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ANALYSIS OF CHEMICAL COMPOSITION AND BIOACTIVE COMPOUNDS IN WET NOODLES PRODUCED FROM MANGROVE FRUIT FLOUR (Rhizophora mucronata Lamk.)

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Abstract

The significant potential of R. mucronata Lamk. mangrove fruit as a functional food source has not been optimally utilized. This study aimed to process mangrove fruit into flour, analyze its nutritional content and bioactive compounds, and develop fresh noodle products with mangrove flour substitution as an environmentally friendly functional food alternative. This experimental study used a Completely Randomized Design (CRD) with four formulations: F1 (50% wheat flour : 50% mangrove flour), F2 (60% : 40%), F3 (70% : 30%), and F4 (80% : 20%). Proximate analysis included moisture content, ash content, fat content, protein content, and carbohydrate content, while bioactive compound analysis included total flavonoids and tannins conducted using spectrophotometry and HPLC methods. Organoleptic tests were conducted on 15 panelists to assess color, aroma, taste, texture, and overall acceptance. The Kruskal-Wallis test results showed significant differences in preference levels for taste, texture, and overall acceptance ($p < 0.05$), while color and aroma showed no significant differences. Mangrove fruit flour contained 7.33% moisture, 9.44% ash, 0.60% fat, 2.81% protein, and 87.14% carbohydrates, with total flavonoids of 0.51% and tannins of 2.94%. The F4 formulation fresh noodles (80% wheat flour : 20% mangrove flour) achieved the highest mean scores for taste preference, texture, and overall acceptance. Mangrove flour substitution significantly increased mineral content (ash content) while maintaining key nutritional characteristics within the range of conventional fresh noodles.

Key words: Bioactive compounds, Fresh noodles, Functional food, Mangrove flour, *R. mucronata* Lamk.

INTRODUCTION

Indonesia, as an archipelago nation with the second-longest coastline in the world, possesses approximately 3.36 million hectares of mangrove forests, equivalent to 23% of the world's total mangrove ecosystem. Although the ecological role of mangroves as coastal erosion protectors and habitat for various marine biota is widely recognized, their utilization as a functional food source remains very limited. Most coastal communities are unaware of the potential of mangrove fruit as a high-value and environmentally friendly functional food source (Rina et al., 2024).

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R. mucronata Lamk. (bakau kurap) is one of the mangrove species dominating tropical coastal areas in Indonesia. The fruit of this species has been scientifically reported to be rich in macronutrients such as carbohydrates and various active phytochemical compounds. Mahdevi et al. (2023) reported that substitution of mangrove fruit flour in noodle products significantly increased antioxidant activity. Purwaningsih et al. (2014) showed that the antioxidant activity of bioactive components of R. mucronata Lamk. remains stable at various temperatures, making it suitable for industrial food thermal processing. Mile et al. (2021) confirmed the presence of essential phytochemical compounds including flavonoids and tannins in mangrove fruit, which play an important role in neutralizing free radicals associated with degenerative diseases.

The increasing consumption of noodles in Indonesia has led to a growing demand for wheat flour as the main raw material. However, wheat flour is derived from wheat, which largely depends on imports, creating vulnerability to price fluctuations and raw material supply (Fadilah et al., 2020). This condition drives the need to develop alternative flour sources based on sustainable local materials. One source with development potential is R. mucronata Lamk. mangrove fruit flour, which contains carbohydrates and bioactive compounds that can provide functional added value to food products (Mile et al., 2021; Budiyanto et al., 2022). The use of mangrove fruit flour as a substitution ingredient in fresh noodle production not only has the potential to reduce dependence on wheat flour, but also supports food diversification, increases the economic value of coastal resources, and promotes sustainable utilization of mangrove ecosystems (Fattah et al., 2025; Budiyanto et al., 2022).

Fresh noodles are a popular staple food consumed by various segments of Indonesian society. The high dependence of the national noodle industry on imported wheat flour demonstrates the importance of substitution efforts using local raw materials. Therefore, this study aims to determine the chemical composition and bioactive compound content of mangrove fruit flour, as well as fresh noodles made from mangrove fruit flour.

