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Enhancing the Physicochemical and Sensory Properties of Purple Yam Wet Noodles through Egg White Addition

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Abstract:
Purple yam (*Dioscorea alata*) is a potential local ingredient for wet noodle production, although improving its texture remains important for product quality and consumer acceptance. This study investigated the effect of egg white addition on the physicochemical and sensory properties of purple yam wet noodles. A completely randomized design was used with seven egg white concentrations: 0%, 2.5%, 5%, 7.5%, 10%, 12.5%, and 15%, with three replications. The data were subjected to ANOVA, followed by DnMRT when significant differences were observed. Egg white concentration significantly affected noodle elongation, cooking time, cooking loss, moisture and protein contents, color, and several sensory attributes. As the concentration of egg white increased, elongation, cooking time, protein content, and moisture content tended to increase, whereas cooking loss decreased. The addition of egg white also changed the color and sensory characteristics of the noodles, particularly at higher concentrations, which resulted in lower scores for color and taste. The 7.5% egg white addition showed the most favorable overall results, with an elongation of 12.62%, cooking time of 190 s, cooking loss of 3.11%, moisture content of 64.6%, protein content of 12.71%, color values of L* = 53.83, a* = −1.20, and b* = −7.33 and obtained the highest overall acceptability score (4.08).

Keywords: Egg white; physicochemical; purple yam; sensory; wet noodles

1. Introduction

Noodles are widely consumed and are generally produced using wheat flour. This makes noodles an interesting product for exploring the use of locally available crops as alternative raw materials, particularly in areas where wheat is not locally produced. Purple yam (*Dioscorea alata*) is one local crop that could be incorporated into noodle products. According to Fauziah *et al*. (2020), purple yam contains 17.10–29.37% carbohydrates, 1.29–3.00% protein, 0.29% fat, 6.70–11.62% fiber, and 0.85–1.44% ash, while its moisture content ranges from 65.47 to 82.46%. Purple yam also contains flavonoid such as anthocyanins, which are responsible for its characteristic purple color (Lavlinesia et al., 2023; Obidiegwu et al., 2020; Ulyarti et al., 2019). The presence of these pigments could contribute to the color and visual characteristics of noodles made with purple yam.

Purple yam flour has previously been used in wet noodle production (Lavlinesia et al., 2019). However, the incorporation of purple yam flour negatively affected the appearance and reduced the overall acceptance of the noodles. Furthermore, the use of alkaline water to improve the textural properties of purple yam wet noodles resulted in a color change from the characteristic purple of the yam flour to an undesirable grey color. An alternative approach for incorporating purple yam into wet noodles is the use of purple yam paste. Rather than processing the tuber into flour, purple yam can be incorporated directly as a paste (Ulyarti et al., 2024). Purple yam paste contains a considerable amount of dietary fiber, which may contribute to its water-binding and gel-forming properties. These properties may help improve the texture of wet noodles without the need for alkaline water. The use of purple yam paste may therefore offer a dual benefit by retaining the characteristic purple color of the yam while potentially improving the textural properties of the resulting noodles.

The use of purple yam paste alone may not provide sufficient structural strength for wet noodle preparation because the fresh paste contains substantial moisture (Ulyarti et al., 2024) and lacks the

concentrated starch. Therefore, an additional starch-based ingredient may be required to provide sufficient structural strength and cohesiveness to the noodle dough. Wheat and rice flours are two types of flour that can be used for this purpose. Wheat flour contributes gluten, which plays an important role in developing the structure, elasticity, and chewiness of noodles. Rice flour does not contain gluten and therefore contributes mainly through its starch during cooking. In the presence of water and heat, starch absorbs water and swells, contributing to the structure and texture of the noodles. However, increasing the proportion of rice flour may reduce the strength of the gluten network and consequently affect noodle elasticity and resistance to breakage (Kasunmala et al., 2020). Therefore, an additional strengthening ingredient may be required to maintain the structural and textural properties of wet noodles containing purple yam and rice flour. In our previous unpublished work, a formulation containing approximately 60% purple yam paste, 20% wheat flour, and 20% rice flour was able to produce purple yam wet noodles with acceptable properties. However, this formulation still requires improvement, particularly in terms of textural performance. The wet noodles appeared to break apart easily and were less appealing.

