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EXPLORING THE SUITABILITY OF MORINGA *(Moringa Oleifera)* AND JUTE *(Corchorus Olitorius)* LEAVES AS NUTRITIONAL ENHANCEMENTS IN BAKED PRODUCTS

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ABSTRACT

This study investigated the process, acceptability, and shelf life of baked products enriched with Moringa *(Malunggay)* and Jute *(Saluyot)* leaves. The process involved harvesting, washing, sun-drying, grinding, and storing the leaves, followed by incorporating them into buns, muffins, and cookies. Each baked product underwent specific preparation stages, including measurement of ingredients, sifting, mixing, baking, cooling, and packing. Consumer perception was assessed through a 9-point Likert scale, revealing that the enriched baked products were *"liked extremely"* for their appearance/color, aroma, taste, and texture. This positive perception was consistent across different age groups, including children, teenagers, adults, and food experts. Moreover, the shelf life of the products at room temperature varied, with buns lasting four days, muffins for ten days, and cookies for two to three weeks. These findings highlight the feasibility of incorporating Moringa and Jute leaves into baked products, not only enhancing their nutritional profile but also ensuring high acceptability among consumers.

Keywords: *Enriched baked products, moringa, jute, acceptability, shelf-life*

INTRODUCTION

In recent years, there has been a growing interest in the utilization of natural ingredients to enhance the nutritional value of baked products. With increasing concerns

about health and wellness, consumers are seeking healthier alternatives without compromising taste and texture. This has prompted researchers and food scientists to explore unconventional ingredients that offer both nutritional benefits and culinary appeal. In this regard, Moringa and Jute leaves have emerged as promising candidates due to their rich nutrient profiles and versatility in culinary applications

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Moringa (called “*Malunggay*” in the Philippines), also known as the "miracle tree" or "drumstick tree," is native to the Indian subcontinent but is now cultivated in various tropical and subtropical regions worldwide. It is renowned for its exceptional nutritional content, being a rich source of vitamins, minerals, antioxidants, and essential amino acids. Moringa leaves contain high levels of vitamin C, vitamin A, calcium, potassium, and iron, among other nutrients (Anwar, et.al, 2007). Additionally, Moringa is recognized for its potential health benefits, including anti-inflammatory, antioxidant, and antimicrobial properties (Leone, et.al, 2015). Its leaves have been traditionally used in herbal medicine and culinary practices for centuries.

Jute, with its local name *Saluyot*, on the other hand, is primarily known for its fibrous nature and extensive use in textile production. However, the leaves of the jute plant (Corchorus species) are also edible and possess noteworthy nutritional attributes. Jute leaves are a good source of vitamins A, C, and E, as well as minerals such as calcium, iron, and magnesium (Amin, & Hussain, 2013). Furthermore, they contain phytochemicals like flavonoids and phenolic compounds, which contribute to their antioxidant properties (Deng, et. al. 2016). Despite being less commonly consumed than Moringa, jute leaves have traditionally been used in cuisines across Asia and Africa, particularly in soups, stews, and salads.

While both Moringa and Jute leaves have been incorporated into various culinary dishes, their potential application as enrichment ingredients in baked products such as buns, muffins, and cookies remains relatively unexplored. Baked goods represent a popular and convenient food category consumed worldwide, offering ample opportunities for nutritional enhancement through ingredient innovation. By incorporating Moringa and Jute leaves into baked formulations, it may be possible to elevate the nutritional profile of these products while introducing unique flavors and colors.

The utilization of Moringa and Jute leaves in baked goods aligns with the current consumer trends favoring natural, plant-based ingredients and functional foods. Moreover, it presents an opportunity to promote sustainable agriculture, as both Moringa and Jute are fast-growing, drought-resistant crops that thrive in diverse agroecological settings. Harnessing these underutilized leaves for culinary purposes not only adds value to the plants but also contributes to biodiversity conservation and economic empowerment, particularly in rural communities where they are cultivated.

Hence, this research aimed to explore the potential use or acceptability of Moringa and Jute leaves as enrichment ingredients for baked products, focusing on their nutritional properties, sensory attributes, and technological implications. By investigating the feasibility and acceptability of incorporating these leaves into various baked formulations,

it seeks to provide insights into the development of healthier and more sustainable bakery products that cater to evolving consumer preferences and dietary needs.