RESEARCH METHODS

A. Fresh Noodle Formulation

Fresh noodle formulations using mangrove fruit flour were developed based on differences in the concentration of *R. mucronata* Lamk. mangrove fruit composite flour as a wheat flour substitution material in fresh noodle production (Moko et al., 2025). Four formulations were applied: F1 (50% mangrove fruit flour : 50% wheat flour), F2 (40% mangrove fruit flour : 60% wheat flour), F3 (30% mangrove fruit flour : 70% wheat flour), and F4 (20% mangrove fruit flour : 80% wheat flour). Each treatment was subsequently analyzed for chemical characteristics and sensory acceptance level to determine the formulation that produced the best product quality.

B. Mangrove Fruit Flour Production

The main raw material used was 50 *R. mucronata* Lamk. mangrove fruits with a length of 30-40 cm.

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Mangrove flour was produced through standardized stages: (1) peeling and separating the fruit flesh from propagules; (2) slicing to 1-2 mm thickness and washing under running water; (3) soaking in 0.5% citric acid solution for 20 minutes to prevent enzymatic browning; (4) soaking in clean water for 3 × 24 hours with daily water replacement to remove heavy metal residues and reduce astringency due to tannin content; (5) sun-drying for 3-4 days; and (6) grinding using a chopper machine and sieving through a 60-mesh sieve to obtain 700 grams of mangrove fruit flour. The flow diagram for mangrove flour preparation is shown in Figure 1.

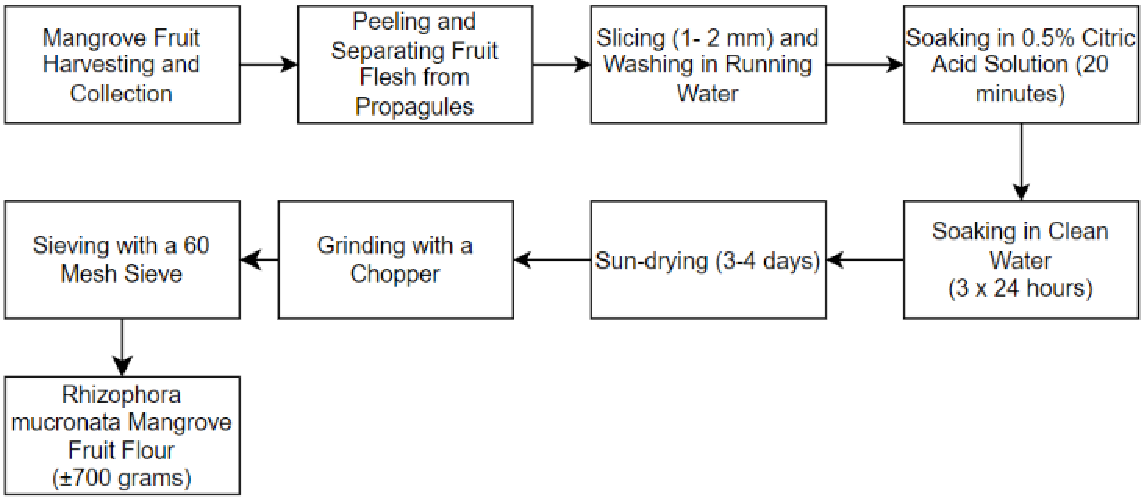

Figure 1. Flow diagram of mangrove fruit flour preparation process

C. Fresh Noodle Production from Mangrove Flour

Fresh noodles were made using *R. mucronata* Lamk. mangrove fruit composite flour and wheat flour according to each treatment formulation. Each formulation used a total of 200 g composite flour with the addition of 2 g carboxymethyl cellulose (CMC) as a binding agent. Additional ingredients consisting of 20 g chicken egg, 3 g salt, 5 mL oil, and 50 mL water were added gradually until a homogeneous dough was obtained. The dough was then rested for 20-30 minutes, then formed into sheets and printed into strands using a noodle press machine. The noodle strands were boiled for 2-3 minutes, drained, and cooled at room temperature before further analysis. The noodle production method was modified from the study conducted by Moko et al. (2025).

