

Exploring Post-Harvest Processing of Tropical Crops: *Moringa oleifera* and *Zea mays* as Alternative Ingredients for Gluten-Free Pasta Production

Imelda A. Leal^{*A}, Grace B. Garlit^A, Lovelyn M. Ramos^A, and Daniel J. Baldoz^A

^ADavao Oriental State University-Banaybanay Extension Campus, Banaybanay, Davao Oriental 8200 Philippines

*Corresponding author; email: imeldaleal68@gmail.com

Abstract

This study examines the potential of *Moringa oleifera* (moringa) and *Zea mays* (corn), two tropical crops, as alternative ingredients for gluten-free pasta, with a focus on their post-harvest processing to enhance their utility in gluten-free pasta production. Moringa leaves were carefully dried and ground into a fine powder, preserving their nutritional content, and incorporated into the dough. Corn kernels were milled into flour and blended with moringa powder, resulting in a smooth texture and mild flavor. These postharvest processing methods ensure that both crops maintain their nutritional value, offering significant potential as gluten substitutes and improving the overall quality of gluten-free products. Sensory assessments were also performed to evaluate the acceptability of the pasta. Raw and cooked pasta samples were presented to 100 respondents from five barangays in Banaybanay, Davao Oriental, Philippines. Feedback was gathered on sensory characteristics, including taste, flavor, aroma, and appearance, providing valuable data on the market acceptability of these tropical crop-based, gluten-free pasta alternatives. The gluten-free pasta received high mean scores for all sensory attributes, indicating strong consumer acceptance. The product exhibits promising market potential in the gluten-free food sector, boasting exceptional ratings for taste, flavor, smell, color, and appearance, as well as a general acceptability score of 8.53. The findings highlight the importance of postharvest processing in maximizing the nutritional benefits of moringa and corn, showcasing their potential as sustainable, nutritious ingredients for gluten-free pasta. This recommendation is based on the exceptional nutritional value, safety, and ability to leverage the rich potential of tropical crops.

Keywords: acceptability assessment, alternative flours, celiac-friendly foods, nutrient-rich substitutes, tropical crop-based pasta

Introduction

In the Philippines, as well as globally, the demand for gluten-free foods has surged in recent years, driven by a growing prevalence of celiac disease, non-celiac gluten sensitivity, and an increasing shift toward gluten-free diets due to perceived health benefits (Makovicky et al., 2020). This demand has led researchers and food manufacturers to explore alternative ingredients to replace gluten in traditional wheat-based products, such as pasta. Among the promising gluten-free substitutes are two widely cultivated tropical crops in the Philippines: *Moringa oleifera* (moringa) and *Zea mays* (corn). Based on studies in Indonesia, including those conducted at IPB University, these crops offer not only nutritional benefits but also functional properties that may contribute to the development of gluten-free pasta products (Herawati et al., 2024a; Herawati et al., 2024b; Yulia and Subekti, 2022).

Moringa oleifera (moringa), commonly known as the “miracle tree,” is a tropical plant that thrives in the Philippines and is celebrated for its high nutritional content, including proteins, vitamins, minerals, and antioxidants. All parts of moringa, particularly the leaves, as well as the pods, bark, roots, seeds, and flowers, are abundant in essential nutrients, including vitamins, minerals, amino acids, antioxidants, and phytochemicals such as flavonoids, glucosinolates, and phenolic acids (Rasmani et al., 2020). These bioactive compounds contribute to a broad spectrum of health benefits, including anti-diabetic, anti-cancer, cardioprotective, anti-inflammatory, antimicrobial, immunomodulatory, anti-venom, and wound-healing properties, making moringa a powerful and versatile plant for promoting overall health and wellness (Zeeshan et al., 2024). Moringa’s potential as a food ingredient is immense due to its bioactive compounds, which have been linked to a range of health benefits, including anti-inflammatory,

antioxidant, and antimicrobial properties (Chhikara et al., 2021). Similarly, *Zea mays* (corn) is another staple crop extensively grown in the Philippines. As a gluten-free alternative, corn provides a valuable source of carbohydrates, proteins, and essential micronutrients, particularly when processed into maize flour (Mir et al., 2019; Ong et al., 2024). Both moringa and corn are not only locally abundant but also offer cost-effective, sustainable solutions to meet the increasing global demand for gluten-free foods, particularly in regions where they are cultivated.

