Characteristics of Wet Noodles From Sago and Sweet Potato Starch with Mung Bean Flour Substitution

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Submitted: 14.03.2024; Revised: 14.12.2024; Accepted: 18.12.2024

ABSTRACT

Sago starch and sweet potato starch are promising alternatives for wet noodle production due to their high amylose and amylopectin content, which contribute to desirable quality characteristics. This study was conducted to determine the effect of the ratio of starch (sago and sweet potato respectively) to mung bean flour on the physicochemical properties of wet noodles, as well as to obtain the best wet noodle formulation. The research was conducted experimentally using a completely randomized design with ten treatments and four replicates. The treatments involved varying ratios of starch to mung bean flour for sago starch-based noodles (SP1: 100:0, SP2: 80:20, SP3: 70:30, SP4: 60:40, SP5: 50:50) and sweet potato starch-based noodles (JP1: 100:0, JP2: 80:20, JP3: 70:30, JP4: 60:40, JP5: 50:50). Parameters measured for the starches included water holding capacity (WHC), swelling power, and solubility. Wet noodle parameters included moisture, ash, and protein content, elongation, water absorption, and sensory characteristics (color, aroma, taste, chewiness, and overall preference). Data were analyzed statistically using ANOVA and further evaluated with DMRT at a 5% significance level. Results showed that different ratios of sago or sweet potato starch and mung bean flour significantly affected all observed parameters. Among the treatments, JP4 (sweet potato starch to mung bean ratio 60:40) received the highest hedonic scores, indicating panelists' preference for all sensory attributes, including color, aroma, taste, chewiness, and overall acceptability. This study demonstrates the potential of using sago starch and sweet potato starch with mung bean flour substitution to develop wet noodles that meet both sensory and nutritional quality standards.

Keywords: sago starch, sweet potato starch, mung bean flour, amylose, protein

INTRODUCTION

Noodles are a staple food in Indonesia, enjoyed by people of all ages. Their high carbohydrate content makes them a common substitute for rice in daily meals. According to the World Instant Noodles Association (WINA), Indonesia ranked second in global instant noodle demand in 2023, with 14.530 million servings, following China/Hong Kong (WINA, 2024). Noodles are generally available in three main types: instant noodles, dry noodles, and wet noodles. Wet noodles are typically made from wheat flour, a processed product derived from wheat seeds. However, Indonesia's dependency on imported wheat to produce wheat flour raises economic and sustainability challenges, with imports reaching 11,172 tons in 2021 (BPS, 2022).

This heavy reliance on imported wheat highlights the need to explore alternative, locally sourced flours for noodle production. Indonesia, as a tropical country, has abundant sources of starch derived from tree trunks, such as sago, and root crops like sweet potatoes. These local ingredients present opportunities for diversification, but their distinct characteristics—especially in elasticity and structure—require innovation to ensure they meet consumer expectations. Therefore, research and development are needed to optimize the use of local starches, such as sago and sweet potato starch, alongside complementary ingredients like mung bean flour, to produce wet noodles that align with SNI 2987-2015 (BSN, 2015)

Sago starch is a widely available local ingredient in Indonesia, particularly in Riau Province. According to Direktorat Jenderal Perkebunan (2022), sago starch production in Riau increased from 359,838 tons in 2019 to an estimated 381,065 tons in 2021. Sago starch is predominantly composed of carbohydrates (85.20%) but has low protein (0.37%) and fat (0.09%) content (Mahmud et al., 2018; Purwani et al., 2006). Similarly, sweet potatoes are another carbohydrate-rich local crop with great potential for the food industry. Sweet potatoes contain 25.1 g carbohydrates, 0.5 g protein, 0.4 g fat, 72.6 g water, 4.2 g fiber, and 1.0 g ash per 100 g (Mahmud et al., 2018). Despite their nutritional benefits, both sago and sweet potato starches have low protein content, which limits their ability to meet the protein requirements for wet noodles as specified by SNI 2987-2015.