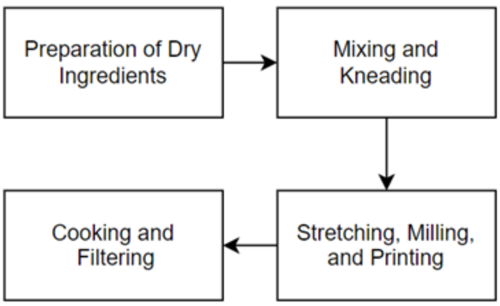

Figure 2. Flow diagram of fresh noodle development process

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D. Proximate Analysis and Bioactive Compounds

Proximate analysis was conducted on *R. mucronata* Lamk. mangrove fruit flour and the resulting fresh noodle products. Parameters analyzed included moisture content, ash content, fat content, protein content, and carbohydrate content. Moisture content was determined using gravimetric method by drying samples in an oven at 105°C until constant weight was obtained. Ash content was analyzed by dry ashing method using a furnace at 550-600°C. Fat content was determined using Soxhlet extraction method with n-hexane solvent, while protein content was analyzed using the Kjeldahl method based on total nitrogen content determination. Carbohydrate content was calculated using the by-difference method based on the difference between 100% and the sum of moisture, ash, fat, and protein content (Latimer, 2023).

Bioactive compound analysis included determination of total flavonoids, quercetin content, and total tannins. Total flavonoids were analyzed spectrophotometrically using the Aluminum Chloride ($AlCl_3$) method with quercetin as the comparison standard (Shraim et al., 2021). Quercetin content was determined using High Performance Liquid Chromatography (HPLC) (Kagawad et al., 2021). Total tannins were analyzed spectrophotometrically based on the formation of a colored complex measured at a specific wavelength. The analytical methods used refer to applicable standard laboratory procedures (Li et al., 2023).

E. Organoleptic Testing

Organoleptic testing was conducted on 15 panelists using two methods: (1) scoring test to assess color, aroma, taste, and texture on a 1-7 scale with specific descriptors at each assessment level; and (2) hedonic test to assess the overall acceptance level using a 7-point scale (1 = dislike very much, 7 = like very much) (Stone et al., 2021). Data normality was tested using the Shapiro-Wilk test. Since most organoleptic data were not normally distributed ($p < 0.05$), analysis was continued using the non-parametric Kruskal-Wallis test with IBM SPSS Statistics software (Mishra et al., 2019) . The reliability of the assessment instrument was evaluated using Cronbach's Alpha coefficient (Sijtsma & Pfadt, 2021).

RESULTS AND DISCUSSION

A. Proximate Composition of Mangrove Fruit Flour

The *R. mucronata* Lamk. mangrove fruit flour produced from the processing had a light brown color with a smooth texture. The appearance of the mangrove fruit flour obtained is presented in Figure 3.

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Figure 3. *R. mucronata* Lamk. mangrove fruit flour

The results of proximate analysis and bioactive compound content of *R. mucronata* Lamk. mangrove fruit flour are presented as mean ± standard deviation in Table 1 and Table 2.

Table 1. Proximate Composition of *R. mucronata* Lamk. Mangrove Fruit Flour

Parameter	Result (%) (mean ± SD)	SNI Reference (Flour)
Moisture Content	7.33 ± 0.12	Max. 14.5% (SNI 3751:2018)
Ash Content	9.44 ± 0.08	Max. 0.7% (SNI 3751:2018)
Fat Content	0.60 ± 0.03	-
Protein Content	2.81 ± 0.05	Min. 7% (SNI 3751:2018)
Carbohydrate Content	87.14 ± 0.21	-

Table 2. Bioactive Compound Content of Mangrove Fruit Flour

Bioactive Compound	Result (mean ± SD)
Total Flavonoids (%)	0.51 ± 0.02
Quercetin (mg/kg)	< 0.034
Total Tannins (%)	2.94 ± 0.05

Note: Data presented as mean ± standard deviation. Total Flavonoids from three replications (n = 3); Total Quercetin from two replications (n = 2); Total Tannins from two replications (n = 2).