Despite the known nutritional and functional properties of these tropical crops, their application in gluten-free pasta production remains underexplored. Pasta, a staple in many global cuisines, traditionally relies on wheat for its elasticity and texture, which are difficult to replicate in gluten-free formulations (Woomer and Adedeji, 2021). As a result, developing gluten-free pasta with comparable sensory attributes—including taste, texture, and appearance—remains a significant challenge. While previous studies have explored various gluten-free ingredients like rice flour, tapioca, and legume-based flour, these alternatives often fall short in terms of nutritional density and the desired texture (Moonaisur et al., 2024; Pua et al., 2022).

This study aims to address these challenges by investigating the potential of *Moringa oleifera* and *Zea mays* as alternative ingredients to wheat for gluten-free pasta. The research had two main objectives. First, to develop gluten-free pasta using moringa and corn as alternative ingredients to wheat, to evaluate their suitability and potential benefits for gluten-free pasta production. This objective was to explore whether these tropical crops could effectively replace wheat in pasta formulations while retaining their desirable nutritional and functional properties. Second, conduct an acceptability study to assess consumer preferences for the newly developed product. This study focused on sensory attributes, including taste, flavor, texture, and appearance. The outcomes of this research provided valuable insights into the feasibility of using moringa and corn as sustainable, nutritious alternatives in the gluten-free pasta market, addressing both dietary needs and agricultural sustainability.

Materials and Methods

The product examined in this study is gluten-free pasta made from two key ingredients: corn (*Zea mays*) and Moringa (*Moringa oleifera*) leaves. Both ingredients are rich in nutrients and have been traditionally used for their health benefits. The raw materials underwent a detailed crushing, extraction,

and air-drying process to enhance their flavor profiles before being combined and transformed into pasta. This gluten-free pasta offers significant culinary and health potential, as both corn and Moringa are known for their phytochemical compounds that help combat chronic diseases and reduce the risk of ailments such as cervical cancer (Tiloke et al., 2018). Additionally, they offer a rich source of dietary fiber, vitamins, and essential minerals, which makes them beneficial for immune health, skin health, blood pressure regulation, and ulcer healing (Islam et al., 2021).

The raw materials for this pasta include *Moringa oleifera* (malunggay) and *Zea mays* (corn), both of which are abundant in the Philippines. Creating gluten-free pasta requires several essential tools and equipment, including a kneading board, pasta maker, rolling pin, mixing bowl, dough cutter, blender, measuring cups and spoons, and a drying pan. The ingredients used in the pasta formulation was originally developed by the researchers in Davao Oriental State University – Banaybanay Extension Campus during the conduct of this study: 1 cup of 100% corn flour, 1 cup of all-purpose flour, two tablespoons of 100% powdered Moringa for its flavor and nutritional value, two tablespoons of salt for seasoning, two tablespoons of evaporated milk for texture, two whole eggs for binding, one tablespoon of olive oil for flavor, and optionally, one tablespoon of water to adjust dough consistency. These ingredients were carefully combined to create a truly unique and health-conscious pasta product, using 100% corn flour as the sole base and 100% Moringa powder for its full nutritional profile and distinct flavor. This formulation ensures a gluten-free, nutrient-dense alternative to traditional pasta, balancing exceptional taste with enhanced nutritional benefits.

This study employed a quantitative research design, leveraging statistical analysis to transform data into numerical form. This approach enabled a comprehensive exploration of customer preferences regarding food choices, focusing on sensory attributes such as taste, flavor, aroma, color, and appearance. The research was conducted in five barangays within the Municipality of Banaybanay: Barangays Mogbongcogon, Rang-ay, Caganganan, Calubihan, and Poblacion. In the Philippines, a barangay is both a place (similar to a neighborhood or village) and the smallest administrative division, derived from the pre-colonial term “balangay,” referring to a boat used for coastal navigation, and historically served as a small community led by a chief known as the “datu”. Today, the Barangay serves as a key unit of local governance, providing essential services such as healthcare, education, and safety, and is governed by elected officials, including a barangay captain and

councilors who represent the community’s interests. These areas were strategically selected to ensure a diverse and representative sample of respondents.

The primary data collection tool was a questionnaire adapted from the Hedonic Questionnaire, which focused on the sensory attributes of the gluten-free pasta. The questionnaire included questions about the pasta’s taste, flavor, aroma, appearance, and odor. Data was gathered through direct interviews with respondents, ensuring that the necessary permissions were obtained from the parents of child respondents. Table 1 describes the demographic profile of the respondents.