To address this limitation, mung bean flour can serve as a protein-rich complementary ingredient. Mung bean flour contains 1.60% water, 22.75% protein, 1.05% fat (Lestari et al., 2017). Its inclusion not only increases the protein content of the noodles but also has the potential to improve their functional and textural properties. Starch-based noodles differ significantly from wheat-based noodles, which rely on gluten proteins to form a viscoelastic dough (Xin-Zhong et al., 2007). In starch-based noodles, network formation is instead driven by gelatinization and retrogradation processes (Tam et al., 2004). However, starch-based noodles are typically characterized by higher hardness (Hormdok & Noormhom, 2007), a drawback that mung bean flour could help mitigate by reducing hardness and enhancing noodle texture.

Previous research on the use of sago starch in wet noodle production has demonstrated the potential of legume flour as a complementary ingredient. Agustia et al., (2016) developed wet noodles using various ratios of sago starch to legume flour (100:0; 90:10; 80:20; 70:30). The best results were obtained with a ratio of 70:30 (sago starch:red bean flour), yielding noodles with a protein content of 10.47% (dry basis), which exceeds the minimum protein requirement for wet noodles as per SNI 2987-2015. These findings highlight the feasibility of incorporating legumes to improve the nutritional quality of starch-based noodles.

Building on this foundation, sweet potato starch can complement sago starch in wet noodle production, leveraging its high carbohydrate content and unique functional properties. While sweet potato starch enhances energy content, the addition of mung bean flour ensures compliance with protein standards while potentially improving textural attributes such as elasticity and chewiness. This combination could provide a sustainable and nutritious alternative to wheat-based noodles, reducing reliance on wheat imports.

This study aims to determine the effect of the ratio of starch (sago and sweet potato respectively) to mung bean flour on the physicochemical properties of wet noodles, as well as to obtain the best wet noodle formulation. Specifically, the best ratio of the ingredients to produce cooked wet noodles that meet the quality requirements set by SNI 2987-2015. By utilizing local resources, this research seeks to contribute to the diversification of raw materials in noodle production, promoting the use of sustainable and locally sourced ingredients while meeting consumer preferences and nutritional standards.

MATERIALS AND METHODS

Tools and Materials

The ingredients used were dry sago starch purchased from PT. Martabat Sagu Sejati in Meranti Islands Regency, white sweet potato starch of Mega Samudera brand, and local varieties of mung beans from local shop in Pekanbaru. Other additives include water, eggs, salt, and carboxymethyl cellulose (CMC). The materials used for analysis were H_2BO_3 1%, H_2SO_4, NaOH 40%, HCl 0.02 N, methyl red indicator 1%, methyl blue indicator 1%, phenolphthalein indicator, alcohol 96%, selenium reagent, and aquades.

The tools used were ovens, flour machines, noodle mills (*ampia*), pots, gas stoves, digital scales, 80 mesh sieves, cutting boards, basins, and knives. Analytical equipment is an analytical oven, furnace, protein distillation machine, desiccator, Teflon burette, Kjeldahl flask, analytical scale, porcelain dishes, measuring cup, measuring flask, trophy cup, erlenmeyer, funnel, drip pipette, water pipette, ball pipette, tongs, and spatula.

Research Design and Data Analysis

This study began with observations of several functional properties of raw materials, namely sago starch and sweet potato starch, including Water Holding Capacity (WHC), swelling power, and solubility. Subsequently, wet noodles were made from each starch type by substituting mung bean flour. The research was conducted experimentally using a completely randomized design. The treatments in this study consisted of the ratio of sago starch to mung bean flour (SP), as well as sweet potato starch to mung bean flour (JP), which were as follows: SP1 (100:0); SP2 (80:20); SP3 (70:30); SP4 (60:40); SP5 (50:50), JP1 (100:0); JP2 (80:20); JP3 (70:30); JP4 (60:40); JP5 (50:50). Data obtained from the observations were statistically analyzed using IBM SPSS Statistics software version 24 with an analysis of variance (ANOVA) test. If the F-value ≥ F-table, further analysis was conducted using Duncan's Multiple Range Test (DMRT) at a 5% significance level to identify differences between treatments.