Research Questions

This study aimed to determine the acceptability of Moringa and Jute leaves as enrichment for baked products (*Buns, Muffins, and Cookies*) to meet consumers' satisfaction and provide them with nutritious food.

Specifically, this study sought to answer the following questions:

1. What are the processes involved in developing baked products enriched with Moringa (*Moringa Oleifera)* and Jute leaves (*Corchorus Olitorios*) such as buns, muffins, and cookies?
2. What is the level of acceptability of the baked products enriched with Moringa and Jute leaves in terms of:
   a. appearance/color
   b. aroma
   c. taste; and
   d. texture
3. What is the general level of acceptability of the baked products enriched with Moringa and Jute leaves as evaluated by the following groups of respondents
   a. children;
   b. teenagers;
   c. adults, and
   d. food experts
4. What is the shelf-life of the enriched foods products at normal temperature?

METHODOLOGY

This study utilized the survey type of research to determine the level of acceptability of Moringa and Jute leaves as enrichment for baked products, namely *buns, muffins, and cookies* in terms of appearance/color, aroma, taste, and texture. The general acceptability of the enriched products was assessed by groups of respondents: children, teenagers, adults, and food experts. Direct observation of the baked products was conducted to determine their shelf-life.

Materials Used in the Preparation of the Products

mixing bowl	baking sheets	oven
kneading dough	pastry brush	muffin tin
mixing batter	non-stick spray	cookie sheets
stand mixer	ice cream scoop	parchment paper
mixing spoon	silicone baking mats	
dough scraper	cooling rack	

Ingredients

Table 1. Ingredients used in the original recipe and enriched recipe with moringa and jute leaves

Original Recipe	Enriched with Moringa and Jute Leaves
BUNS ***Ingredients:*** 1 ¾ C Bread Flour 1 tsp Yeast ¼ C Sugar 1pc. Egg ½ C Water 2 tsp+2tsp Shortening	**BUNS** ***Ingredients:*** 1 ¾ C Bread Flour 1 tsp Yeast ¼ C Sugar 1pc. Egg ½ C Water 2 tsp+2tsp Shortening 1tsp. Malunggay powder 1 tsp. Saluyot powder
MUFFIN ***Ingredients***: 100 grams Butter ½ C Sugar 2 pcs. Egg 1 C All-purpose Flour ½ C Condense 1 tsp. Baking powder	***MUFFIN*** ***Ingredients***: 100 grams Butter ½ C Sugar 2 pcs. Egg 1 C All-purpose Flour ½ C Condense 1 tsp. Baking powder 1tsp. Malunggay powder 1 tsp. Saluyot powder
COOKIES ***Ingredients:*** ¾ bar Butter 100g Powdered Sugar 1pc. Egg ¼ kl. Cake Flour 1 tsp. Vanilla	***COOKIES*** ***Ingredients:*** ¾ bar Butter 100g Powdered Sugar 1pc. Egg 125g Cake Flour 1 tsp. Vanilla 1tsp. Malunggay powder 1 tsp. Saluyot powder

Developmental Procedure

The developmental procedure for baking began with the gathering and preparation of all necessary materials. This includes ensuring that ingredients were properly sifted, measured, and, if needed, creamed or beaten to achieve the desired consistency. Once the major ingredients were adequately prepared, they were mixed to form a dough. Next,

the prepared mixture was poured into designated molds or tins, ready for the baking process. The filled molds were then placed into the oven and baked at the appropriate temperature until they reached the desired level of doneness. After the baking process was complete, the freshly baked goods were removed from the oven and allowed to cool completely. This step ensured that the texture and flavor of the baked items were fully developed. Finally, once cooled, the baked goods were carefully packed and stored, ready to be enjoyed or distributed as desired.

Data Gathering Procedure

Permission was sought to conduct a study involving evaluation, with respondents comprising children, teenagers, adults, and experts. Once permission was granted, the administration of questionnaires commenced. The researcher personally discussed instructions for completing the questionnaires with the evaluators. Copies of the questionnaire checklist were collected after respondents had completed them.

The study utilized sensory evaluation via a questionnaire checklist to gather information on the acceptability of buns, muffins, and cookies containing *malunggay* and *saluyot* as the primary ingredients. Additionally, the observation method was employed to assess changes in the baked products concerning color, appearance, texture, taste, and aroma. This comprehensive approach allowed for a thorough examination of the products' sensory attributes and overall acceptability among different age groups and expertise levels.

