the same row are significantly different at α=0.05
- ND = Not detected

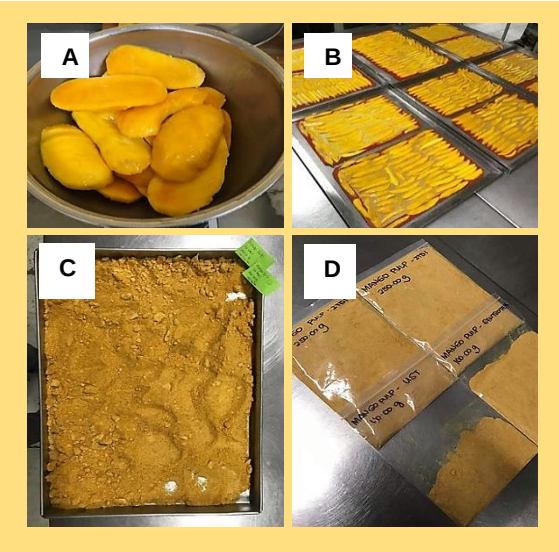

Figure 1: Carabao Mango (*Mangifera indica var. carabao*) pulp powder processing. A) Fresh mango pulps removed from stones manually; B) Mango pulp slices set for drying; C) Coarse powder produced from dried pulp slices using a high-speed electric blender; D) Final product packed in PET bags set for laboratory testing.

Through the current study's method, approximately 190-200 g of powder could be derived from 1 kg of Carabao mango pulp, representing an 80% reduction in weight primarily attributed to significant moisture removal. This substantial weight reduction, while retaining essential nutrients as indicated in Table 1, facilitates the transport of more significant nutrient quantities from the fruit per unit weight, potentially leading to significant cost savings in logistics. A noteworthy observation was the non-detection of Vitamin C in the powder samples, attributed to its sensitivity to high temperatures (Qadri & Srivastava, 2014). The notable decrease in Vitamin C during the transition from fresh mango pulp to powder through heat-drying aligns with the findings of Agustini (2018) and Kadam et al. (2010), suggesting the potential compensation by incorporating Vitamin C into the produced mango powder.

Furthermore, the rehydration of the present mango pulp powder can be efficiently achieved by adding and homogenizing with water or by directly incorporating it into foods with high moisture content. The rehydrated form exhibits a consistency ranging from pasty to puree,

depending on the level of hydration. While possessing a similar aroma to unprocessed mango pulp, the rehydrated form is less sweet. Both the powder and its rehydrated forms can be seamlessly integrated into food compositions as ingredients.

3.2 Nutritional quality of food products incorporated with mango pulp powder

Nutritional analysis plays a vital role in determining the safety, stability, and overall quality of foods, serving as the basis for assessing conformity with established standards. The proximate composition, widely employed as an index for nutritional quality and the foundation for creating nutritional labels, was utilized to evaluate the five developed food compositions in this study. Proximate composition analysis involves measuring food components and estimating their chemical contents.

The nutritional composition of the developed products is detailed in Table 2. Moisture content per 100 g serving ranged from 10.43% to 18.04% across all products. Protein, carbohydrate, and energy content exhibited ranges of 4.86-7.86%, 56.35-75.17%, and 393.63-434.18 kcal/100g, respectively. Ash content, measuring the mineral load, including elements like magnesium, calcium, potassium, and zinc (USDA, 2016), ranged from 0.61% to 2.38% in the developed products. Lastly, total dietary fiber and fat content showed ranges of 1.58-8.03% and 7.9-19.36%, respectively.

Table 2: Nutritional quality of food products incorporated with Carabao Mango (*Mangifera indica var. carabao*) pulp powder.