Production of Mung Bean Flour

The manufacture of mung bean flour refers to Jumanah et al. (2017). Green pea seeds are cleaned of dirt and damaged seeds. Green bean seeds are then washed using running water. Clean green bean seeds are soaked in hot water at 60°C and left to stand for 8 hours. The following stage for green bean seeds is peeling off the seed coat. Green bean seeds are then dried using an oven at 60°C for 7 hours. The seeds are then mashed using a flour machine. The next flour stage is sifted using an 80mesh sieve, and green bean flour is obtained.

Production of Wet Noodle

The manufacture of wet noodles refers to Agustia et al. (2016), with formulation referring to Effendi et al. (2016). Sweet potato starch and mung bean flour mixed according to treatment. A mixture of sweet potato starch and mung bean flour as much as 20%, which is 11.90 g for each treatment, mixed homogeneously with other ingredients, namely water 26.79 ml, eggs 11.90 g, salt 1.19 g, and CMC 0.60 g. The mixture is then cooked until thick, and a paste-shaped dough is obtained. In each treatment, this pasta dough is mixed with 80% or 47.60 g of sweet potato starch and mung bean flour and doughed until smooth, manually. The smoothed dough is then molded with a noodle mill (ampia), boiled in boiling water for 1 minute, drained for 5 minutes, and cooked wet noodles. The cooked wet noodles are then directly analyzed.

RESULTS AND DISCUSSION

Water Holding Capacity (WHC) of Starch

WHC analysis can measure flour or starch's ability to retain the water it absorbs. The results showed that the different types of starch, had a significant effect on the WHC of the starch produced. The average WHC of starch is presented in Table 1.

The analysis showed that the average Water Holding Capacity (WHC) of sweet potato starch is higher than that of sago starch. This difference can be attributed to variations in granule composition and structure, including amylose and amylopectin content, granule size, and starch-water interactions. Studies indicate that starch with higher amylose content typically exhibits greater WHC due to the ability of amylose to form gel matrices that effectively retain water (Hoover, 2001). In this study, preliminary data showed amylose content at 33.19% (sweet potato starch) and 29.72% (sago starch), consistent with findings by Polnaya et al. (2015) at 38.98% for sweet potato starch, and 27-33% for sago starch (Polnaya et al., 2015). Amylose, with its linear structure, offers more accessible hydroxyl groups compared to branched amylopectin. Additionally, granule size plays a role, as smaller granules, like those of sweet potato starch (2–45 µm) (Zhu & Wang, 2014), provide a larger surface area for water binding compared to sago starch (10–50) µm, average diameter 32 µm (Karim et al., 2008).

Swelling Power of Starch

Swelling power is a property that characterizes the development of a material. Starch with a high water absorption capacity will produce value swelling power or great starch expanding power. The results showed that the different types of starch, have a significant effect on swelling power. The average swelling power of starch is presented in Table 2.

Table 2 shows that the swelling power of sago starch is 7.48 g/g, while sweet potato starch is 8.58 g/g. The swelling power value of sago starch is lower than that of sweet potato starch because of the difference in starch levels in each ingredient. Muchlisyiyah et al. (2016) state that swelling power is influenced by the ability of starch molecules to bind to water through the formation of hydrogen bonds. After gelatinization occurs, the hydrogen bonds between starch molecules are broken and replaced by hydrogen bonds with water so that the starch gelatinizes and the starch granules expand to the maximum. Expanding starch granules is due to the amount of water absorbed into each starch granule that expands, resulting in swelling power becoming inflated.

The starch molecule that plays an essential role in binding water is amylose. According to Darmawan et al. (2013), the starch's amylose content can affect the high and low swelling power. Starches with a high amylose content have a higher swelling power. Sago starch has lower amylose content compared to that of sweet potato starch. According to Polnaya et al. (2015), sago starch consists of 27-33%, amylose while sweet potato starch contains 38.98%.

The higher amylose content in sweet potato starch contributes to stronger water retention and swelling. Additionally, the amorphous regions in starch granules facilitate water absorption, with sweet potato starch likely having a greater proportion of such regions compared to sago starch. Literature suggests that swelling power is also affected by granule size and crystalline structure, as smaller granules with lower crystallinity swell more easily (Hoover, 2001; Singh et al., 2007). These findings align with the structural properties of sweet potato and sago starches reported in previous studies.

