Journal of Indonesia Applied Nutrition

1(1):32-39, 2026, https://doi.org/10.56303/jian.v1i1.1305

E-ISSN: 3125-1188, https://www.journalmpci.com/index.php/jian

Optimization of the Sensory and Nutritional Properties of Sago-Based Wet Noodles Fortified with Red Fruit Oil

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ARTICLES

Submitted: Feb 25, 2026

Accepted: Apr 10, 2026

Keywords:

Wet noodles, Sago, Red fruit oil, Organoleptic properties, Nutrient content

ABSTRACT

Wet noodles are widely consumed food products in Indonesia; however, they are generally made from wheat flour, increasing dependence on imported raw materials. The utilization of sago (*Metroxylon sp.*) as a local carbohydrate source offers potential as a wheat flour substitute. Red fruit oil (*Pandanus conoideus*) contains carotenoids and tocopherols that function as natural colorants and antioxidants.

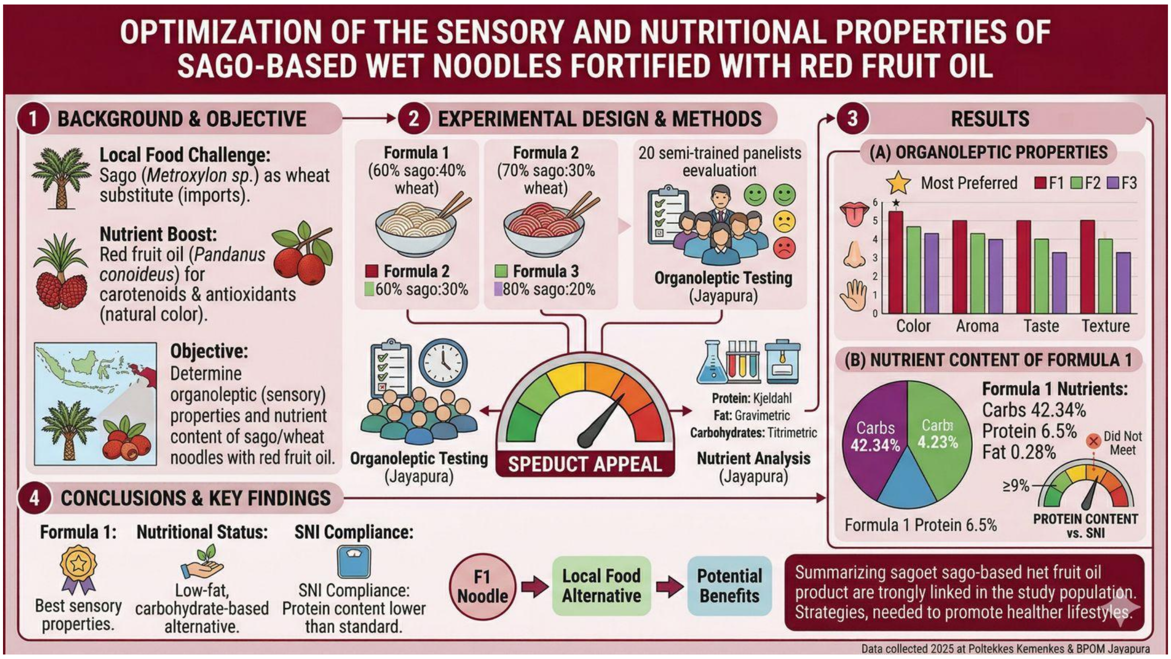
This study aimed to determine the organoleptic properties and nutrient content of wet noodles substituted with sago and supplemented with red fruit oil. The study evaluated three formulations based on the proportion of sago and wheat flour: Formula 1 (60% sago : 40% wheat flour), Formula 2 (70% sago : 30% wheat flour), and Formula 3 (80% sago : 20% wheat flour). The research was conducted from July 30 to August 1, 2025, for organoleptic testing at the Food and Nutrition Laboratory of Poltekkes Kemenkes Jayapura, involving 20 semi-trained panelists aged 18–25 years. Nutrient analysis (protein, fat, and carbohydrates) was carried out at the BPOM Laboratory of Jayapura from August 21 to September 4, 2025. Protein was analyzed using the Kjeldahl method, fat using the gravimetric method, and carbohydrates using the titrimetric method. Data were analyzed descriptively and presented in tables and graphs.

