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Development and Acceptability of Gluten-freeMacaroons using Palmyra(*Borassus flabellifer*) Fruit

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Abstract:*This study aimed to develop gluten-free macaroons using Palmyra (Borrasus flabellifer) fruit as the main ingredient and to evaluate their sensory acceptability and nutritional composition. Specifically, it assessed the acceptability of three macaroon formulations based on appearance, aroma, taste, texture and compared the sensory acceptability of the three formulations. Data were collected using a 9-point Hedonic Scale and analyzed through mean, and standard deviation, MANOVA and Bonferroni's test to determine significant differences across formulations. The results revealed that among the three formulations, Formulation A was the most acceptable across all sensory attributes and was significantly different from the other two. No significant differences in acceptability were found based on participant profiles, suggesting broad market appeal. Physicochemical analysis of Formulation A showed moderate fat, protein, and sugar content, supporting its potential as a nutritious and appealing gluten-free snack product.*

Keywords: Palmyra fruit, gluten-free macaroons, sensory evaluation, consumer acceptability, food formulation

I. INTRODUCTION

A growing understanding of gluten-related disorders such as celiac disease alongside non-celiac gluten intolerance has created worldwide demands for gluten-free food products. Gluten-free baked products have increased in demand because consumers want healthier alternative dietary choices that ensure safety. Consumers commonly bash gluten-free products because they feel the products are too dry and crumbly with poor flavor along with lowered nutritional content (Wieser & Koehler, 2020). Novel approaches need development to improve both taste and dietary value in gluten-free baking applications. The inclusion of Palmyra (Borassus flabellifer) fruit shows promises for enhancing gluten-free product development. The tropical Asian and African plant Borassus flabellifer produces a fruit that naturally provides essential nutrients alongside its high fiber content and sweetness (Baskar et al., 2020). Antioxidants and natural sugars contained in Palmyra fruit pulp enhance both taste and texture characteristics while improving the nutritional values in gluten-free food products (Kumar et al., 2020).

Research into gluten-free baked goods shows increasing interest in alternative ingredients such as tapioca starch combind with almond flour and rice flour. Researchers have yet to investigate the potential uses of underutilized ingredients including Palmyra palm fruit in gluten-free baking. Products developed without gluten usually lack structural properties and elasticity resulting in below-average sensory experiences for consumers (Arendt et al., 2020). Integrating Palmyra fruit into food products would solve texture and structural problems and introduce distinctive taste notes. Current research lacks sufficient examination of the sensory acceptability of baked items made from Palmyra fruit regarding their taste, texture, color, and aroma properties. This research fills an existing knowledge gap through exploration of Palmyra fruit's feasibility and consumer approval potential as a main component in gluten-free macaroon production.

The main purpose of this research concerns gluten-free macaroon development using Palmyra fruit for sensory evaluation of taste, texture, aroma, and color acceptability. The study establishes how Palmyra pulp nutritionally

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supports baked products alongside its ability to improve dietary benefits in gluten-free products. Additionally, the study seeks to explore the commercial viability of gluten-free macaroons, promoting the incorporation of this underutilized tropical resource into mainstream food production. By emphasizing the sustainable and innovative use of Palmyra palm fruit this research aligns with global efforts to address the growing demand for nutritious and eco-friendly food options (Sharma et al., 2021).

The identified research demonstrates substantial value to multiple interested parties. Customers with gluten sensitivities gain access to a healthy gluten-free baked alternative with the addition of Palmyra fruit macaroons. The research adds diversity to gluten-free food products through the underutilized tropical fruit which demonstrates proven nutritional values (Sharma et al., 2021). The food industry can use these findings to create modern food creations and incentivize sourcing ingredients from local regions. On a broader scale, the study aligns with global goals for sustainable food production. By promoting the use of Palmyra palm fruit, it supports efforts to minimize food waste, enhance biodiversity, and provide economic opportunities for local farmers. The study focuses on the development of gluten-free macaroons using Palmyra fruit as a primary ingredient. It evaluates sensory attributes such as taste, texture, aroma, and appearance, as well as the overall acceptability of the product. The research does not include other baked goods or alternative uses of Palmyra fruit. By bridging the gap in research on the use of Palmyra palm fruit in gluten-free baking, this study aims to contribute to the development of innovative, sustainable, and nutritious food products. It addresses both consumer demand for higher-quality gluten-free options and the need to utilize underexploited tropical resources effectively.