Solubility of Starch

Solubility is the ability of a material to be absorbed in water. The higher the solubility value, the more quickly a material will dissolve in water. The results showed that the different types of starch had an insignificant effect on solubility. The average solubility of starch is presented in Table 3.

The study results indicate that the solubility of sago starch is 3.62±1.08, while that of sweet potato starch is 2.96±1.08, with the difference being statistically insignificant. Solubility reflects the release of starch molecules, particularly amylose, into the aqueous medium during heating. This insignificant difference may be attributed to the relatively similar molecular structures, such as comparable amylose content (Hoover, 2001). Additionally, the crystallinity of starch, where higher crystallinity tends to reduce solubility, might explain the similar values observed (Singh et al., 2007).

Wet Noodles

Moisture Content

Moisture content is the amount in a material expressed in units of percent. Moisture content can affect food ingredient's quality, shelf life, and consistency, such as texture, appearance, and taste. The results showed that the ratio of starch and mung bean flour significantly affected the wet noodles' moisture content. The average moisture content of wet noodles is presented in Figure 1.

Based on Figure 1, it can be seen that the moisture content of wet noodles made from sago starch and sweet potato starch with mung bean flour substitution ranges from 57.94–72.51%. The SP5 treatment has the lowest moisture content and significantly differs from the other treatments. The moisture content of wet noodles decreases with less sago starch and sweet potato starch and more mung bean flour used. This is thought to be due to differences in moisture content in each raw material. Based on data from raw material analysis, sago starch and sweet potato starch have a higher moisture content than mung bean flour. The water content of sago starch and sweet potato starch is 10.70 and 11.55%, respectively, while mung bean flour is 5.78%.

The high and low water content in wet noodles is also influenced by the starch content in each raw material, especially the amylose content. High levels of amylose in a material cause a higher water absorption level. Yuliansar et al. (2020) state that the amylose content of the starch influences the ease of gelation of starch; the higher the amylose content, the greater the ability of the starch to absorb water. The raw materials in this study, namely sago starch and sweet potato starch, have higher starch levels than mung bean flour's starch content. According to Kusnandar et al. (2015), native sago starch contains a starch content of 87.13%. Yuliansar et al. (2020) stated that white sweet potatoes contains starch of 85.16%. According to Triwitono et al. (2017), mung bean of several varieties contain starch levels ranging from 40.41–43.46%. Reducing the amount of sweet potato starch and increasing the amount of mung bean flour decreases the amylose content of wet noodles, resulting in a lower moisture content. The moisture content of wet noodles, according to SNI 2987-2015, should not exceed 65%. The results showed that all sago starch-based wet noodle treatments met this standard, while treatments JP1 and JP2 of sweet potato starch-based wet noodles did not.

Ash Content

The ash content in a food can indicate the amount of minerals it contains (Purwasih, 2021). The showed that the ratio of sago starch and mung bean flour had a significant effect on the average moisture content of the noodles. The average value ash content of wet noodle is presented in Figure 2.

Based on Figure 2, it can be seen that the ash content of wet noodles made from sago starch and sweet potato starch with mung bean flour substitution ranges from 0.37–0.98%. The ash content in the SP5 treatments did not differ significantly from that of the JP5 and SP4 treatments, but it was significantly different from the other treatments. The increase in ash content in wet noodles can be attributed to the lower use of sago starch and sweet potato starch and the higher use of mung bean flour due to the varying ash content in each raw material. As per the analysis of raw materials, sago starch and sweet potato starch have a lower ash content than mung bean flour. The ash content of sago starch and sweet potato starch is 0.37% and 0.24%, respectively, while the ash content of mung bean flour is 3.46%.