The results showed that Formula 1 (60% sago:40% wheat flour) was the most preferred in terms of color, aroma, taste, and texture. The nutrient content of Formula 1 consisted of 42.34% carbohydrates, 0.28% fat, and 6.5% protein. Although the protein content did not meet the Indonesian National Standard (SNI ≥9%), the product showed potential as a low-fat, carbohydrate-based local food alternative.

Key Messages:

- The substitution of 60% sago and 40% wheat flour (F1) produces the most preferred texture and color of the wet noodles.
- Red fruit oil fortification acts as a natural colorant while providing potential antioxidant properties from carotenoids.
- The product is a potential low-fat carbohydrate source, but requires further protein fortification to meet the national standard (≥9%)

GRAPICHAL ABSTRACT



INTRODUCTION

Fresh noodles are a processed food product with high consumption rates in Indonesia. These products are widely favored due to their distinctive sensory characteristics, including a chewy texture and a broadly accepted flavor profile, as well as their ease of preparation and serving. Furthermore, noodles often serve as an alternative carbohydrate source to rice in both urban and rural dietary patterns (1). Noodles represent a strategic commodity within the national food system; however, the primary raw material, wheat flour, remains heavily dependent on imports. This dependency potentially leads to supply vulnerabilities and fluctuations in production costs. Consequently, food diversification based on local resources is essential to bolster national food security and reduce reliance on wheat imports (2,3).

Sago (*Metroxylon sp.*) is a prominent local commodity with significant potential as a substitute for wheat flour. Sago is a starch-producing plant characterized by high productivity, particularly in eastern Indonesia such as Papua, yielding approximately 20–40 tons of dry starch per hectare annually (4). It possesses a high starch content and a relatively larger proportion of resistant starch compared to cereals like wheat (5). Consequently, sago serves as a promising raw material for starch-based food diversification and a viable alternative to wheat in supporting food security and local food utilization (6). Nevertheless, sago has limitations regarding protein content and lacks gluten, which may adversely affect the texture and elasticity of noodle products. Therefore, precise formulation is required to ensure the resulting product maintains acceptable sensory quality for consumers.

In addition to sago, Papua harbors another local commodity with high functional value: Red Fruit (*Pandanus conoideus*). This endemic plant has long been utilized by the Papuan people as both a food source and traditional medicine (7). A widely researched derivative is red fruit oil, a vegetable oil with a high total fat content and a fatty acid profile dominated by oleic, linoleic, and palmitic acids. Furthermore, red fruit oil contains approximately 1.1% total tocopherols and 1.2% total carotenoids, which are relatively higher than those found in several other vegetable oils. The β-carotene and α-tocopherol content act as natural antioxidants capable of neutralizing free radicals and contributing to immune system enhancement (8,9). The high concentration of carotenoid pigments imparts a distinctive red color to the oil, offering potential as both a natural colorant and a functional fortification agent in food products (10). Beyond its antioxidant properties, red fruit is also rich in energy, vitamins, and minerals that can enhance the nutritional value of processed foods (11).

The development of sago-based fresh noodles incorporated with red fruit oil represents a food innovation aimed at supporting diversification and regional resource utilization. While sago is a suitable base due to its high starch content, its gluten-free nature can compromise the structural quality of the noodles, necessitating an optimized formulation (12). The addition of red fruit oil as a functional ingredient may enhance the nutritional

https://doi.org/10.56303/jian.v1i1.1305

profile through its carotenoid and tocopherol content; however, it may also influence the physical, chemical, and organoleptic characteristics of the product (13,14). Therefore, an evaluation of the nutritional content and consumer acceptance of sago-based fresh noodles enriched with red fruit oil is essential to produce a high-quality product that is acceptable to the public (15). Based on these considerations, this study aims to analyze the nutritional composition and organoleptic properties of the substituted fresh noodles.