Respondents of the Study

The finished products were subjected to sensory evaluation by eighty (80) evaluators from varied age groups such as children (20), teenagers (20), adults (20), and food experts (20). They were selected bakery owners/bakers, children, and adults in Ilagan North, the City of Ilagan, students and faculty of Manaring Integrated School, and Food Technology Teachers of Ilagan North District in the City Division. The researcher chose respondents at random from among children, teenagers, and adults.

Sensory Evaluation

The selected respondents were instructed on how to evaluate the products utilizing evaluation instruments. The study was conducted in the second semester of School Year 2022-2023. The flavored baked products (*buns, muffins, and cookies)* with Moringa (*Malunggay)* and Jute (*Saluyot)* as the main ingredients. Each respondent was asked to taste the samples of each product. Data on the appearance/color, aroma, taste, and texture of each product were collected and subjected to statistical analysis. The evaluation was conducted through an evaluation card, using a quantitative analysis method to determine the acceptability of the product.

The level of acceptability of baked products (Buns, Muffins, and Cookies) with *Malunggay* and *Saluyot* as main ingredients in terms of appearance/color, aroma, taste, and texture was assessed using hedonic nine-point Likert's scale as follows:

Means/ Range	Qualitative Description
9	Like Extremely (LE)
8	Like very much (LVM)
7	Like moderately (LM)
6	Like slightly (LS)
5	Neither like nor dislike (NL)
4	Dislike slightly (DS)
3	Dislike moderately (DM)
2	Dislike very much (DVM)
1	Dislike extremely (DE)

RESULTS AND DISCUSSION

Product Development

The process of preparing buns, muffins, and cookies enriched with Moringa and Jute leaves involved distinct steps tailored to each baked good.

For the Moringa and Jute leaves, the process began with harvesting, followed by washing, drying (typically through sun drying), grinding the dried leaves into a fine powder, and finally storing the pulverized leaves for use in the recipes.

The buns recipe underwent several stages, including the measurement of ingredients, sifting, mixing, fermentation to allow the dough to rise, panning (shaping the dough into individual buns), baking, cooling, and packing for storage or distribution.

Similarly, the muffin recipe started with measuring the ingredients, followed by sifting, mixing the batter, portioning it into muffin tins, baking, allowing the muffins to cool, and finally packing them for later consumption.

As for the cookie recipe, it commenced with measuring the ingredients, sifting dry ingredients, creaming butter and sugar together, mixing in other ingredients, portioning the dough onto baking sheets, baking the cookies, letting them cool, and then packing them.

Each recipe's unique process ensures the optimal incorporation of Moringa and Jute leaves while maintaining the desired texture, flavor, and appearance of the final baked goods.

Figure 1. The researcher mixes butter and sugar as a procedure for making muffins enriched with Moringa and Jute leaves

Figure 2. The finished products (Buns, Muffins, and Cookies) enriched with Moringa and Jute leaves

Level of Acceptability of the Baked Products Enriched with Moringa and Jute Leaves

Table 2 presents the level of acceptability of baked products enriched with Moringa and Jute leaves as assessed by participants in terms of appearance/color, aroma, taste, and texture across three types of baked goods: buns, muffins, and cookies.

For buns, the respondents rated the appearance/color of the buns highly, with a mean score of 8.34, indicating they liked it extremely. Similarly, the aroma of the buns received a high rating with a mean of 8.20, indicating strong preference. The taste of the buns was also well-liked, with a mean of 8.29. Also, the texture was rated positively as well, with a mean of 8.25. The overall mean score for buns was 8.27, suggesting a high level of acceptability across all criteria.

This finding is similar to that of Pajarillo (2021) who assessed the level of acceptability of corn and banana flour Nutri-bun. The Nutri-bun was tested in terms of appearance/color, aroma, and texture. Results showed no significant difference in the level of acceptability of corn and banana flour Nutri-bun as evaluated by the respondents.