The moisture content of mangrove flour (7.33%) is much lower than that reported by Ogi et al. (2023) for fresh *R. mucronata* Lamk. fruit (65.54%), reflecting the effectiveness of the sun-drying process in reducing water activity and extending shelf life. According to SNI 3751:2018, the maximum moisture content for flour is 14.5%, and this result (7.33%) is well below the standard, ensuring longer shelf life and preventing microbial contamination during storage (Mahdevi et al., 2023). The high ash content (9.44%) indicates a substantial mineral composition absorbed from the mineral-rich coastal mangrove ecosystem environment. The dominant carbohydrate content (87.14%) confirms the potential of this flour as an energy-dense material, consistent with Nawaty (2006) as cited in Mukaram (2010), who reported 91.60% carbohydrates in mangrove fruit from similar species.

B. Bioactive Compound Content of Mangrove Fruit Flour

Total flavonoids (0.51%) and total tannins (2.94%) indicate significant antioxidant potential. Mile *et al*. (2021) confirmed the presence of flavonoids, saponins, tannins, triterpenoids, steroids, and hydroquinone phenols in *R. mucronata* Lamk. The quercetin concentration detected by HPLC was below the detection limit (< 0.034 mg/kg), indicating that quercetin is present at trace levels or bound in glycoside forms requiring specific hydrolysis treatment for detection. The broader flavonoid group detected spectrophotometrically likely consists of a mixture of flavones, flavonols, and their glycoside derivatives such as kaempferol and rutin (Hasnat et al., 2024; Zayed et al., 2025).

C. Proximate Composition of Fresh Noodle Products

Fresh noodle products produced from each formulation showed different visual characteristics. The appearance of fresh noodle products from each formulation is presented in Figure 4.

Figure 4. Fresh noodle products of formulations F1 (50:50), F2 (60:40), F3 (70:30), and F4 (80:20) wheat flour : mangrove fruit flour.

The nutritional composition comparison between the best composite fresh noodle product (F4: 80% wheat flour : 20% mangrove flour) and conventional commercial fresh noodles is presented in Table 3.

Table 3. Nutritional Content Comparison of Fresh Noodles per 100 g

Parameter	Conventional Fresh Noodles	F4 Substituted Noodles	Change
Moisture Content (%)	38 - 40	39.13	Comparable
Fat Content (%)	2 - 3	2.15	Comparable
Protein Content (%)	8 - 10	8.62	Comparable
Carbohydrate Content (%)	48 - 52	49.24	Comparable
Ash Content (%)	0.5 - 0.7	0.86	↑ 23 - 72%

The results show that substituting 20% wheat flour with mangrove flour (F4) does not significantly alter the main nutritional profile of fresh noodles. Protein content (8.62%) remains well above the SNI minimum standard of 3% for fresh noodles. The most notable change is ash content (0.86%), which is 23%-72% higher than conventional fresh noodles (0.5%-0.7%), confirming enrichment of essential micro-macro mineral salts derived from coastal mangrove raw materials. These findings are consistent with Moko et al. (2025), who reported that substitution with local starch sources from coastal environments generally increases ash content without significantly affecting protein, fat, or carbohydrate content.

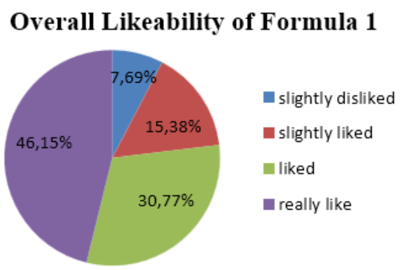
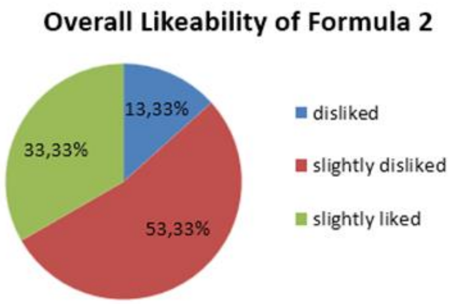
D. Organoleptic Test Results

Based on hedonic test results, panelist satisfaction (n=15) showed an increasing trend as the proportion of wheat flour in the formulation increased (Table 4).