The ash content of wet noodles increases with the amount of mung bean flour used because mung beans' mineral content is higher than sago starch and sweet potato starch. Minerals contained in 100 g of sago starch per 100 g of ingredients, namely calcium 30 mg, phosphorus 30 mg, iron 0.2 mg, sodium 11 mg, copper 0.1 mg, zinc 0.1 mg and minerals contained in 100 g white sweet potatoes including calcium 0.03 g, phosphorus 0.01 g, iron 0.005 g, sodium 0.02 g, potassium 0.04 g, copper 0.001 g, and zinc 0.002 g (Mahmud et al., 2018). The mineral content of sago starch and sweet potato is lower than the mineral content in 100 g of mung beans, including calcium 0.22 g, phosphorus 0.31 g, iron 0.07 g, sodium 0.04 g, potassium 0.82 g, copper 0.02 g, and zinc 0.03 g. The high mineral content in mung beans causes the ash content of wet noodles to increase, along with the increased use of mung bean flour. The findings of this study are consistent with the research of Jumanah et al. (2017), which states that the higher proportion of mung bean flour causes an increase in ash content. The ash content in this study, overall, has met the quality standards for the ash content of cooked wet noodles as stipulated by SNI-2987-1992, which sets a maximum limit of 3%.

Protein Content

Protein analysis aims to determine the effect of the ratio of sago starch, sweet potato starch, and mung bean flour on the protein produced in wet noodles. The results showed that using sago starch, sweet potato starch, and mung beans with different ratios significantly affected wet noodles' protein content. The average protein content of wet noodles is presented in Figure 3.

Based on Figure 3, the protein content of wet noodles increased with more mung bean flour, less sago starch, and sweet potato starch. Based on data from raw material analysis, sago starch and sweet potato starch have much lower protein levels than mung bean flour. The protein content of sago starch and sweet potato starch was 0.69% and 1.15%, respectively, and that of mung bean flour was 29.18%.

Mung bean flour contains a relatively high protein content of 22.75% (Lestari et al., 2017). The protein content of wet noodles in this study is in line with the research of Agustia et al. (2016), the protein content of wet noodles made from sago starch and mung bean flour increases along with less sago starch and more amount of mung bean flour added. Protein levels in the study ranged from 0.74–10.43% with a ratio of sago starch and mung bean flour (100:0; 90:10; 80:20; 70:30).

In this study, mung bean flour was utilized as a protein-rich substitute to enhance the nutritional profile of starch-based wet noodles. However, the protein content of wet noodles in treatments SP1, SP2, JP1, JP2, and JP3 did not meet the minimum protein content of 6% as stipulated by SNI 2987-2015.

Elongation

Elongation is the maximum extension of noodles when given mechanical treatment in the form of attraction and expressed in percent. Elongation is closely related to elasticity. The results showed that the ratio of sago starch and mung bean flour had a significant effect on the elongation of wet noodles. The average wet noodle elongation is presented in Figure 4.

Figure 4 shows that the elongation of wet noodles made from sago starch and sweet potato starch ranges from 2.50% to 30.00%. The highest elongation obtained at the JP1 treatment differed markedly with all treatments. The wet noodle elongation in this study decrease with less starch and more mung bean flour. This is thought to be caused by protein content derived from mung bean flour.

This study utilized mung bean flour, a protein-rich ingredient, which resulted in lower elongation values for wet noodles. This is due to the absence of gluten in mung bean flour. Prabawa et al. (2023) stated that noodles made from non-gluten-containing ingredients tend to break more easily. Gluten is a protein capable of developing elasticity and chewiness in flour-based products such as noodles and bread (Agusandi et al., 2013).

Water Absorption

The water absorption of wet noodles is the amount of water that the noodles can absorb during the boiling process. The higher water absorption indicates that more water can be absorbed by the noodles so that the noodles expand more (Lala et al., 2013). The results showed that sago starch, sweet potato starch, and mung bean flour with different ratios had a significant effect on the water absorption of wet noodle . The average values are presented in Figure 5.