II. LITERATURE REVIEW

Demand for Gluten-Free Products

The demand for gluten-free products has increased manifold globally over the past five years, due to growing health consciousness and instances of gluten-related disorders. Parker et al. (2021) emphasized that the global gluten-free market showed vast growth, not only based on medical requirements but also general consumer preference for healthier and allergen-free options. However, gluten-free baked products are often criticized for their inferior sensory qualities such as dryness, lack of elasticity, and blandness. These shortcomings have created a demand for innovative ingredients that can help correct these problems. In the Philippines, demand has also surged for gluten-free items, especially among the urban and health-conscious segments. Local market segmentation of gluten-free products has increased as more Filipinos embrace specialized diets, requiring locally sourced and sustainable solutions to meet that demand, as mentioned by Santos et al. in 2022.

Nutritional and Functional Properties of Palmyra Palm Fruit

Palmyra (*Borassus flabellifer*) is one of the underutilized fruits in Southeast Asia, which has a rich nutritional profile. According to Basava Prasad (2023) and Baskar et al. (2021), the fruit is rich in dietary fiber, antioxidants, vitamins A, B-complex, and C, and essential minerals such as potassium and calcium. These components not only have nutritional value for the food product but also provide functional properties such as moisture retention and texture improvement, hence pulp is an excellent ingredient for baking without gluten.Kumar et al. (2020) note that Palmyra fruit has the properties of natural sweetness and fruity aromaticity, with a potential beneficial role in giving more flavor to food products. Perhaps the use in gluten-free baked goods provides an added layer of advantage towards addressing sensory and nutritional limitations with respect to food products. The various parts of palmyra are rich in many nutrients and phytochemicals which is essential for daily activities. The roots of the palmyra are rich in protein (8.54%) and fiber, fruit pulp is high in ascorbic acid and calcium level which is the main essential micronutrient required by the body. The palmyra tuber powder is a good source of fiber, iron and phosphorus which is essential for RBC synthesis, bone development and to eliminate the toxins from the body (Basava Prasad et al., 2022.

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Sensory Attributes in Gluten-Free Baking

Tastiness, texture, flavor, and color of gluten-free baked products are extremely important factors to be achieved successfully. According to Wieser and Koehler (2020), the elastic and soft characteristic of gluten leads to the deficiency of elasticity and softness of the gluten-free product, and usually, these crumbly and dry textures fail to gain acceptability in consumers. Sharma et al. (2021) have stated that the natural fruit pulps incorporation can improve texture and moisture retention in gluten-free foods, hence acceptability. Palmyra pulp has a high-water content and has natural binding properties, so it may improve the texture of gluten-free baked products to be soft, moist, and cohesive. According to Santos et al. (2022), Filipino consumers significantly consider sensory attributes, especially taste and texture, in the assessment of new food products. This corresponds to optimizing the sensory characteristic of Palmyra based gluten-free baked goods.

Sustainability in Gluten-free food production

Because sustainability is now a major component of the food industry, it is complementary to the global shift towards sustainable agriculture that comes with using underutilized fruit like the Palmyra fruit. According to Kumar et al. (2021), they believe to use native fruits that have contributed to cutting down on food waste, increasing the species richness, and supporting the economy of the rural society. Furthermore, the procurement of ingredients including but not limited to Palmyra pulp locally may also be effective in an attempt to minimize transportation GHG emissions in food manufacturing (Vecchio et al., 2023). The market segment that utilizes gluten-free products has had significant advancement in the recent past with scientist looking for the best materials to incorporate in the product. Already, in Arendt et al. (2023), it was demonstrated that by incorporating natural binders from fruit pulps, the textural quality of GF baked products can be enhanced. Palmyra pulp contains some features such as polysaccharides and pectin, which are good to enhance the characteristics, such as texture and elasticity of gluten-free based products. It has also applied or incorporates the concept in coming up with marketing strategies and campaigns too. According to Vecchio et al. (2023), consumers are more attracted if the gluten free products have labels that read “natural” or “local” and “organic”. Micro-growths such as showing creativity, value addition, use of locally sourced raw material such as the Palmyra pulp make it possible for food manufacturers to set a record against their competitors in the market.