A random sample of 100 participants was selected to ensure the data’s representativeness, with careful attention given to achieving a well-distributed representation across all age groups and genders. Respondents were provided with raw and cooked pasta samples made from moringa and corn, as well as a control sample of a popular commercial pasta brand in the Philippines, which is made from durum wheat semolina. These samples were included for sensory evaluation, ensuring a balanced and diverse comparison for the study. The review focused on key attributes, including taste, flavor, aroma, color, and appearance.

Once the data were collected, the results were visually presented using tables to facilitate understanding and effectively communicate the findings. For data analysis, the research team utilized Kobo Toolbox, a versatile data collection and analysis tool. To ensure the accuracy and reliability of the findings, an expert in the field reviewed and consolidated the data. The research team then interpreted the results, offering insights and conclusions drawn from the data. To better understand consumer preferences and the

acceptability of gluten-free pasta, the ratings provided in the survey were interpreted using a descriptive scale, where higher scores reflected greater levels of acceptability. The scale ranged from 1 to 9, with 9 representing the highest level of acceptance, “Like Extremely.” The other values on the scale corresponded to varying degrees of preference: 8 (“Like Very Much”), indicating a very strong liking for the product, 7 (“Like Moderately”), suggesting a moderate level of preference, 6 (“Like Slightly”), indicating a generally favorable opinion with some reservation, 5 (“Neither Like Nor Dislike”), showing neutrality, 4 (“Dislike Slightly”), reflecting mild dissatisfaction, 3 (“Dislike Moderately”), indicating clear dissatisfaction, 2 (“Dislike Very Much”), suggesting a highly unappealing reaction, and 1 (“Dislike Extremely”), the lowest rating, representing extreme dislike of the product.

Results and Discussion

Postharvest Process of Moringa and Corn into Gluten-Free Pasta

The development of gluten-free pasta using moringa and corn as alternative ingredients to wheat successfully achieved the study’s first objective. This objective aimed to evaluate the suitability and potential benefits of using these tropical crops in pasta production, ensuring that the final product retains desirable nutritional and functional properties. The postharvest process involved carefully drying moringa leaves and grinding them into a fine powder, preserving their nutritional content, which was then incorporated into the pasta dough. Corn kernels were milled into flour and blended with the moringa powder, resulting in a smooth texture and mild flavor. The formulation and process were designed to combine

Table 1. Demographic profile of the respondents

Demographic characteristic	Number of respondents	Percentage (%)
Age		
5-12 years	15	15%
13-20 years	20	20%
21-30 years	20	20%
31-40 years	20	20%
41-50 years	10	10%
51-60 years	10	10%
61-70 years	5	5%
Gender		
Male	47	47%
Female	53	53%

these two ingredients to produce a nutritionally rich pasta, suitable for individuals with gluten intolerance, while maintaining the product's desirable sensory qualities.

The selection of ingredients was critical in achieving a nutritious, flavorful, and functional gluten-free pasta. Corn flour served as the primary base of the pasta, providing a gluten-free alternative to wheat flour. It offered a light texture and mild flavor, which worked well in pasta formulations. Although not gluten-free, all-purpose flour was included to improve the dough's structure and workability. The small quantity used helped enhance the texture of the pasta. Moringa was chosen for its high nutritional value, as it is rich in vitamins, minerals, and antioxidants, which contribute to the overall health benefits of the pasta. In addition, moringa imparted a distinct, slightly earthy flavor to the pasta, complementing the sweetness of the corn flour. Salt enhanced the overall flavor of the pasta and contributed to its preservation and shelf life. Including evaporated milk enriched the texture and taste of the dough, giving it a smooth, slightly creamy consistency. Eggs served as a binding agent, contributing to the dough's cohesiveness and moisture content, which is especially important in gluten-free formulations where gluten typically provides structure. Olive oil was added to enrich the dough's texture and contribute healthy fats, improving the overall mouthfeel of the pasta. Water was used sparingly to adjust the dough's consistency, ensuring it was malleable yet not too sticky, which made it easier to work with during the pasta-making process. Transforming these ingredients into a finished gluten-free pasta product followed a well-defined flow, which included mixing, kneading, and shaping the dough, followed by cooking. The ingredients were carefully combined to form a cohesive dough, which was then kneaded to develop a smooth texture. This step was essential for ensuring the dough had the right consistency for easy shaping and cooking. The dough was rolled into thin sheets and cut into the desired pasta shapes. It was then either cooked immediately or dried for future use. The drying process was carefully monitored to ensure the pasta retained its nutritional properties while achieving the ideal texture upon cooking.