Based on Figure 5, it can be seen that the water absorption of wet noodles made from sago starch and sweet potato starch ranges from 106.15–129.37%. The highest water absorption was obtained in the JP1, which is not significantly different from SP5. Sago starch noodles exhibited increasing water absorption from SP1 to SP5, while sweet potato starch noodles showed a decreasing trend from JP1 to JP5

The water absorption of wet noodles made from sago starch and mung bean flour increased as the proportion of sago starch decreased and mung bean flour increased. This phenomenon can be attributed to the high protein content of mung bean flour, which enhances water-binding capacity. The higher the protein concentration in food, the greater the amount of water that can be bound, primarily due to the hydrophilic nature of amino acids (Kusnandar, 2019). Previous studies have shown that protein-rich materials exhibit superior water retention capacity compared to starch-based counterparts, attributable to the formation of a more extensive protein network (Ikhlas et al., 2020).

Conversely, wet noodles made from sweet potato starch and mung bean flour showed a decrease in water absorption capacity under similar conditions. This contrasting result may stem from the denser granule structure and lower amylopectin content in sweet potato starch, which limit hydration and interaction with mung bean flour. Mulyadi et al. (2014) state that amylose will absorb more water in the cooking process.

Water absorption significantly impacts wet noodles' development rate, quality, and texture. As stated by Lala et al. (2013), high water absorption results in a more significant expansion of the noodles. According to Canti et al. (2020), noodles with low fluffing power will have a soft and sticky texture, whereas noodles with low fluffing power will have a complex and non-sticky texture. It is expected that wet noodles will have a normal texture, similar to the texture of wet noodles in general, as outlined in SNI 2987-2015.

Hedonic Test

The results showed that the ratio of sago starch, sweet potato starch, and mung bean flour had significant effect on color, aroma, taste, chewiness, and overall acceptance of wet noodles hedonically. The average values are presented in Table 4.

Color

Color is one of the main parameters that can determine the level of panelists' liking for the products produced. The raw materials used in making wet noodles will affect the wet noodles' color. Based on Table 4, the average hedonic score of wet noodle color ranged from 1.46–3.98, which was immensely disliked to like. Based on the results, panelists prefer the yellowing color of wet noodles. This is because the color of the noodles looks similar to the color of wet noodles in general. Jayati et al. (2018) state that color plays an essential role in a food product because, in addition to its nutritional content, the attractive color of food products will make someone interested in consuming it. All treatments have met the quality requirements of cooked wet noodles following SNI 2987-2015, which is normal (Figure 6a and 6b).

Aroma

The deliciousness of a food can be determined by its aroma. The average aroma assessment score of wet noodles ranges from 1.68 to 3.23 (dislike to somewhat like). Based on results, panelists prefer wet noodles with a green bean aroma because they have a distinctive (peas-like) aroma. This study aligns with the findings of Situmorang et al. (2017), based on hedonic evaluation, panelists preferred the aroma of flakes made with the highest addition of mung bean flour (80%) with a mean score of 1.02, as measured using the Visual Analogue Scale (VAS). The study by Lestari et al. (2017) confirms that the hedonic assessment score of *bingka* cake aroma aligns with the results of this study. It is clear that panelists increasingly favored the aroma of *bingka* cake as more mung bean flour was used due (2.9 as like for 100% mung bean) to its distinctive mung bean aroma.

Taste

Taste is one of the impressions influenced by the constituent ingredients of a food product that can be received through the sense of taste, namely the tongue. Table 4 showed that the average assessment score of wet noodles taste ranges from 1.51–3.70, namely, dislike to like. Based on results, panelists liked wet noodles made with more mung bean flour. This is because sago starch and sweet potato starch do not have a specific taste and tend to be tasteless, so the amount of mung bean flour influenced the taste in this study. This research aligns with Situmorang et al. (2017), panelists preferred the taste of flakes made with the highest addition of mung bean flour (80%) because of the distinctive taste of beans, with a mean score of 1.22, as measured using the Visual Analogue Scale (VAS).

Chewiness

Chewiness refers to the degree of firmness or resistance to chewing of the noodles. Table 4 showed the average chewiness assessment score of wet noodles, ranges from 2.80–3.84, which is somewhat like to like. Based on results, it was found that panelists' preference for the chewiness of wet noodles from sago starch decreased with less sago starch and more mung bean flour. In comparison, panelists' preference for the chewiness of sweet potato starch wet noodles increased with less sweet potato starch and more mung bean flour. This is due to differences in raw materials. The decrease in the chewiness of sago starch wet noodles, according to panelists, caused the chewiness to be much reduced, while despite the decrease, the chewiness level of sweet potato starch wet noodles was still in the normal category and tended to be more similar to the chewiness of wet noodles in general.