Egg white is rich in albumin proteins that coagulate during heating and form a gel (Razi et al., 2023). In noodle products, this behavior may help improve firmness and elasticity while supporting the noodle structure during cooking. Bai *et al*. (2022) reported that the addition of egg white affected both the textural and sensory characteristics of noodles. Another study showed that inclusion of 15% egg white minimized the cooking loss and enhanced the springiness, adhesiveness, and chewiness of the noodles, which in turn resulted in the highest sensory scores (Li et al., 2024). Therefore, the present study investigated how different amounts of egg white addition influence the physicochemical and sensory properties of wet noodles prepared with purple yam paste, wheat and rice flour.

2. Material and Method

Material

The raw materials used for the preparation of purple yam wet noodles included chicken egg white, purple yam tubers, high-protein wheat flour, rice flour, salt, cooking palm oil, and water. The formulation of the wet noodles is presented in Table 1.

Table 1. Formulation of purple yam wet noodles

Material	Egg white (% w/w)						
	0	2.5	5	7.5	10	12.5	15
Egg white (g)	0	2.5	5	7.5	10	12.5	15
Yam paste (g)	60	60	60	60	60	60	60
Wheat flour (g)	20	20	20	20	20	20	20
Rice flour (g)	20	20	20	20	20	20	20
Salt (g)	1	1	1	1	1	1	1
Cooking palm oil (g)	5	5	5	5	5	5	5

Experimental design

The experiment followed a Completely Randomized Design (CRD) with egg white concentration as the single treatment factor. Seven concentrations were tested: 0%, 2.5%, 5%, 7.5%, 10%, 12.5%, and 15% (w/w), calculated based on the combined weight of purple yam paste, wheat flour, and rice flour. Each treatment was prepared in three replications.

Preparation of purple yam paste

Purple yam tubers were first cleaned to remove adhering soil, then peeled, washed, and cut into pieces approximately 1–2 cm in size. The pieces were steamed for 20 minutes and mashed using a chopper. The resulting paste was passed through a 30-mesh sieve twice to obtain a uniform consistency.

Preparation of purple yam wet noodles

The wet noodle dough was prepared by combining wheat flour, rice flour, purple yam pastes, egg white at the concentration specified for each treatment, oil, and salt. The ingredients were mixed until a homogeneous

dough was obtained. The dough was considered sufficiently mixed when it formed a cohesive mass when pressed by hand. It was then passed through a noodle press fitted with a 3 mm die to form noodle strands. The noodles were immediately cooked by boiling them in water maintained at 100°C.

Elongation

Elongation was determined using a texture analyzer MCT 2150 made in Japan. A noodle strand was cut to an initial length of 10 cm and mounted on the instrument. The sample was stretched at a speed of 100 mm/min until breakage occurred, and the elongation was calculated using Eq. 1.

$$\text{Elongation (\%)} = \frac{\text{Extension break (mm)}}{\text{Initial length (mm)}} \times 100\% \quad (1)$$

Cooking characteristics

Cooking time was determined following method by Bhavadharani & Gurumoorthi (2026) with modification. About 10 grams of noodles were boiled in water at 100°C. Every 10 seconds, a noodle strand was removed and placed between two transparent glass slides, then pressed gently. This procedure was repeated until the white core in the center of the noodle strand disappeared, indicating that the noodles were fully cooked. Cooking loss was determined by weighing 10 g of noodle sample and boiling it in 200 mL of water for the predetermined cooking time. After cooking, the noodles were removed and drained, while the cooking water was dried in an oven at 105°C until all moisture had evaporated and a constant residue weight was obtained. Cooking loss was then calculated using Eq 2.

$$\text{Cooking Loss (\%)} = \frac{\text{Dry residu weight}}{\text{Weight of noodles before cooking}} \times 100\% \quad (2)$$

Protein content

Protein analysis was performed using the Kjeldahl method, in which concentrated sulfuric acid was used to digest organic matter and convert protein nitrogen into ammonium sulfate. The solution was then alkalized with concentrated NaOH, allowing the nitrogen to be distilled as NH_3 into a standard acid solution. The ammonia reacted with a portion of the acid, while the remaining unreacted acid was titrated with standard NaOH to determine the nitrogen content. Crude protein content was calculated using Eq 3.

$$\text{Crude protein (\%)} = \frac{(\text{K} - \text{J}) \times \text{Norm NaOH} \times 0.014 \times 6.25}{\text{I}} \times 100\% \quad (3)$$

Description:
K= Sample titration volume (mL)
J = Blank titration volume (mL)
I = Sample weight (gram)

Color

Color analysis was performed using a color reader. The sensor of the color reader was positioned perpendicular to the sample surface, and the measurement button was pressed until the color values appeared on the screen. The color parameters were expressed as L*, a*, and b* values, where L* represents lightness, a* represents red-green axis, and b* represents yellow-blue axis.