III. METHODOLOGY

The research design for this study is the developmental design combined with the descriptive design research design. The experimental phase centralizes on the enhancement and stabilization of the macaroons by trial and error on the formulation of the pulp of Palmyra (Borassus flabellifer) fruit, and performed various tests in the laboratory to identify the nutritional values of the macaroons. The descriptive phase is a sensory analysis whereby the panel of consumers gives the baked goods a taste, texture, aroma and color-coded score. Nutritional profile and sensory evaluation ratings will be analyzed using appropriate statistical tools for quantitative analysis and the qualitative consumer feedback will be useful in supplementing the quantitative results. This design is all-encompassing to guarantee consumers’ acceptability and nutrition density of the end product as required by the study. The food development was conducted in food laboratory. Data were gathered from 20 food experts and 100 consumers using 9-point Hedonic Scale. Mean and Standard Deviation were used to determine the acceptability of the Gluten-Free Macaroons using Palmyra Fruit in terms of appearance, aroma, flavor/taste, and texture. Multivariate Analysis of Variance (MANOVA) for Repeated Measures and Bonferroni’s Tes were used to compare the three formulations of Gluten-Free Macaroons using Palmyra Fruit in terms of the four sensory attributes: appearance, aroma, taste, and texture.

IV. RESULTS AND DISCUSSION

Table 1 presents the sensory evaluation results on the acceptability of appearance of gluten-free macaroons using Palmyra fruit across three different formulations: A, B, and C. Each formulation was assessed by participants based on five specific appearance-related statements, and the responses were measured using a 9-point hedonic scale.

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TABLE 1
ACCEPTABILITY OF APPEARANCE OF GLUTEN-FREE MACAROONS USING PALMYRA (*Borassus flabellifer*) FRUIT

Statement	Formulation A			Formulation B			Formulation C		
	M	SD	*D*	M	SD	*D*	M	SD	*D*
1. The color of the product looks appealing.	7.82	0.63	***LVM***	7.65	0.62	***LVM***	7.73	0.66	***LVM***
2. The color is vibrant and fresh.	7.63	0.93	***LVM***	7.53	1.62	***LVM***	7.57	0.93	***LVM***
3. The product's color is consistent and uniform.	7.48	0.92	***LM***	7.30	2.62	***LM***	7.41	0.78	***LM***
4. The color of the product is suitable for its type.	7.87	0.59	***LVM***	7.57	3.62	***LVM***	7.56	0.65	***LVM***
5. The product's color matches my expectations for this type of product.	7.95	1.11	***LVM***	7.31	4.62	***LM***	7.21	1.07	***LM***
Average	7.75	0.49	***LVM***	7.47	5.62	***LM***	7.50	0.53	***LM***

For Formulation A, the overall average score for appearance was 7.75, with a descriptive rating of Like Very Much (LVM). Among the items evaluated, the statement "The product's color matches my expectations for this type of product" received the highest mean score of 7.95, indicating strong alignment with consumer expectations. Meanwhile, the lowest mean score of 7.48 was observed in the item "The product's color is consistent and uniform," though this still reflects a positive evaluation with a Like Moderately (LM) rating. The results suggest that Formulation A was favorably rated in terms of its overall visual appeal, especially in meeting consumer expectations and suitability of color. In Formulation B, the average appearance rating was 7.47, described as Like Moderately (LM). The highest mean was 7.65, given to "The color of the product looks appealing," while the lowest was 7.30 for "The product's color is consistent and uniform." Despite some variation in standard deviations, all appearance indicators still fell within the moderately to very much liked range, showing generally positive but slightly less enthusiastic responses compared to Formulation A. For Formulation C, the average appearance score was 7.50, also rated as Like Moderately (LM). The item with the highest mean was "The color of the product looks appealing" at 7.73, indicating favorable visual attractiveness. The lowest score was 7.21, given to "The product's color matches my expectations for this type of product." Overall, Formulation C garnered consistent and favorable responses, similar in trend to Formulation B, but with slightly higher uniformity in standard deviations.

Table 2 displays the evaluation results on the acceptability of aroma of the gluten-free macaroons developed using Palmyra fruit, categorized across Formulations A, B, and C.