Table 4. Summary of Hedonic Test Results by Formulation

Formulation	Color	Aroma	Taste	Texture	Overall
F1 (50:50)	Moderate	Moderate	Low	Low	Low
F2 (60:40)	Moderate	Moderate	Moderate	Moderate	Moderate
F3 (70:30)	Moderate	Moderate	Good	Good	Good
F4 (80:20)	Good	Moderate	Best	Best	Best

Table 5. Summary of Scoring and Hedonic Organoleptic Test Results

Test	Aspect	Result Distribution (%)
Overall Hedonic	F1 (50:50)	
Overall Hedonic	F2 (60:40)	

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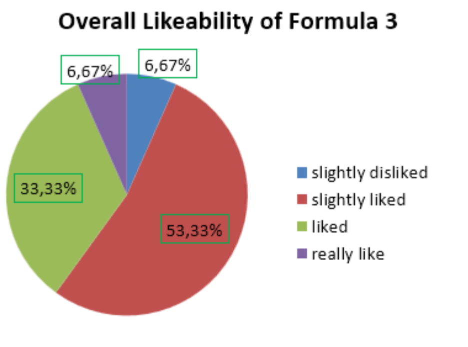
<tr><td>Overall Hedonic</td><td>F3 (70:30)</td><td>
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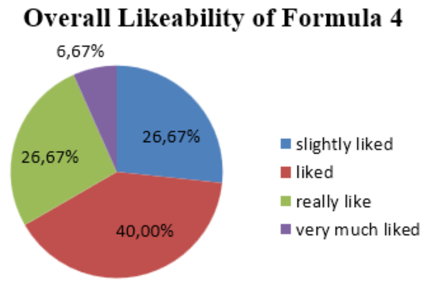
<tr><td>Overall Hedonic</td><td>F4 (80:20)</td><td>
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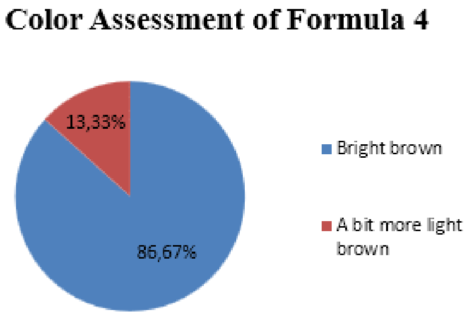
<tr><td>Scoring (F4)</td><td>Color</td><td>
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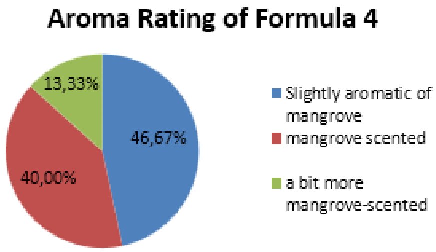
<tr><td>Scoring (F4)</td><td>Aroma</td><td>
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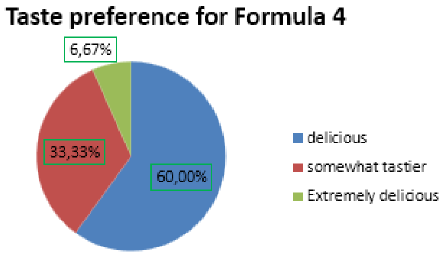
<tr><td>Scoring (F4)</td><td>Taste</td><td>
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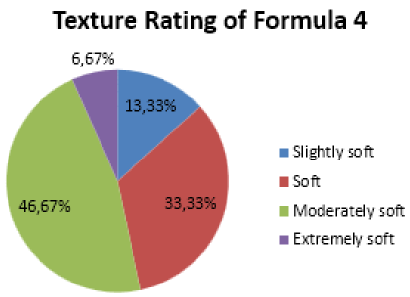
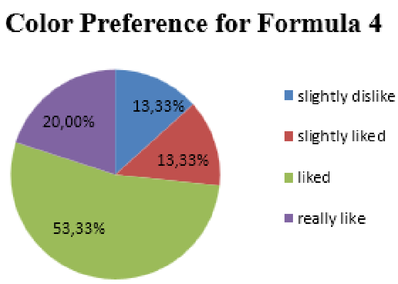
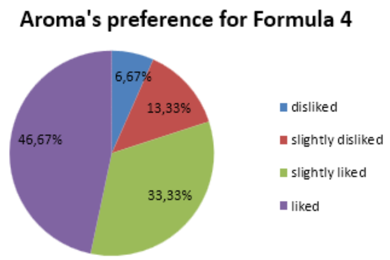
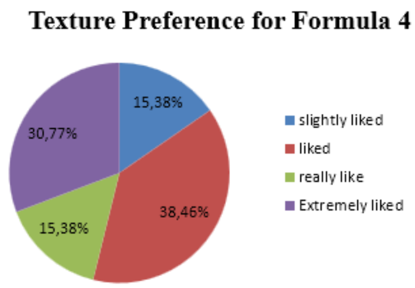
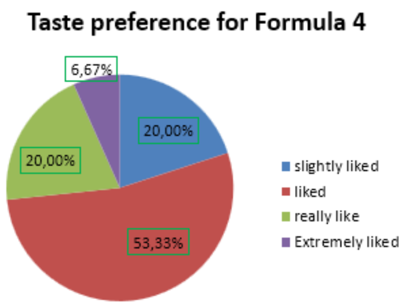
Scoring (F4)	Texture	
Hedonic Preference (F4)	Color	
Hedonic Preference (F4)	Aroma’s	
Hedonic Preference (F4)	Taste	
Hedonic Preference (F4)	Texture	