METHODS

This study utilized a laboratory experimental design focusing on the formulation of fresh noodles with sago substitution and red fruit oil enrichment. Three formulations were established based on the ratio of sago flour to wheat flour: F1 (60:40), F2 (70:30), and F3 (80:20). Each formulation was supplemented with 30 mL of red fruit oil, ½ teaspoon of salt, and 100 mL of water. Red fruit oil (*Pandanus conoideus*) and sago flour were sourced from local producers and vendors in Jayapura City. The noodle production process involved mixing dry ingredients, adding red fruit oil and water, and kneading until a homogeneous dough was formed. The dough was then processed using a pasta maker to achieve a uniform thickness and cut into fresh noodles. The noodles were boiled, drained, and cooled prior to analysis.

Sensory evaluation was conducted using a hedonic test involving 20 semi-trained panelists, assessing color, aroma, flavor, and texture on a 5-point scale. A 5-point hedonic scale was employed to measure consumer preference, ranging from 1 (strongly dislike) to 5 (strongly like). Nutritional analysis, including protein, fat, and carbohydrate content, was performed at a food testing laboratory. Protein was determined using the Kjeldahl method, fat by the gravimetric method, and carbohydrates by the titrimetric method. Sensory data were analyzed descriptively by calculating mean values for each parameter, while nutritional data were presented in tabular form. All results were interpreted through comparison with the Indonesian National Standard (SNI) for fresh noodles and relevant scientific literature.

RESULTS

This research yielded three formulations of sago-based fresh noodles enriched with red fruit oil (F1, F2, and F3). Prior to establishing the final formulations, several preliminary trials were conducted to optimize the dough composition, ensuring that the noodle characteristics complied with the quality standards for fresh noodles. The resulting products were subsequently subjected to organoleptic evaluation by 20 panelists, assessing color, aroma, flavor, and texture parameters

(a) (b) (c)

Figure 1. Stages of sago-based fresh noodle formulation enriched with red fruit oil: (a) Material preparation and weighing; (b) Extruded fresh noodles; (c) Final product of sago-based fresh noodles with red fruit oil addition.

Organoleptic test results indicated varying levels of panelist preference across the formulations. The highest mean score for color was observed in F1 and F2 (3.80), while F3 recorded a lower value (3.50). Regarding aroma, F1 achieved the highest average score (3.40), whereas F2 and F3 each obtained a score of 3.00. For the flavor attribute, F2 received the highest rating (3.60), followed by F1 (3.35) and F3 (3.30). In terms of texture, F1 earned the highest score (4.05), followed by F2 (3.45) and F3 (3.10). Overall, F1 was identified as the optimum formulation due to its superiority across most sensory parameters, particularly color and texture. Although F2 achieved a higher flavor score, texture remains a critical parameter for fresh noodles, as it determines chewiness, elasticity, and structural integrity. Consequently, the formulation with the superior texture profile was prioritized in determining the optimum formula over the one with the highest flavor rating alone.

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Table 1. Mean sensory evaluation scores of sago-based (*Metroxylon sp.*) fresh noodles enriched with red fruit oil (*Pandanus conoideus*)

Parameters	Perlakuan		
	F1 (60 g sago : 40 g wheat flour)	F2 (70 g sago : 30 g wheat flour)	F3 (80 g sago : 20 g wheat flour)
Color	3.80	3.80	3.50
Aroma	3.40	3.00	3.00
Flavor	3.35	3.60	3.30
Texture	4.05	3.45	3.10

The distribution of panelist preferences further revealed that F1 achieved the highest mean in categories for color and texture. Regarding the aroma attribute, F1 demonstrated a higher acceptance rate compared to F2 and F3. Meanwhile, for flavor, F2 recorded a relatively higher preference level than the other formulations. Generally, F3 obtained the lowest mean scores across nearly all assessed attributes.