TABLE 2
ACCEPTABILITY OF AROMA OF GLUTEN-FREE MACAROONS USING PALMYRA (*Borassus flabellifer*) FRUIT

Statement	Formulation A			Formulation B			Formulation C		
	M	SD	*D*	M	SD	*D*	M	SD	*D*
1. The product has an appealing odor.	7.58	1.29	***LVM***	6.18	1.64	***LS***	5.75	1.39	***LS***
2. The product's odor is pleasant and not overpowering.	7.09	1.31	***LM***	6.16	1.62	***LS***	5.62	1.35	***LS***
3. The product has a natural odor.	7.21	1.30	***LM***	6.02	1.55	***LS***	5.72	1.26	***LS***
4. The odor of the product is pleasant enough to encourage	7.03	1.21	***LM***	5.96	1.63	***LS***	5.39	1.32	***NLND***

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consumption.

5. The product's odor is consistent with its intended flavor.	7.17	1.04	***LM***	5.92	1.33	***LS***	5.68	0.96	***LS***
Average	7.21	1.02	***LM***	6.05	1.30	***LS***	5.63	0.99	***LS***

In Formulation A, the overall aroma acceptability received an average score of 7.21, corresponding to a rating of Like Moderately (LM). The highest mean score was 7.58 for the statement "The product has an appealing odor," suggesting that the initial smell of the product was well appreciated by the panelists. The lowest score, 7.03, was given to "The odor of the product is pleasant enough to encourage consumption," though this still reflected a moderately positive impression. These results indicate that Formulation A was perceived as aromatic and pleasant overall, with a natural and appealing scent profile. Formulation B, on the other hand, showed a noticeable decline in aroma ratings, with an average mean of 6.05, interpreted as Like Slightly (LS). The highest mean score was 6.18, assigned to "The product has an appealing odor," while the lowest was 5.92 for "The product's odor is consistent with its intended flavor." These results reflect a general sense of mild appreciation from the panelists, with the aroma being considered acceptable but less compelling than Formulation A. For Formulation C, the aroma acceptability scored the lowest among the three, with an average mean of 5.63, also rated as Like Slightly (LS). The statement with the highest rating was again "The product has an appealing odor," but it only reached 5.75. The lowest score of 5.39 was noted for "The odor of the product is pleasant enough to encourage consumption," which fell into the Neither Like Nor Dislike (NLND) category. This suggests that Formulation C's aroma was the least appreciated and may not have sufficiently appealed to the participants to stimulate interest in consumption.

Table 3 illustrates the sensory evaluation results on the acceptability of taste of the gluten-free macaroons formulated with Palmyra fruit.

TABLE 3
THE ACCEPTABILITY OF TASTE OF GLUTEN-FREE MACAROONS USING PALMYRA (*Borassus flabellifer*) FRUIT

Statement	Formulation A			Formulation B			Formulation C		
	M	**SD**	***D***	**M**	**SD**	***D***	**M**	**SD**	***D***
1. The taste of the product is enjoyable.	7.96	0.61	***LVM***	2.26	1.28	***DVM***	4.88	1.63	***NLND***
2. The product has a balanced taste.	7.81	0.94	***LVM***	2.39	1.11	***DVM***	4.66	1.70	***NLND***
3. The taste of the product is unique and refreshing.	7.65	0.93	***LVM***	2.18	1.26	***DVM***	4.70	1.70	***NLND***
4. The product has the right level of sweetness or saltiness.	8.02	0.59	***LVM***	2.35	1.29	***DVM***	4.73	1.65	***NLND***
5. The aftertaste of the product is pleasant.	8.29	0.96	***LVM***	2.56	1.29	***DM***	5.04	1.77	***NLND***
Average	7.95	0.52	***LVM***	2.35	1.11	***DVM***	4.80	1.58	***NLND***

Formulation A received the highest overall average rating of 7.95, interpreted as Like Very Much (LVM), demonstrating a strong preference for its taste. The highest mean score among the items was 8.29 for "The aftertaste of the product is pleasant," indicating that not only was the initial flavor well-received but it also left a favorable lingering impression. The lowest mean, still high at 7.65, was found in "The taste of the product is unique and refreshing," suggesting that uniqueness was appreciated, though slightly less than other taste factors. These scores reflect that

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Formulation A was overwhelmingly well-liked in terms of taste, from its balance and sweetness to its aftertaste. By contrast, Formulation B scored significantly lower, with an average mean of 2.35, corresponding to Dislike Very Much (DVM). All five taste indicators were rated poorly, with the lowest mean of 2.18 given to "The taste of the product is unique and refreshing," and the highest mean, 2.56, given to "The aftertaste of the product is pleasant." This indicates strong dissatisfaction with the overall flavor profile of Formulation B, with participants expressing notable dislike across all taste dimensions. Formulation C performed moderately, receiving an overall average score of 4.80, which falls into the category of Neither Like Nor Dislike (NLND). The highest mean score was 5.04 for "The aftertaste of the product is pleasant," suggesting some mild favorability in how the taste lingers. The lowest mean, 4.66, was recorded for "The product has a balanced taste." These scores reflect a neutral reception from participants, with the flavor neither evoking strong approval nor aversion.