Sensory analysis

The sensory evaluation of purple yam wet noodles was conducted with 25 students from Agricultural Product Technology Study Program, University of Jambi who were considered moderately trained panelists. A hedonic test was performed to evaluate five sensory attributes: color, aroma, taste, texture, and overall

acceptability. Panelists rated each attribute using a five-point hedonic scale, where 1 = strongly dislike and 5 = strongly like.

Data analysis

The data were analyzed using analysis of variance (ANOVA), followed by Duncan's new Multiple Range Test (DnMRT) when significant differences were detected.

3. Results and Discussion

Elongation

The elongation of wet noodles increased with increasing levels of egg white addition, ranging from 10.79% to 16.22% (Table 2). This increase in elongation indicates that a higher amount of egg white improved the noodles' ability to stretch before breaking. These findings are consistent with those of Biyumna *et al*., (2017), who reported that egg addition improved the extensibility and textural properties of noodles due to the binding properties of egg white proteins. The improved elongation observed in this study is likely attributable to the formation of a stronger protein network through interactions between egg white proteins and wheat gluten, enabling the noodles to withstand greater deformation before rupture. In addition, hydrogen bonding between egg white proteins and starch may further strengthen the noodle matrix, thereby contributing to the increased elongation (Ding et al., 2024).

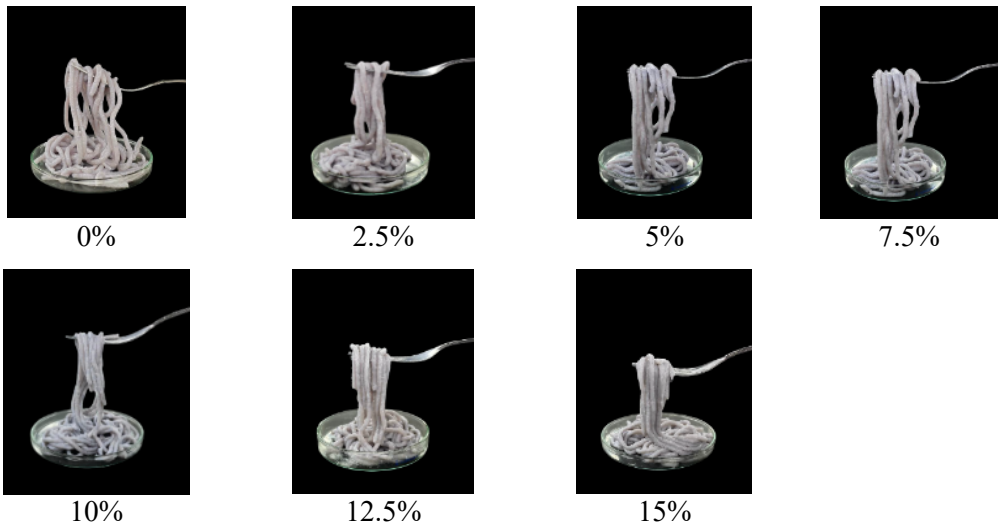

Figure 1. Purple yam wet noodle with various concentrations of egg white

Table 2. Characteristics of purple yam wet noodles with various concentrations of egg white

Egg White (%)	Elongation (%)	Cooking Time (s)	Cooking Loss (%)	Water Content (%)	Protein Content (%)*
0	10.79 ± 0.80^{a}	150 ± 00.00^{a}	4.05 ± 0.23^{d}	62.95 ± 1.14^{a}	11.25±1.20
2.5	11.15 ± 0.82^{a}	160 ± 17.32^{ab}	3.55 ± 0.61^{cd}	63.77 ± 0.77^{ab}	12.52±0.64
5	11.30 ± 0.90^{a}	170 ± 17.32^{abc}	3.32 ± 0.50^{c}	64.50 ± 0.42^{abc}	12.66±0.52
7.5	12.62 ± 1.47^{a}	190 ± 17.32^{bcd}	3.11 ± 0.06^{bc}	64.60 ± 0.43^{abc}	12.71±0.64
10	13.58 ± 1.24^{ab}	190 ± 17.32^{bcd}	2.88 ± 0.36^{abc}	65.35 ± 1.31^{bcd}	13.85±2.40
12.5	15.73 ± 2.40^{b}	200 ± 17.32^{cd}	2.56 ± 0.23^{ab}	66.26 ± 1.08^{cd}	15.29±0.73
15	16.22 ± 2.71^{b}	220 ± 17.32^{d}	2.32 ± 0.28^{a}	67.11 ± 1.25^{d}	16.63±1.34