Table 2. Proximate analysis results of sago-based fresh noodles with red fruit oil incorporation

Parametes	Result	Requirement (SNI)	Remarks	Method
Cabohydrate	42.34 %	Not regulated (01-2891-1992)	Acceptable; lower than commercial instant noodles	Titrimetric
Fat	0.28 %	Not regulated (01-2891-1992)	Low; consistent with fresh noodle characteristics	Gravimetric
Protein	6.5 %	Min. 9.0% (01-2891-1992)	Does not meet requirements	Titrimetric

Source: Balai Besar BPOM Dijayapura (2025)

Nutritional analysis revealed that the sago-based fresh noodles incorporated with red fruit oil contained 42.34% carbohydrates, 0.28% fat, and 6.5% protein. Carbohydrates constituted the primary component of the product, while the fat content was categorized as low. The observed protein level remained below the minimum requirement for fresh noodles as stipulated by the Indonesian National Standard (SNI ≥ 9%). Overall, the chemical analysis indicates that the substituted sago-based fresh noodles function primarily as a carbohydrate source with low fat content and relatively lower protein levels compared to conventional wheat-based fresh noodles.

DISCUSSION

The organoleptic test results indicated that variations in the proportion of sago and wheat flour, alongside the addition of red fruit oil, influenced the panelists' acceptance levels regarding color, aroma, taste, and texture attributes. In general, Formula 1 (F1) demonstrated the most consistent performance, achieving the highest mean scores in three primary attributes: color (3.80), aroma (3.40), and texture (4.05). Meanwhile, Formula 2 (F2) excelled in the taste attribute (3.60), whereas Formula 3 (F3) tended to receive the lowest scores across almost all tested parameters. These findings indicate that the compositional balance of ingredients plays a crucial role in shaping the sensory characteristics of sago-based wet noodle products.

1. Color

Color is an initial sensory attribute that significantly determines consumer perception regarding the quality and attractiveness of a food product. The results indicated that formulas F1 and F2 achieved the highest mean color scores (3.80), outperforming F3 (3.50). Over 70% of the panelists expressed a "liking" for the color of F1 and F2, indicating that the proportion of red fruit oil in these two formulas successfully produced an appealing orange-red hue. This distinctive color is attributed to the presence of carotenoid pigments, primarily β-carotene and lycopene, which impart a natural red color to the product. However, at a higher concentration, as seen in F3, the color became excessively intense, rendering its appearance less appealing to the panelists. This finding aligns with a previous study on mayonnaise products, which reported that while increasing the concentration of red fruit oil enhances color intensity and carotenoid content, excessive addition adversely affects the panelists' visual acceptance (16). This demonstrates that increasing the concentration of natural colorants requires a proportional formulation to achieve an optimal and consumer-acceptable product appearance

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Furthermore, previous studies on carotenoid stability have demonstrated that the pigments in red fruit oil are highly influenced by concentration, storage conditions, and processing methods; consequently, excessive application can adversely affect the final color of the food product. This indicates that the utilization of red fruit oil as a natural colorant requires precise concentration adjustments to yield a stable and visually appealing color without compromising consumer acceptance (17). Therefore, the incorporation of red fruit oil in the production of wet noodles serves not only as a natural colorant and a source of functional compounds, but also necessitates an exact formulation to ensure optimal visual characteristics and sustained consumer preference.