Table 4 presents the results of the sensory evaluation on the acceptability of texture for gluten-free macaroons made with Palmyra fruit, comparing Formulations A, B, and C.

TABLE 4
ACCEPTABILITY OF TEXTURE OF GLUTEN-FREE MACAROONS USING PALMYRA (*Borassus flabellifer*) FRUIT

Statement	Formulation A			Formulation B			Formulation C		
	M	**SD**	***D***	**M**	**SD**	***D***	**M**	**SD**	***D***
1. The texture of the product is smooth and pleasant.	7.62	0.97	***LVM***	6.52	1.48	***LM***	5.86	1.47	***LS***
2. The product has the right amount of crunch or softness.	7.43	0.99	***LM***	6.18	1.76	***LS***	5.63	1.86	***LS***
3. The texture is consistent throughout the product.	7.07	0.86	***LM***	5.78	1.57	***LS***	5.53	1.53	***LS***
4. The texture makes the product enjoyable to eat.	7.56	0.74	***LVM***	5.75	1.54	***LS***	5.42	1.57	***NLND***
5. The texture is suitable for the type of product.	7.61	1.09	***LVM***	5.93	1.55	***LS***	5.63	1.53	***LS***
Average	7.46	0.62	***LM***	6.03	1.26	***LS***	5.61	1.35	***LS***

Formulation A received the highest overall average texture rating of 7.46, corresponding to Like Moderately (LM). Among the individual items, the highest mean score was 7.62 for the statement "The texture of the product is smooth and pleasant," suggesting that panelists found the mouthfeel appealing. The lowest score, though still positive, was 7.07 for "The texture is consistent throughout the product," indicating a slightly lesser but still favorable impression. Overall, Formulation A was perceived as enjoyable to eat, with a smooth, consistent, and appropriate texture for the type of product. For Formulation B, the average score for texture was 6.03, which corresponds to Like Slightly (LS). The item with the highest mean was 6.52 for "The texture of the product is smooth and pleasant," while the lowest was 5.75 for "The texture makes the product enjoyable to eat." These results show a moderate level of acceptability, with some attributes leaning closer to the neutral range. Although the texture was not disliked, it did not generate strong positive reactions either, suggesting that improvements could be made to enhance overall tactile satisfaction. Formulation C received the lowest average score of 5.61, still falling within the Like Slightly (LS) range. The highest mean, 5.86, was recorded for "The texture of the product is smooth and pleasant," while the lowest was 5.42 for "The texture makes the product enjoyable to eat," which dipped into the Neither Like nor Dislike (NLND) category. These scores indicate a fairly neutral reception, with panelists finding the texture acceptable but not particularly noteworthy.

Tables 5 and 6 collectively present the results of the inferential analysis on the sensory acceptability of gluten-free macaroons made with Palmyra fruit, focusing on whether significant differences exist among the three formulations (A, B, and C) in terms of appearance, aroma, taste, and texture.

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TABLE 5
SIGNIFICANT DIFFERENCE ON THE ACCEPTABILITY OF THE SENSORY ATTRIBUTES OF THE THREE FORMULATIONS OF P GLUTEN-FREE MACAROONS USING PALMYRA (*Borassus flabellifer*) FRUIT

Attribute	F	p	Decision on Ho	Interpretation
Appearance	11.09	<0.01	Rejected	Significant
Aroma	79.44	<0.01	Rejected	Significant
Taste	730.17	<0.01	Rejected	Significant
Texture	94.12	<0.01	Rejected	Significant

Wilks' Lambda Λ= 0.079, F=149.81, p<0.01

Table 5 summarizes the results of the multivariate analysis of variance (MANOVA), which tested for overall differences in the four sensory attributes across the three formulations. The Wilks' Lambda value of 0.079, with an associated F-value of 149.81 and a p-value less than 0.01, indicates a highly significant multivariate effect. This means that, collectively, the sensory attributes vary significantly among the formulations. When broken down by individual attribute, all four—appearance (F = 11.09), aroma (F = 79.44), taste (F = 730.17), and texture (F = 94.12)—also show significant differences ($p < 0.01$) across formulations. The null hypotheses for all sensory attributes were therefore rejected, confirming that the macaroons' formulations had a statistically significant impact on how each sensory characteristic was perceived by the evaluators.