Note: Numbers followed by different superscripts in the same column indicate significant difference according to the 5% DnMRT.
*Values are obtained from 2 replications

Cooking characteristics

The highest cooking time was observed in the 15% egg white, while the lowest cooking time was found in the treatment without egg white addition (Table 2). In general, increasing the amount of egg white resulted in a longer cooking time. This increase may be associated with the interaction among egg white proteins, wheat flour gluten, and starch from rice flour and purple yam paste. The addition of egg white increased the protein content of the dough (Table 2). During cooking, the denaturation and coagulation of eggs white protein may promote interaction with gluten and starch, potentially resulting in more compact matrix and contributing to the longer cooking time. This denser structure may have reduced the rate of water penetration into the noodles during boiling, which could contribute to the longer time required for the noodles to reach a fully cooked state (Roh et al., 2020).

The cooking loss of purple yam wet noodles decreased as the amount of egg white increased, ranging from 4.05% to 2.32% (Table 2). This decrease in cooking loss may be associated with the role of egg white protein (albumin), which is able to form a gel network during heating. This network might strengthen the noodle structure by binding starch from wheat flour, rice flour, and purple yam paste. Such a structure may reduce the number of solids dissolved in water during cooking. This finding is in line with the research of Biyumna et al. (2017), who reported that increasing egg addition could reduce noodle cooking loss, which may be associated with the high protein content of eggs that acts as an emulsifier. Similarly, other studies reported that the addition of egg white decreased cooking loss in wheat-oat noodles (Guo et al., 2020) and in wheat-mung bean composite noodles (Li et al., 2024).

Moisture content

The use of purple yam paste contributes to the presence of soluble and insoluble dietary fibers of the product. They absorb and bind large amounts of water which may be associated with high water content of the yam wet noodle observed in this study. The water content of purple yam wet noodles increased with increasing egg white concentration (Table 2). This increase in water content may be attributed to the high moisture content of egg whites, which is approximately 88-90%, so the addition of egg whites directly increases the amount of water in the dough. In addition, the main proteins in egg whites, such as ovalbumin, have a high water-binding capacity, allowing more water in the dough system to be retained (Li et al., 2022).

Color profiles

Wet noodles made using purple yam exhibited a dark grayish-blue color in all treatments (Table 3). The L* value (53.03–57.70) increased with increasing egg white addition, particularly at higher concentrations, indicating enhanced brightness due to the light color of egg white and increased surface reflectance (Pathare et al., 2013). The a* value (0.53 to −2.96) decreased as the level of egg white increased, indicating a reduction in the intensity of the red color. This reduction may be attributed to the dilution of anthocyanin pigments and interactions between egg white proteins and anthocyanins. The b* values remained negative across all treatments, indicating the predominance of blue hues derived from purple yam pigments. The observed color changes may also be associated with the reduced stability of anthocyanins during processing, including thermal degradation and pigment leaching during boiling (Oancea, 2021). Furthermore, anthocyanins are unstable at high temperatures, potentially contributing to a decreased color intensity and a shift toward darker or bluish hues.

Table 3. Average color values of purple yam wet noodles with various concentration of egg white

Egg White (%)	L*	a*	b*	Description
0	53.13±3.19	0.53±1.65^{c}	-5.93±1.36	*Dark grayish blue*
2.5	54.03±3.42	-0.68±0.91^{bc}	-7.13±1.27	*Dark grayish blue*
5	53.96±2.25	-0.10±1.15^{bc}	-7.10±0.78	*Dark grayish blue*
7.5	53.83±1.58	-1.20±1.27^{abc}	-7.33±0.77	*Dark grayish blue*
10	53.03±1.81	-1.33±0.90^{abc}	-7.00±1.34	*Dark grayish blue*
12.5	56.60±1.41	-1.86±0.89^{ab}	-7.86±1.00	*Dark grayish blue*
15	57.70±3.45	-2.96±1.19^{a}	-7.36±0.81	*Dark grayish blue*

Note: Numbers followed by different lowercase letters in the same column indicate significant differences according to the 5% DnMRT.