Nutritive Parameter	Mango Polvoron	Mango Tart	Mangonitas	Mango Bar	Mango Pastimallows
Moisture (%w/w)	10.43±0.04	12.19±0.11	18.04±0.08	14.28±0.15	11.08±0.10
Protein (%w/w)	5.46±0.45	4.86±0.16	7.65±0.07	5.69±0.24	7.86±0.34
Fat (%w/w)	7.90±0.04	14.77±0.09	17.34±0.21	19.36±1.03	12.68±0.57
Ash (%w/w)	1.03±0.02	0.76±0.01	0.61±0.01	1.37±0.06	2.38±0.06
Carbohydrate (%w/w)	75.17±0.44	67.41±0.29	56.35±0.16	59.30±1.13	66.00±0.73
Energy (kcal/100g)	393.63±0.30	422.04±0.57	412.09±1.30	434.18±5.05	409.53±3.2
Total Dietary Fiber (%w/w)	1.58±0.08	7.27±0.36	1.68±0.06	1.69±0.06	8.03±0.46
Values were expressed as mean±standard deviation of triplicate analysis.					

Based on the current data, it can be affirmed that each product development has the potential to serve as a nutritious delicacy, demonstrating parity with, and occasionally surpassing, similar products available in the market. For example, the nutritional composition of Mango Polvoron aligns with common polvoron data, showcasing comparable figures for protein (6.80%), ash (0.50%), carbohydrate (73.6%), and total dietary fiber (1.20%). Similarly, Mango Tart exhibits nutritional content in protein, fat, carbohydrate, and energy that is in line with typical

market boat tarts (5.00%, 13.00%, 65.00%, and 400 kcal/100g, respectively).