Table 6 further explores these significant differences through pairwise comparisons between the means of each formulation per sensory attribute. For appearance, Formulation A (M = 7.75) was significantly different from both B (M = 7.47) and C (M = 7.5), but there was no significant difference between B and C, as shown by a p-value of 1.000. In terms of aroma, significant differences were observed across all pairs, with Formulation A again having the highest mean (M = 7.21), followed by B (M = 6.05), and C (M = 5.63). Similar trends are seen in taste, where all comparisons were significant, with Formulation A (M = 7.95) outperforming B (M = 2.35) and C (M = 4.80), while B and C also significantly differed from each other. Lastly, for texture, all pairs differed significantly as well, including the B–C comparison (p = .041), which, although less strong than the others, still indicates a meaningful distinction. Taken together, these two tables strongly support the conclusion that Formulation A was significantly superior in all sensory dimensions compared to B and C. The statistical results validate the earlier descriptive findings and confirm that formulation changes substantially affect consumer perception of product quality.

TABLE 6
PAIRWISE COMPARISONS ON SENSORY ATTRIBUTES OF GLUTEN-FREE MACAROONS USING PALMYRA
(*Borassus flabellifer*) FRUIT IN THREE FORMULATIONS

Attribute	Formulation (Mean)		p	Decision on Ho	Interpretation
Appearance	A (M=7.75)	B (M=7.47)	<0.01	Rejected	Significant
	A (M=7.75)	C (M=7.5)	<0.01	Rejected	Significant
	B (M=7.47)	C (M=7.5)	1.000	Not Rejected	Not Significant
Aroma	A (M=7.21)	B (M=6.05)	<0.01	Rejected	Significant
	A (M=7.21)	C (M=5.63)	<0.01	Rejected	Significant
	B (M=6.05)	C (M=5.63)	<0.01	Rejected	Significant
Taste	A (M=7.95)	B (M=2.35)	<0.01	Rejected	Significant
	A (M=7.95)	C (M=4.8)	<0.01	Rejected	Significant
	B (M=2.35)	C (M=4.8)	<0.01	Rejected	Significant
Texture	A (M=7.46)	B (M=6.03)	<0.01	Rejected	Significant

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A (M=7.46)	C (M=5.61)	<0.01	Rejected	Significant
B (M=6.03)	C (M=5.61)	.041	Rejected	Significant

Table 7 presents the results of the physicochemical composition analysis of the most acceptable product—Formulation A of the blue gluten-free macaroons using Palmyra fruit.

TABLE 7
PHYSICOCHEMICAL PARAMETERS OF FORMULATION "A" OF GLUTEN-FREE MACAROONS USING PALMYRA (*Borassus flabellifer*) FRUIT

Analysis	Unit	Results
Total Fat	g/100g	13.9
Crude Protein (N × 6.25)	g/100g	5.88
ᵠTotal Sugar	g/100g	6.24

The analysis reveals that Formulation A contains 13.9 g of total fat per 100 g, indicating a moderate fat content, which likely contributes to its rich texture and mouthfeel. The crude protein content was found to be 5.88 g/100 g, providing a modest amount of protein that enhances the nutritional value of the product. Meanwhile, the total sugar content was 6.24 g/100 g, which suggests that the product has a balanced sweetness—aligning with the sensory evaluation results where sweetness was perceived as appropriate and enjoyable. These values support the acceptability of Formulation A not only in sensory terms but also in terms of its nutritional appeal, making it a promising option for consumers seeking gluten-free snack alternatives with decent nutritional content.

V. CONCLUSION

Among the three formulations, Formulation A was concluded to be the most sensorially acceptable in terms of appearance, aroma, taste, texture, and overall appeal, making it the best candidate for further development and potential commercialization. The results show that Formulation A is most preferred by the participants. The most preferred formulation (Formulation A) meets desirable nutritional standards with moderate fat, protein, and sugar content, contributing to both its sensory appeal and potential health value as a gluten-free snack option.

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