2. Aroma

Aroma arises from the volatilization of compounds detected by the olfactory system, significantly contributing to the overall flavor perception. The results indicated that the highest mean aroma score was achieved by Formula 1 (F1) at 3.40, whereas F2 and F3 both received a score of 3.00. Furthermore, the hedonic distribution demonstrated that F1 exhibited a higher acceptance rate, recording the lowest percentage of disliking compared to the other formulations. The distinctive aroma of the noodles is primarily influenced by the volatile compounds derived from the red fruit oil. At a balanced concentration, red fruit oil imparts a characteristic aroma that remains acceptable and non-dominant. Conversely, at higher concentrations, such as in F3, the aroma becomes more pungent, thereby reducing panelist acceptability. Additionally, an increased lipid fraction potentially accelerates lipid oxidation, leading to the generation of volatile compounds associated with undesirable off-odors (17). Therefore, controlling the proportion of red fruit oil is imperative to preserve the aroma characteristics favored by consumers. These findings align with previous studies reporting that the addition of 0–1.5% red fruit oil did not significantly affect the aroma of nuggets (scores 3.50–3.70; “slightly like” category) as it was masked by seasoning, effectively preventing the emergence of pungent odors at higher doses (18). Furthermore, other research has demonstrated that a balanced proportion of ingredients in wet noodles substituted with moringa flour (95:10) successfully maintained an acceptable aroma (mean score 3.87), underscoring the critical role of formulation balance in preserving sensory quality (19).

3. Flavor

Taste is a crucial parameter in determining consumer acceptance of a food product. The results indicated that Formula 2 (F2) achieved the highest mean taste score (3.60), followed by F1 (3.35) and F3 (3.30). The superiority of F2 is hypothesized to be associated with the relatively balanced proportion of sago and wheat flour, which allows the savory profile of the wheat component to remain sufficiently dominant, thereby balancing the characteristic flavors of both sago and red fruit oil. Red fruit oil contains essential fatty acids and carotenoid compounds that impart a distinct flavor sensation and enhance product differentiation. At an appropriate concentration, these components contribute positively to the overall flavor; however, higher concentrations may produce an undesirable aftertaste for some panelists. Furthermore, the interaction among sago starch, wheat gluten, and the lipid fraction influences the complexity and balance of the developed flavor. Previous studies have reported that the addition of 1% red fruit oil yielded the highest taste preference (score 4.05), whereas higher concentrations reduced consumer acceptability (19). Additionally, other research has demonstrated that optimizing the flour ratio in wet noodles can improve taste quality without compromising nutritional value, underscoring the critical importance of proportional formulation in the development of local resource-based food products (20).

4. Texture

Texture is a crucial attribute of noodle products, as it directly correlates with chewiness, elasticity, and overall mouthfeel during consumption. The results indicated that Formula 1 (F1) achieved the highest texture score (4.05), followed by F2 (3.45) and F3 (3.10). The high consumer preference for the texture of F1 indicates that the composition of 60% sago and 40% wheat flour remains capable of maintaining the formation of a gluten network, which plays a pivotal role in producing an elastic and chewy noodle structure. Conversely, in F3, which incorporates a higher proportion of sago (80%), the gluten content decreases significantly, resulting in a softer and less elastic noodle structure. Furthermore, an elevated oil content can inhibit the interaction of gluten-forming proteins, thereby contributing to a reduction in the product's chewiness.

https://doi.org/10.56303/jian.v1i1.1305

The optimal noodle texture is achieved through a balance between sago starch, which imparts softness and water-binding capacity, and wheat gluten, which forms a viscoelastic network, yielding chewy noodles that are resistant to breakage. This finding aligns with previous studies stating that increased sago substitution tends to decrease noodle chewiness due to the lack of gluten content (20). Additionally, other research has reported that the addition of oil at a moderate concentration (0.5%) can improve the textural characteristics of processed products by enhancing softness without compromising sensory acceptability (18). Therefore, formulation F1 demonstrates the most optimal compositional balance in preserving the textural quality of sago-based wet noodles.