Table 2. Level of acceptability of the baked products enriched with Moringa and Jute leaves in terms of appearance/color, aroma, taste, and texture

BUNS			
Evaluation Criteria	**Mean**	**Sd**	**Description**
Appearance/Color	8.34	0.7310	Like Extremely
Aroma	8.20	0.8194	Like Extremely
Taste	8.29	0.8120	Like Extremely
Texture	8.25	0.8423	Like Extremely
Overall Mean	**8.27**		**Like Extremely**
MUFFINS			
Evaluation Criteria	**Mean**	**Sd**	**Description**
Appearance/Color	8.70	0.5059	Like Extremely
Aroma	8.69	0.5190	Like Extremely
Taste	8.73	0.4246	Like Extremely
Texture	8.70	0.4654	Like Extremely
Overall Mean	**8.71**		**Like Extremely**
COOKIES			
Evaluation Criteria	**Mean**	**Sd**	**Description**
Appearance/Color	8.57	0.5537	Like Extremely
Aroma	8.61	0.5892	Like Extremely
Taste	8.67	0.5210	Like Extremely
Texture	8.67	0.5613	Like Extremely
Overall Mean	**8.63**		**Like Extremely**

Muffins scored slightly higher for appearance/color compared to buns, with a mean of 8.70. The aroma of the muffins received a similar high rating of 8.69. Likewise, the

muffins had a mean taste score of 8.73, indicating participants liked the taste very much. In terms of texture, it was also well-received with a mean of 8.71. With an overall mean of 8,71, muffins were the highest among all products at 8.71, indicating strong acceptance across all criteria.

Similarly, Soberano, et. al. (2022) conducted a study titled "Sensory Evaluation of Herbs Flavored Muffin Using Banana Blossom 'Saba' (Musa acuminata x balbasiana) Flour," which demonstrated noteworthy results. Their research revealed that homemade muffins infused with various herbal flavors, including banana blossom, oregano, and *sambong*, received consistently high ratings of "like very much" across multiple sensory dimensions such as appearance, color, aroma, and texture. These findings underscore the positive reception and potential enhancement of muffin sensory experiences through the incorporation of unique herbal ingredients.

Cookies received a mean score of 8.57 for appearance/color, indicating strong liking. Similarly, aroma scored slightly higher for cookies with a mean of 8.61. The taste was highly rated for cookies, with a mean score of 8.67. In like manner, the texture of cookies received a mean score of 8.67, similar to taste. The overall mean score for cookies was 8.63, indicating high acceptability across all criteria.

The data show that the level of acceptability of the baked products enhanced with Moringa and Jute leaves was extremely acceptable. This means that the participants generally liked the appearance/color, aroma, taste, and texture of the baked products. However, muffins received the highest overall mean score suggesting that they were the most preferred among the three types of baked products enhanced with Moringa and Jute leaves.

General Level of Acceptability of the Baked Products Enriched with Moringa and Jute Leaves as Evaluated by the Groups of Respondents

Table 3 shows a comprehensive analysis of the general level of acceptability of baked products enriched with Moringa and Jute leaves, as evaluated by different groups of respondents categorized into children, teenagers, adults, and food experts across three types of baked goods: buns, muffins, and cookies.

As for the children, they rated the buns highly, with an overall mean score of 8.36, indicating they liked them extremely. Similarly, the teenagers rated the buns slightly lower compared to children, with an overall mean score of 8.08. As for the adults, they rated the buns positively, with an overall mean score of 8.17, showing a strong liking for the product. Lastly, the food experts rated the buns the highest among all groups, with an overall mean score of 8.48, indicating a very high level of acceptability.

Table 3. The general level of acceptability of the baked products enriched with Moringa and Jute leaves as evaluated by the different groups of respondents

BUNS			
a. Children	**Mean**	**Sd**	**Description**
Appearance/Color	8.52	0.7982	Like Extremely
Aroma	8.23	0.8990	Like Extremely
Taste	8.35	0.6257	Like Extremely
Texture	8.33	1.0596	Like Extremely
Overall Mean	**8.36**		**Like Extremely**
b. Teenagers	**Mean**	**Sd**	**Description**
Appearance/Color	8.07	0.7461	Like Very Much
Aroma	7.97	0.6916	Like Very Much
Taste	8.15	0.9519	Like Extremely
Texture	8.12	0.7114	Like Extremely
Overall Mean	**8.08**		
c. Adult	**Mean**	**Sd**	**Description**
Appearance/Color	8.18	0.7530	Like Extremely
Aroma	8.12	0.9258	Like Extremely
Taste	8.23	1.0151	Like Extremely
Texture	8.13	0.9219	Like Extremely
Overall Mean	**8.17**		**Like Extremely**
d. Food Experts	**Mean**	**Sd**	**Description**
Appearance/Color	8.60	0.5026	Like Extremely
Aroma	8.47	0.7125	Like Extremely
Taste	8.43	0.6031	Like Extremely
Texture	8.43	0.6315	Like Extremely
Overall Mean	**8.48**		**Like Extremely**
MUFFINS			
a. Children	**Mean**	**Sd**	**Description**
Appearance/Color	8.90	0.2671	Like Extremely
Aroma	8.92	0.2388	Like Extremely
Taste	8.78	0.3111	Like Extremely
Texture	8.78	0.3789	Like Extremely
Overall Mean	**8.85**		**Like Extremely**
b. Teenagers	**Mean**	**Sd**	**Description**
Appearance/Color	8.52	0.5459	Like Extremely
Aroma	8.45	0.6603	Like Extremely
Taste	8.60	0.5253	Like Extremely
Texture	8.63	0.5153	Like Extremely
Overall Mean	**8.55**		**Like Extremely**
c. Adult	**Mean**	**Sd**	**Description**
Appearance/Color	8.56	0.6863	Like Extremely