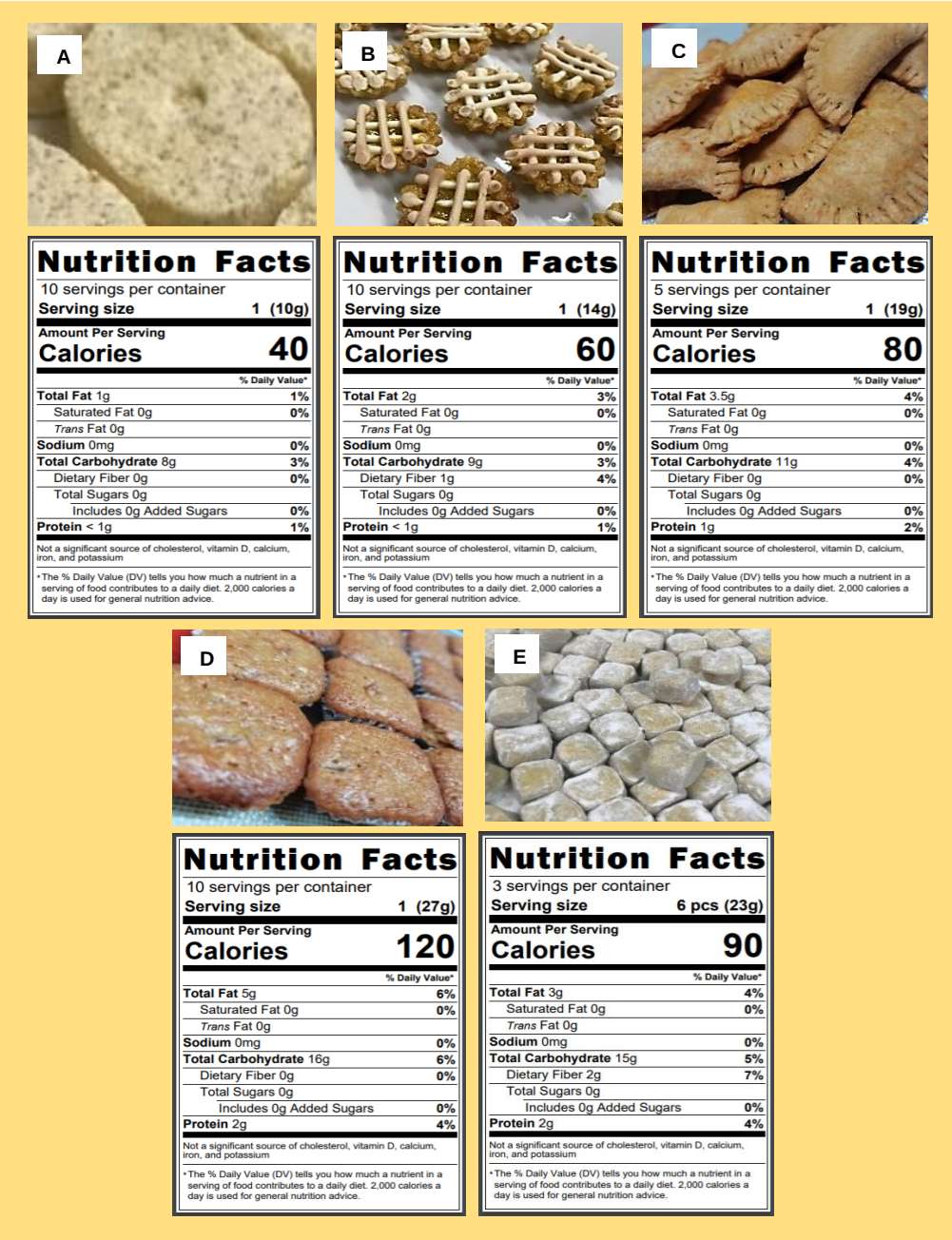

Figure 2: Nutritional labels for the product developments. A) Mango Polvoron; B) Mango Tart; C) Mangonitas; D) Mango Bar; and E) Mango Pastimallows.

For the developed Mangonitas, the figures for protein, carbohydrate, energy, and total dietary fiber were higher than those commonly found in fruit-filled empanadas (5.00%, 37.00%, 215.00%, and 1.60% correspondingly). For the present Mango Bar, on the other hand, the numbers

for protein and total dietary fiber were lower than those commonly indicated in caramel bars (10.00% and 3.00%, respectively) but similar in terms of fat, carbohydrate, and energy contents (20.00%, 60.00%, and 400.00% respectively). Lastly, for the present Mango Pastimallows, the numbers for protein were lower than those indicated for common pastillas (10.00%) but higher in terms of fat, carbohydrate, and energy contents (10.00%, 60.00%, and 375.00%, correspondingly).

The nutritional labels for the product developments were crafted based on the proximate composition analysis. Figure 2 presents the labels.

3.3 Sensory acceptability of food products incorporated with mango pulp powder

This study evaluated the sensory acceptability of the five developed products through a sensory analysis of appearance, color, aroma, texture, flavor, and general acceptability using 50 untrained panelists. Table 3 shows the sensory scores for all products.

The Mango Polvoron's appearance, color, aroma, flavor, and general acceptability were significantly higher ($P<0.05$) than the control. For the Mango Tart, the figures for all parameters were higher than the control, but the differences were not significant ($P>0.05$). The Mangonitas' aroma, flavor, and general acceptability were significantly higher ($P<0.05$) than the control. The same trend can be seen in the Mango Bar. Lastly, the Mango Pastimallows' appearance, color, aroma, flavor, and general acceptability were significantly higher ($P<0.05$) than the control.

Table 3: Sensory acceptability of food products incorporated with Carabao Mango (*Mangifera indica var. carabao*) pulp powder.