5. Nutrient Content

Chemical analysis revealed that the sago-based wet noodles fortified with red fruit oil contain 42.34% carbohydrates, 0.28% fat, and 6.5% protein. The predominantly high carbohydrate content confirms that this product continues to serve as a primary energy source. Although this value is lower compared to dry wheat-based noodles, it is influenced by the high moisture content typical of wet noodles (generally 60–70%), which proportionally reduces the nutrient concentration on a wet weight basis. These carbohydrates are primarily derived from sago starch, which possesses a resistant starch fraction, thereby potentially providing a slower energy release and supporting the stability of the glycemic response (22). This finding is consistent with previous studies indicating that the starch composition in non-wheat substitutes can contribute to more favorable metabolic characteristics compared to conventional noodles (20).

The fat content of the sago-substituted wet noodles fortified with red fruit oil was measured at 0.28%, which is classified as exceptionally low and complies with the Indonesian National Standard (SNI 2973:2011), as the standard does not specify a maximum fat limit for wet noodles. Despite the incorporation of red fruit oil, the increase in total fat was insignificant due to its limited application. Furthermore, the lipid profile is predominantly composed of unsaturated fatty acids, such as oleic and linoleic acids, which function as antioxidants and enhance the oxidative stability of the product. Previous studies have reported that the addition of oil at low concentrations can improve stability without significantly elevating the overall fat content (19). Compared to conventional wheat noodles, which typically exhibit a fat content of approximately 1–2%, this product possesses a remarkably lower lipid profile. Consequently, it demonstrates strong potential for development as a low-fat noodle alternative, promoting healthy dietary patterns and supporting obesity prevention

The protein content of 6.5% remains below the minimum requirement of the Indonesian National Standard (SNI) (≥9%) for wet noodles. This low protein content is attributed to the characteristics of sago, which intrinsically possesses an exceptionally low protein content (±0.2–0.5%) and lacks significant amounts of gluten. The 60–80% sago substitution directly reduces the protein contribution from the wheat flour, which typically contains approximately 10–12% protein, thereby resulting in a decreased protein content in the final product. This finding is consistent with previous research indicating that pure sago noodles contain only about 0.20–1.5% protein; thus, protein fortification is a recommended strategy to enhance nutritional quality (21). Furthermore, other studies have demonstrated that the addition of 10% moringa leaf flour can increase the protein content of wet noodles to 8–10% without compromising sensory quality (hedonic score >3.5) (20). Such a fortification model can be considered an ideal approach for the further development of Formula 1 (F1), ensuring that the product is not only sensorially optimal but also meets the requisite protein content standards (23,24).

Overall, from a nutritional perspective, this product possesses the advantage of being a low-fat carbohydrate source while containing bioactive components, specifically carotenoids derived from red fruit oil, which potentially serve as natural antioxidants. Nevertheless, as the protein content has not yet met the minimum standard requirement (≥9%), there is a clear necessity for further formulation innovation. Fortification strategies utilizing plant-based protein sources, such as tempeh flour or soy protein isolate, can be considered to enhance the protein content without compromising textural quality and sensory acceptability (24). This development aligns with functional food trends in Indonesia, which emphasize diversification based on local food resources, including sago, as an effort to enhance nutritional value while simultaneously strengthening the competitiveness of national food products.

CONCLUSION

The optimal formulation was achieved in Formula 1 (F1), comprising 60% sago and 40% wheat flour, which demonstrated the highest sensory acceptability and textural characteristics most closely resembling those

https://doi.org/10.56303/jian.v1i1.1305

of conventional noodles. Furthermore, the fortification with red fruit oil successfully imparted an attractive natural color while providing functional value through its bioactive carotenoid compounds. Although this composition classifies the product as a promising sago-based composite noodle, the incorporation of wheat flour remains essential to establish the requisite gluten network for structural integrity and chewiness. Therefore, future research should focus on utilizing alternative binding agents to accommodate higher sago proportions, thereby further reducing reliance on wheat flour. Additionally, subsequent studies should explore protein fortification strategies using plant-based sources to ensure the final product meets the requisite national nutritional standards.

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