Aroma	8.53	0.6060	Like Extremely
Taste	8.60	0.5141	Like Extremely
Texture	8.50	0.5567	Like Extremely
Overall Mean	**8.55**		**Like Extremely**
d. Food Experts	**Mean**	**Sd**	**Description**
Appearance/Color	8.85	0.3148	Like Extremely
Aroma	8.87	0.2942	Like Extremely
Taste	8.93	0.1744	Like Extremely
Texture	8.90	0.2671	Like Extremely
Overall Mean	**8.89**		**Like Extremely**
COOKIES			
a. Children	**Mean**	**Sd**	**Description**
Appearance/Color	8.82	0.3329	Like Extremely
Aroma	8.77	0.4968	Like Extremely
Taste	8.80	0.2736	Like Extremely
Texture	8.88	0.3111	Like Extremely
Overall Mean	**8.82**		**Like Extremely**
b. Teenagers	**Mean**	**Sd**	**Description**
Appearnce/Color	8.23	0.6848	Like Extremely
Aroma	8.40	0.7843	Like Extremely
Taste	8.40	0.7059	Like Extremely
Texture	8.47	0.7446	Like Extremely
Overall Mean	**8.38**		**Like Extremely**
c. Adult	**Mean**	**Sd**	**Description**
Appearance/Color	8.35	0.5459	Like Extremely
Aroma	8.45	0.5851	Like Extremely
Taste	8.55	0.5751	Like Extremely
Texture	8.42	0.6201	Like Extremely
Overall Mean	**8.44**		**Like Extremely**
d. Food Experts	**Mean**	**Sd**	**Description**
Appearance/Color	8.90	0.2190	Like Extremely
Aroma	8.83	0.2962	Like Extremely
Taste	8.93	0.2052	Like Extremely
Texture	8.90	0.2442	Like Extremely
Overall Mean	**8.89**		**Like Extremely**

For the muffins, the children rated the muffins the highest among all groups, with an overall mean score of 8.85, indicating strong preference. Likewise, the teenagers and adults rated the muffins equally, with an overall mean score of 8.55, indicating a high level of acceptability. Moreover, the Food experts rated the muffins very highly, with an overall mean score of 8.89, indicating strong acceptance.

For the cookies, the children rated the cookies highly, with an overall mean score of 8.82, indicating they liked them extremely. The teenagers rated the cookies slightly

lower compared to children, with an overall mean score of 8.38. The adults' ratings for cookies were not provided in the data. The Food experts rated the cookies the highest among all groups, with an overall mean score of 8.89, indicating very high acceptability.

The findings suggest that there were differences in how different age groups perceived the acceptability of the baked products. Children consistently rated all three types of baked goods the highest, followed by adults, teenagers, and then food experts.

In addition, across all age groups, muffins consistently received the highest ratings, followed by cookies and then buns. This indicates that muffins enriched with Moringa and Jute leaves were the most universally accepted among all respondents. Therefore, these findings suggest that incorporating Moringa and Jute leaves into baked products can be particularly appealing to children and generally well-received across different age groups, including teenagers, adults, and even food experts.

Shelf-life of the Enriched Foods Products

After processing the three products, they were stored at room temperature. During the *first* and *second* days of observation, the buns were visually beautiful, perfectly flavored, scented, and had a pleasant texture. Additionally, on the third day, the buns' flavor and aroma were pleasant, but their texture was a little dry. However, the buns began to spoil on the fourth day of observation.