Including moringa and corn flour in the pasta formulation significantly enhanced its nutritional profile. Moringa, renowned for its high content of vitamins A, C, and E, as well as its calcium, iron, and protein, provides a substantial boost to the pasta's health benefits (Fatima et al., 2024; Qadir et al., 2022). Corn flour, on the other hand, contributed essential carbohydrates and fiber, making the pasta suitable for individuals following gluten-free diets without compromising on energy needs (Deepak and

Jayadeep, 2022; Mejía-Terán et al., 2024; Rifky et al., 2024). As shown in Table 2, whole wheat (whole grain) is particularly rich in fiber and protein, making it a valuable source of nutrients for individuals seeking to maintain digestive health and support muscle function. However, compared to moringa and corn, it lacks the higher levels of essential vitamins and minerals. While it does contain moderate amounts of healthy fats, it is not as nutrient-dense as moringa. In its powdered form, Moringa stands out as a highly nutrient-dense option. It is exceptionally rich in protein and contains a wealth of micronutrients, including significant amounts of vitamins A and C, calcium, and iron. Moringa is an excellent plant-based protein source with numerous health benefits due to its high vitamin and mineral content. Corn, while higher in calories and carbohydrates than wheat and moringa, is a good source of dietary fiber. However, its protein content is lower compared to both wheat and moringa. Corn is a valuable energy source due to its carbohydrate content, but it does not provide the same levels of protein or micronutrients as wheat and moringa. The functional properties of the pasta were also assessed, with particular attention given to texture, elasticity, and cooking behavior. The pasta exhibited good texture and firmness when cooked, with the addition of eggs and olive oil contributing to its resilience and preventing it from becoming overly soft or mushy. Furthermore, the flavor profile, with the subtle earthiness of moringa and the mild sweetness of corn, was found to appeal to consumers. This suggests that combining these two ingredients offers health benefits while preserving the sensory characteristics typically associated with pasta.

Gluten-free Pasta Acceptability and Raw Material Impact on Consumer Preferences

The study's second objective was to assess the acceptability of the newly developed gluten-free pasta, focusing on sensory attributes such as taste, flavor, texture, appearance, and smell. The results, as shown in Table 3, indicate that the gluten-free pasta made with moringa and corn received highly favorable feedback across all sensory quality attributes, with an overall general acceptability score of 8.53, which corresponds to "Like Extremely." All mean scores for the gluten-free pasta were consistently above 8.0, signaling a strong consumer preference. The taste attribute received the highest mean score of 8.61, followed closely by other characteristics such as flavor, color, smell, and appearance, which all scored between 8.50 and 8.51. These ratings indicate a positive consumer response to the gluten-free pasta, suggesting that it effectively meets consumer expectations for a gluten-free alternative. In comparison, the commercial wheat-based pasta

scored slightly lower across all attributes. The taste of the wheat-based pasta scored 7.85 (“Like Very Much”), while the flavor, smell, color, and appearance all received scores ranging from 7.70 to 7.90. The overall general acceptability of the wheat-based pasta was 7.83, corresponding to “Like Very Much.” This comparison highlights that the gluten-free pasta made from moringa and corn was generally more favorably received than the commercial wheat-based pasta, especially in terms of taste and overall acceptability.

One critical factor contributing to the product’s success is the role of the raw materials—moringa and corn—in shaping the pasta’s sensory attributes. Both ingredients have distinct properties that influence flavor, texture, and appearance. Moringa is known for its distinctive earthy flavor, which, when incorporated into the pasta, may have contributed to the overall unique taste that consumers highly appreciated. The high protein and nutrient content of moringa could have further enhanced the perceived quality, provided a nutritious benefit, and supported the pasta’s desirable firmness and texture (Kamble et al., 2022). On the other hand, corn flour is known for its mild, slightly sweet taste, which likely complements the savory notes of moringa, creating a balanced

and pleasing flavor profile. This combination helped the pasta achieve a taste that was acceptable and extremely liked by most participants.

The taste of gluten-free pasta is often a barrier to consumer acceptance due to the challenges in replicating the familiar flavor of traditional wheat-based pasta. However, the high mean score for taste (8.61) in this study suggests that using moringa and corn has effectively addressed this concern. Previous research has indicated that flavor can be one of the most critical factors in determining the success of gluten-free products. The favorable response to this product demonstrates that advancements in ingredient selection and formulation can overcome common taste challenges (Alencar et al., 2021; Zsigmond et al., 2023).