In formulation F4, panelist responses showed an excellent level of acceptance: (1) Color - 86.67%

of panelists rated the noodle color as slightly bright brown, a distinctive characteristic of the product; (2) Aroma - 46.67% of panelists rated the noodle aroma as slightly mangrove-scented, which is still acceptable at the 20% substitution level; (3) Taste - the parameter with the best results, with 60% of panelists rating the noodle taste as good and 33.33% rating it as slightly better; (4) Texture - 46.67% of panelists rated the noodle texture as slightly softer, caused by the reduced proportion of gluten-forming protein from wheat flour due to partial substitution with gluten-free mangrove flour.

The Shapiro-Wilk normality test results showed that the organoleptic data were not normally distributed ($p < 0.05$), so analysis was continued using the Kruskal-Wallis non-parametric test. The test results showed that formulation variation significantly affected taste, texture, and overall acceptance level ($p < 0.05$), but did not have a significant effect on color and aroma ($p > 0.05$). Increasing the proportion of mangrove flour substitution above 30% (as in formulations F1 and F2) caused a decrease in panelist acceptance. This is presumably due to the remaining tannin compounds that impart astringency to the product and the reduced elasticity of the gluten matrix in the noodle dough due to the increased use of gluten-free mangrove flour. The organoleptic test instrument also showed adequate reliability, with a Cronbach's Alpha value of 0.752, which exceeded the minimum reliability threshold of 0.60.

CONCLUSION

Mangrove fruit flour has a chemical composition of 87.14% carbohydrates, 0.60% fat, 2.81% protein, and 9.44% ash, as well as bioactive compound composition of 2.94% total tannins and 0.51% total flavonoids. The best composite fresh noodle formulation is F4 (80% wheat flour : 20% mangrove flour), which achieved the highest sensory satisfaction scores for taste, texture, and overall acceptance parameters. Formulation F4 significantly increases mineral contribution as indicated by an ash content of 0.86%, representing an increase of approximately 23-72%.

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