The above result is supported by the findings of Pajarillo (2021). Based on her study titled "Corn and Banana Flour Nutri-Bun", the Nutri-bun products can be stored and best consumed until 4-5 days from the production date.

As to the shelf life of muffins, on their *first* and *second day* and *third day* of observation, the muffins had a perfect taste, and aroma, appealing to the eye, and had a nice texture. On its *fourth* and *fifth days* of observation, the taste and aroma were still good; also, the muffins had a good appearance and texture. Meanwhile, on the sixth day, seventh day, and eighth day, the muffins smelled good, still appealing, and still had a good texture. On its ninth day, the muffins started to dry. Their texture, aroma, and flavor diminished, and their taste became less appealing. And, on the tenth day, the muffins began to spoil.

The result of the study differs from what Pedrosa et.al (2021) found. According to the study of Pedrosa, entitled "Sensory evaluation of herbs flavored muffin using banana blossom "saba", the muffin lasted two to four days when stored at room temperature.

With regard to the cookies' shelf-life observations spanning sixteen days. Initially, from days 1 to 5, the cookies exhibited perfection in taste, aroma, appearance, and texture, followed by consistently good attributes from days 6 to 15, albeit with slight changes noted in appearance and texture by day 16 due to potential moisture loss. Despite these minor alterations, the cookies remained appealing with a good taste and

aroma throughout the observation period, demonstrating a remarkable shelf-life of 2-3 weeks when stored at room temperature.

The result of this study differs from what Saladino (2018) found. According to the study of Saladino, cookie products using different root crops flour stored at a normal temperature would last for five to seven days.

Conclusions

This study concludes that the process of incorporating Moringa and Jute leaves into baked goods involved meticulous steps including harvesting, washing, drying, grinding, and storing. These processes ensure the retention of the nutritional benefits and flavors of the leaves, contributing to the overall quality of the baked product.

The buns, muffins, and cookies enriched with Moringa and Jute leaves were highly favored by respondents in terms of appearance/color, aroma, taste, and texture. This suggests that the incorporation of these leaves not only adds nutritional value but also enhances the sensory attributes of the baked goods, making them appealing to consumers.

The high level of acceptability was consistent across different demographic groups, including children, teenagers, adults, and food experts. This broad appeal shows the potential marketability of these baked products to a diverse range of consumers.

In terms of shelf life, the baked products demonstrated reasonable durability under room temperature conditions. While the buns had a shorter shelf life of four days, the muffins and cookies showed longer shelf lives of ten days and two to three weeks, respectively. This indicates that these products could be stored and distributed efficiently without compromising their quality over time.

Recommendations

Based on the foregoing findings and conclusions, the study forwards these recommendations:

1. Food technology teachers, students, and practitioners are encouraged to develop a wider range of baked products enriched with Moringa and Jute leaves to cater to diverse consumer preferences and dietary needs, such as gluten-free or vegan options.

2. Educators are encouraged to increase consumer awareness about the nutritional benefits of Moringa and Jute leaves and their incorporation into baked goods through educational campaigns and product labeling.

3. Food practitioners and food technology teachers are encouraged to implement quality control measures throughout the production process to ensure consistency in product quality, including ingredient sourcing, processing, and storage.

4. Opportunities to market Moringa and Jute-enriched baked goods to health-conscious consumers, specialty food stores, and online platforms, leveraging their unique nutritional properties and extended shelf-life as selling points should be explored.

5. Collaboration between food scientists, nutritionists, and food manufacturers to continuously innovate and improve Moringa and Jute-enriched baked products, addressing consumer preferences and market demands effectively should be fostered.

6. Additional research to explore different formulations and ratios of Moringa and Jute leaves in baked goods to optimize their sensory attributes, nutritional content, and shelf-life is encouraged.

Compliance with Ethical Standards

The researcher attests to his unwavering commitment to ethical research standards throughout this study. Informed consent was diligently obtained from all participants, ensuring transparency and respect for their autonomy. Participants were assured of their freedom to withdraw from the study at any point, and their anonymity was rigorously maintained to safeguard confidentiality. Measures were implemented to protect participants' well-being, and no conflict of interest influenced the research process. Plagiarism was strictly avoided, and findings were interpreted impartially to prevent bias.

The results are solely intended for advancing knowledge and were obtained with the utmost integrity, adhering to ethical principles for the betterment of research and society.

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