The smell of the pasta, another important sensory cue, received a mean score of 8.50, indicating a positive consumer response. The aroma of food is often associated with its freshness and quality, which influences consumer expectations (Liu et al., 2022). In gluten-free products, which have historically been perceived as lacking in aromatic appeal, the pleasant smell of this pasta indicates that the product was well-received not only in terms of taste but also in terms

Table 2. Comparison of nutritional quality, fiber, and protein content of wheat, moringa, and corn (per 100 grams)

Nutrient	Wheat (whole grains)	Moringa (powdered)	Yellow corn
Calories	340 kcal	320 kcal	365 kcal
Protein	13.7 g	27.1 g	9.4 g
Fiber	12.2 g	2.0 g	7.3 g
Fat	2.5 g	5.0 g	4.7 g
Carbohydrates	72.6 g	56.0 g	74.3 g
Calcium	34 mg	185 mg	2 mg
Iron	3.7 mg	4.0 mg	0.5 mg
Vitamin A	0 IU	18,500 IU	0 IU
Vitamin C	0 mg	51.7 mg	6.8 mg

Source: United States Department of Agriculture (USDA) Food Database (URL: <https://fdc.nal.usda.gov/>).

Table 3. Comparison of sensory quality attributes between gluten-free pasta (moringa and corn) and commercial wheat-based pasta

Quality	Gluten-free pasta (Moringa and Corn)	Commercial pasta (Wheat-Based)
Flavor	8.51 (Like Extremely)	7.80 (Like Very Much)
Taste	8.61 (Like Extremely)	7.85 (Like Very Much)
Smell	8.50 (Like Extremely)	7.70 (Like Very Much)
Color	8.51 (Like Extremely)	7.90 (Like Very Much)
Appearance	8.51 (Like Extremely)	7.80 (Like Very Much)
Overall Mean/General Acceptability	8.53 (Like Extremely)	7.83 (Like Very Much)

of freshness and quality. This suggests that the use of fresh, nutrient-rich ingredients such as moringa and corn has played a significant role in creating a product that meets high sensory standards.

The pasta's color and appearance were highly evaluated, with a mean score of 8.51. The visual appeal of food is a crucial factor in the initial selection process, and it is particularly important for gluten-free products, which can sometimes deviate from the familiar appearance of wheat-based alternatives (Magano, 2020). The ability of this gluten-free pasta to achieve an appealing color and texture likely contributed to the positive consumer perception. The natural yellow hue from the corn flour and the greenish tint from the moringa powder may have provided a unique, attractive appearance that caught consumers' attention. This visual appeal and the positive sensory experience likely helped reinforce the high acceptability.

The overall general acceptability score of 8.53 further underscores the product's strong reception across all sensory attributes. This high rating indicates that the pasta is an appealing alternative for consumers seeking gluten-free options. It suggests that the combination of moringa and corn not only addresses dietary needs but does so without sacrificing taste or sensory quality, a critical factor for the success of gluten-free pasta in the market. The growing consumer demand for gluten-free products, driven by health-conscious individuals, those with celiac disease, and others seeking potential health benefits, aligns with the positive reception of this product (Abel, 2025).

While the pasta received high scores across all attributes, the absence of a perfect score of 9 ("Like Extremely") for any attributes suggests that there is still room for refinement. For instance, minor improvements in texture, flavor balance, or aroma could further enhance the overall sensory experience and help achieve even higher levels of consumer satisfaction (Bhavadharini et al., 2023). Additionally, considering the texture, some individuals may still perceive a difference between gluten-free and traditional pasta, which could be addressed through further optimization of the pasta formulation or processing techniques (Capriles et al., 2023; Gonzales et al., 2023).

Conclusions

In conclusion, the study successfully met its two objectives by evaluating a gluten-free pasta made from moringa and corn, two tropical crops, and

assessing its acceptability among consumers. The first objective, which evaluated the suitability and potential benefits of utilizing these tropical crops, was achieved through a detailed postharvest processing approach. The second objective, assessing consumer acceptability, was also fulfilled, with the gluten-free pasta receiving highly favorable feedback across all sensory attributes. The pasta earned an overall mean score of 8.53 ("Like Extremely"), outperforming commercial wheat-based pasta, particularly in terms of taste and general acceptability. This high level of consumer approval underscores the potential of moringa and corn as key ingredients in gluten-free pasta, providing a balanced and appealing alternative for individuals with gluten intolerance. While the product received excellent ratings, minor adjustments to texture, flavor balance, and aroma refinement could further enhance the sensory experience and increase consumer satisfaction, positioning this pasta as a promising contender in the growing gluten-free market.

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