Product	Appearance	Color	Aroma	Texture	Flavor	General Acceptability
Mango Polvoron	5.88±1.06[a]	6.08±0.88[a]	5.90±1.04[a]	5.94±1.06	5.92±1.10[a]	6.04±1.01[a]
Control	5.30±0.68[b]	5.50±1.02[b]	5.42±0.67[b]	6.00±0.53	5.36±0.83[b]	5.56±0.67[b]
Mango Tart	6.14±0.83	6.16±0.93	6.00±0.99	5.94±0.91	5.92±1.10	6.06±0.98
Control	5.84±0.68	6.08±0.90	5.70±0.84	5.88±0.56	5.56±0.67	5.80±0.76
Mangonitas	6.00±0.83	6.06±0.74	5.78±0.89[a]	5.88±1.10	6.04±0.90[a]	5.92±0.94[a]
Control	5.82±0.98	6.04±0.83	5.28±0.57[b]	5.74±0.53	5.46±0.73[b]	5.60±0.49[b]
Mango Bar	5.94±1.11	6.14±0.90	6.12±0.94[a]	5.94±0.89	6.00±1.18[a]	6.06±1.11[a]
Control	5.74±0.88	5.88±1.10	5.50±0.51[b]	5.98±0.68	5.50±0.74[b]	5.42±0.78[b]
Mango Pastimallows	6.26±0.83	6.40±0.78[a]	6.18±0.87[a]	6.44±0.79	6.42±0.84[a]	6.28±0.83[a]
Control	6.04±0.90	5.90±0.97[b]	5.58±1.07[b]	6.40±0.67	5.52±0.76[b]	5.70±0.46[b]

- Values for the present study were expressed as mean ± standard deviation.
- Values with a different superscript in the same cell are significantly different at α=0.05

Creating products with sensory attributes that meet consumer expectations is a formidable challenge in the food processing sector, given that the primary goal of the food industry is to satisfy consumer preferences. Based on the recent results of sensory evaluations, all products incorporating mango pulp powder achieved acceptability, with mean scores indicating

an average to moderate level of satisfaction (5-6 on the 7-point hedonic scale). Among these, Mango Pastimallows emerged as the most favored product, garnering praise for its appealing color and enticing mango aroma and flavor, as observed in comments. Notably, significant statistical differences were identified between the products and their respective control counterparts for most sensory parameters, excluding Mango Tart. Hence, it can be stated that the incorporation of Carabao mango pulp powder contributed to the overall enhancement of product quality.

3.4 In-house sensory shelf-life testing of the product developments

Shelf-life represents the duration between a product's production and its intended consumption. Various methods, encompassing the assessment of sensory qualities to the evaluation of microbiological safety (FDA, 2013), can be employed to determine a product's shelf-life. In this study, an in-house sensory shelf-life assessment of the developed products was carried out, employing trained panelists specific to this research. The evaluation took place under the designated storage conditions (room temperature) and utilized the packaging associated with each respective product development, as illustrated in Figure 3.

Table 4: Shelf-life estimation by sensory parameters of food products incorporated with Carabao Mango (*Mangifera indica var. carabao*) pulp powder.

Developed Product	Sensory Parameter	Week			
		1	2	3	4
Mango Polvoron	**Appearance**	6.00±0.00^{a}	6.00±0.00^{a}	5.00±0.00^{b}	5.00±0.00^{b}
	Color	6.00±0.00^{a}	6.00±0.00^{a}	5.00±0.00^{b}	5.00±0.00^{b}
	Aroma	6.00±0.00^{a}	6.00±0.00^{a}	5.00±0.00^{b}	5.00±0.00^{b}
	Texture	6.00±0.00^{a}	6.00±0.00^{a}	5.00±0.00^{b}	5.00±0.00^{b}
	Flavor	6.00±0.00^{a}	6.00±0.00^{a}	5.00±0.00^{b}	5.00±0.00^{b}
	General Acceptability	6.00±0.00^{a}	6.00±0.00^{a}	5.00±0.00^{b}	4.00±0.00^{c}
Mango Tart	**Appearance**	6.00±0.00^{a}	6.00±0.00^{a}	5.00±0.00^{b}	5.00±0.00^{b}
	Color	6.00±0.00^{a}	6.00±0.00^{a}	5.00±0.00^{b}	5.00±0.00^{b}
	Aroma	6.00±0.00^{a}	6.00±0.00^{a}	5.00±0.00^{b}	5.00±0.00^{b}
	Texture	6.00±0.00^{a}	6.00±0.00^{a}	5.00±0.00^{b}	5.00±0.00^{b}
	Flavor	6.00±0.00^{a}	6.00±0.00^{a}	5.00±0.00^{b}	5.00±0.00^{b}
	General Acceptability	6.00±0.00^{a}	6.00±0.00^{a}	5.00±0.00^{b}	5.00±0.00^{b}
Mangonitas	**Appearance**	6.00±0.00^{a}	3.00±0.00^{b}	NED	NED
	Color	6.00±0.00^{a}	4.00±0.00^{b}	NED	NED
	Aroma	6.00±0.00^{a}	3.00±0.00^{b}	NED	NED
	Texture	6.00±0.00	NED	NED	NED
	Flavor	6.00±0.00	NED	NED	NED