Sensory profiles

The addition of egg white affected color and taste preference in the hedonic test (Table 4). The color hedonic scores ranged from 2.68 to 3.76. with the lowest score was obtained at 15% addition. The decrease in color preference may be caused by pigment dilution due to egg white addition causing the red or purple color to become less intense. Similar to the color preferences, taste preferences also obtained lowest score at the highest amount of white egg addition. The addition of egg white in moderate amounts can improve the taste of the noodles; however, excessive addition may decrease the panelists' preference level.

Table 4. Average hedonic test scores of purple yam wet noodles with various concentration of egg white

White egg (%)	Color	Aroma	Taste	Texture	Overall Acceptance
0	3.76 ± 0.87^{c}	3.52 ± 0.71	3.52 ± 0.71^{b}	3.52 ± 0.77	3.36 ± 0.86^{a}
2.5	3.76 ± 0.66^{c}	3.64 ± 0.70	3.64 ± 0.63^{b}	3.60 ± 0.70	3.64 ± 0.63^{ab}
5	3.64 ± 0.56^{c}	3.32 ± 0.80	3.76 ± 0.77^{b}	3.64 ± 0.56	3.68 ± 0.74^{ab}
7.5	$3.72 \pm 0{,}54^{c}$	3.44 ± 0.71	3.52 ± 0.71^{b}	3.64 ± 0.70	4.08 ± 0.49^{cd}
10	3.60 ± 0.76^{bc}	3.44 ± 0.82	3.64 ± 0.81^{b}	3.72 ± 0.67	4.36 ± 0.56^{d}
12.5	3.20 ± 0.76^{b}	3.40 ± 0.81	3.56 ± 0.58^{b}	3.44 ± 0.58	3.96 ± 0.53^{bc}
15	2.68 ± 0.94^{a}	3.32 ± 0.80	3.08 ± 0.70^{a}	3.28 ± 0.73	3.72 ± 0.61^{abc}

Note: Numbers followed by different lowercase letters in the same column indicate significant differences according to the 5% DnMRT. The assessment score consists of (1) Strongly Dislike, (2) Dislike, (3) Somewhat like, (4) Like, and (5) Strongly Like.

The aroma and texture preference scores were relatively stable across all treatments (Table 4) with no significant differences based on ANOVA results. Egg white has a relatively neutral aroma due to its low-fat content, whereas fat is the primary source of volatile compounds responsible for aroma formation. Aroma in food products is generally produced through lipid oxidation and Maillard reactions during the heating process (Wang *et al*., 2022). Therefore, the lack of significant differences in aroma parameters was likely due to the relatively small contribution of egg white to aroma formation

The overall acceptance of the noodles was significantly affected ($p<0.05$) by the amount of egg white added, based on the ANOVA results. The hedonic scores ranged from 3.36 to 4.36, with the addition of 10% egg white resulting in the highest score (4.36), indicating that the product was liked by the panelists. In contrast, the lowest score was obtained with the addition of 0% egg white, which was categorized as somewhat liked. The changes in the preference scores indicates that the addition of egg white was able to improve the overall sensory characteristics of the noodles, including taste and color. Egg white contains proteins that play an important role in the formation of food tissue structure and may influence sensory characteristics through interactions with other components during processing. However, the addition of higher amounts of egg white (≥12.5%) tended to decrease the panelists' preference levels. This may be because excessive egg white addition produced a more dominant flavor and disrupt the overall flavor balance of the product. In addition, high protein content may contribute to an undesirable sensory characteristics if not properly balanced with other ingredients (Damodaran *et al*., 2017).

4. Conclusion

The addition of egg white significantly influenced the physicochemical and selected sensory characteristics of purple yam wet noodles. Increasing the level of egg white improved the textural and cooking properties of the noodles while enhancing their protein content. Based on the overall quality evaluation, the addition of 7.5% egg white was identified as the optimum treatment, providing the best balance of physical, chemical, and sensory characteristics. These findings demonstrate that egg white is an effective ingredient for improving the quality and consumer acceptability of purple yam wet noodles and supports the development of value-added noodle products based on local raw materials.

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