	General Acceptability	6.00±0.00[a]	1.00±0.00[b]	NED	NED
Mango Bar	**Appearance**	6.00±0.00[a]	4.00±0.00[b]	3.00±0.00[c]	NED
	Color	6.00±0.00[a]	4.00±0.00[b]	3.00±0.00[c]	NED
	Aroma	6.00±0.00[a]	4.00±0.00[b]	3.00±0.00[c]	NED
	Texture	6.00±0.00[a]	4.00±0.00[b]	NED	NED
	Flavor	6.00±0.00[a]	4.00±0.00[b]	NED	NED
	General Acceptability	6.00±0.00[a]	4.00±0.00[b]	1.00±0.00[c]	NED
Mango Pastimallows	**Appearance**	6.00±0.00[a]	5.00±0.00[b]	5.00±0.00[b]	5.00±0.00[b]
	Color	6.00±0.00[a]	6.00±0.00[a]	5.00±0.00[b]	5.00±0.00[b]
	Aroma	6.00±0.00[a]	6.00±0.00[a]	5.00±0.00[b]	5.00±0.00[b]
	Texture	6.00±0.00[a]	6.00±0.00[a]	5.00±0.00[b]	5.00±0.00[b]
	Flavor	6.00±0.00[a]	6.00±0.00[a]	5.00±0.00[b]	5.00±0.00[b]
	General Acceptability	6.00±0.00[a]	6.00±0.00[a]	5.00±0.00[b]	5.00±0.00[b]

- Values were expressed as mean±standard deviation.
- Values with a different superscript in the same row are significantly different at α=0.05.
- NED=No evaluation done.

As indicated in Table 4, the Mango Polvoron, Mango Tart, and Mango Pastimallows still had stable sensorial qualities after one month of room temperature storage. Specifically, all parameters still had a mean score of 5.00±0.00 after four weeks. A score of 5 is equivalent to average acceptability based on the 7-point hedonic scale.

Meanwhile, the stability of Mango Bar extended only to two weeks, with its appearance, color, aroma, and overall acceptability receiving mean scores below four after three weeks of storage. Scoring below four on the 7-point hedonic scale deems it unacceptable, leading to the exclusion of further testing for texture and flavor. Similarly, Mangonitas exhibited stability for just a week, as its appearance, aroma, and overall acceptability garnered mean scores below four after two weeks of storage. Consequently, no further assessment was conducted for the product's texture and flavor. Overall, the findings indicate that the majority of product developments can maintain stability for an extended storage duration. For those with shorter shelf-lives, improvements in formulations and packaging are recommended.

Figure 3: Packaging for the product developments. Each Mango Polvoron was wrapped using gold aluminum foil and then inserted into a customized box. Ten packed pieces were loaded in PP plastic; B) Each Mango Tart was packed using PP plastic, and then ten packed pieces were loaded in a resealable clear plastic pouch; C) Each Mangonitas piece was wrapped using glassine/greaseproof paper, and then 5 wrapped pieces were loaded in a resealable white plastic pouch; Each Mango Bar was packed using a resealable gold aluminum foil bag, and then ten packed pieces were in a boxboard; Sixteen pieces of Mango Pastimallows were carefully arranged and loaded in a stand-up square bottom plastic food bag.

3.5 Costing of the new product developments

Cost estimation for developed products involved factors like production cost and selling price, markup percentage and estimated profit, pieces per packaging, and overall profit per product development.

The cost versus selling price dynamic, a crucial factor in product development, was determined for the five product developments based on the expenditure per gram of ingredient, resulting in distinct cost structures for each product. Mangonitas and Mango Pastimallows were the most cost-effective at 18.25 and 18.34 pesos. Mid-level products, Mango Tart and Mango Polvoron, incurred costs of 27.07 and 29.29 pesos, while Mango Bar demanded 111.15 pesos per

box, reflecting higher costs. This breakdown serves as the foundation for establishing selling prices, ensuring a strategic approach to Carabao mango-based product development.

The markup percentage, by adding an additional amount to the product's cost and encompassing factors like utilities, electricity, and labor, plays a pivotal role in determining the selling price as well, contributing to estimated profit and serving as a buffer for additional expenses, thereby enhancing the overall profitability of each product. In the current study, a markup ranging from 55% to 145% was applied to all products, with an exception for Mango Bar, which received a higher markup of 195.00 pesos. This discrepancy suggests that the costs associated with utilities, electricity, and labor are elevated for Mango Bar in comparison to the other products.

The interaction between pieces per packaging and estimated profit is pivotal. Mangonitas' five pieces per pack suggest a potentially lower unit cost, while Mango Pastimallows' 16 pieces indicates a larger volume, impacting unit cost and competitive pricing. Mango Bar's 10 pieces per box prompts considerations for packaging costs and economies of scale. Mango Polvoron and Mango Tart, both with 10 pieces per pack, require a nuanced balance between production efficiency, packaging costs, and overall profitability. These varying configurations underscore the need for a precise approach to cost estimation, directly shaping estimated profit.

Table 5: Cost estimation of the food products incorporated with Carabao Mango (*Mangifera indica var. carabao*) pulp powder

Product developments	Pieces per packaging	Cost (PHP)	Selling price (Php)	Mark-up (%)	Estimated profit per product (PHP)
Mangonitas	5 per plastic pack	18.25	45.00	65	90.00
Mango Pastimallows	16 per plastic pack	18.34	45.00	145	185.00
Mango Bar	10 per box	111.15	195.00	75	201.00
Mango Polvoron	10 per plastic	29.29	45.00	55	99.00
Mango Tart	10 per plastic	27.07	45.00	145	198.00

4. Conclusion and recommendation

The current study focused on the development and evaluation of Carabao mango pulp powder, as well as the creation of five food compositions derived from this innovation. This involved detailing the essential attributes and nutritional quality of the mango pulp powder, conducting sensory and nutritional assessments for five distinct food products (Mangonitas, Mango Bar, Mango Polvoron, Mango Pastimallows, and Mango Tart), and estimating the shelf-life and cost-effectiveness of these new developments. Notably, the mango pulp powder retained key qualities even after six months of room temperature storage, demonstrating stability and

preserving essential nutrients. The 20% yield from the pulp maintained nutritional integrity, presenting logistical advantages.

Furthermore, the mango pulp powder exhibited versatility, allowing efficient rehydration and easy incorporation into various food compositions. Researchers identified potential for improvement, particularly in nutritional aspects, by considering the addition of Vitamin C, which might have diminished during the drying process. Exploring alternative drying techniques, such as the drum-drying method, was suggested. The nutritional compositions of the five product developments aligned with similar market products, indicating their marketability as nutritious delicacies. These developments scored high in sensory acceptability, with experiments confirming the positive impact of mango pulp powder on the products' sensory qualities. While the nutritional quality and acceptability were well-established, the study recommended additional tests on vitamin and mineral content to further enhance consumer appeal.

In terms of shelf-life, most product developments demonstrated stability based on in-house sensory testing. However, products with shorter shelf-lives, such as Mangonitas and Mango Bar, could benefit from formulation optimization and improved packaging. Profitable costing estimations suggested competitive pricing, presenting these product developments as a potential supplementary income source for mango farmers. The study recommended additional storage stability analysis, incorporating microbiological parameters over an extended period, to ensure the safety of the products for consumption.

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