Overall Assessment

The overall assessment of wet noodles was hedonically judged based on panelists' level of liking for color, aroma, taste, and chewiness. Based on Table 4, the average overall score of wet noodles ranged from 2.21–3.69, namely, dislike to like. The less sago starch and sweet potato starch and the more mung bean flour, the panelists' preference for the whole wet noodles increased. This is because panelists prefer wet noodles with yellow color, mung bean aroma, mung bean flavor, and very chewy texture.

CONCLUSION

This study concludes that sago starch exhibits lower water-holding capacity (WHC) and swelling power but higher solubility compared to sweet potato starch. The ratio of sago starch or sweet potato starch to mung bean flour significantly influences the physicochemical properties of wet noodles, including moisture, ash, and protein content, as well as elongation and water absorption. Among the treatments, JP4 (a 60:40 ratio of sweet potato starch to mung bean flour) emerged as the best formulation, meeting the quality standards of SNI 2987-2015 for wet noodles. Sensory evaluation results further supported this finding, with JP4 receiving high panelist preferences for all assessed attributes, including color, aroma, taste, chewiness, and overall acceptability. These results demonstrate the potential of sweet potato starch and mung bean flour as sustainable and nutritionally viable alternatives in wet noodle production.

ACKNOWLEDGEMENT

We appreciate the research grant from the Faculty of Agriculture, Universitas Riau.

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Table 1. Average starch water holding capacity

Treatment	Water Holding Capacity (g/g)±SD
Sago starch	0.97^{a}±0.07
Sweet potato starch	1.08^{b}±0.03

Means in the same column followed by different superscript letters indicate significant (P<0.05), n=4

Table 2. Average swelling power of starch

Treatment	Swelling power (g/g)±SD
Sago starch	7.48^{a}±0.50
Sweet potato starch	8.58^{b}±0.47

Means in the same column followed by different superscript letters indicate significant (P<0.05), n=4

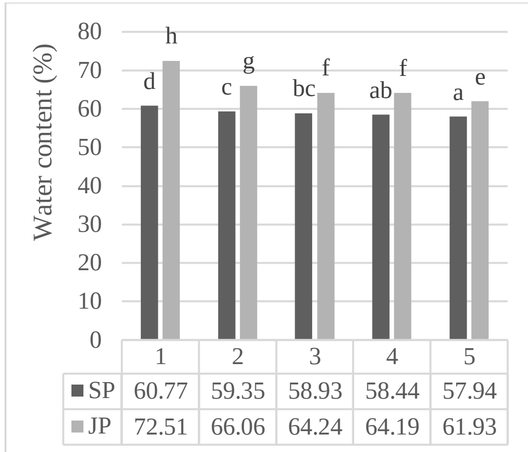
Table 3. Average solubility of starch

Treatment	Solubility (g/g)±SD
Sago starch	3.62±1.08
Sweet potato starch	2.96±1.08

Table 4. Hedonic test of wet noddles from sago starch and sweet potato starch with substitution of mung bean flour

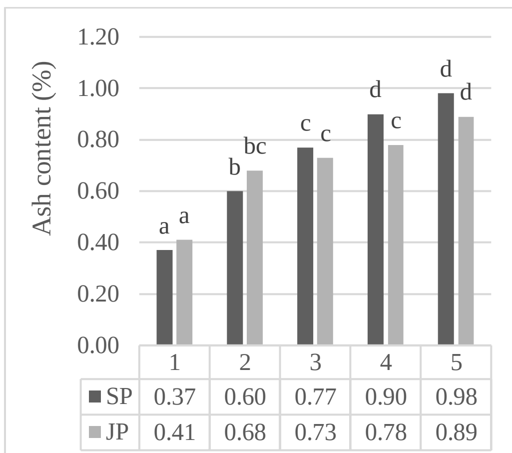
Treat-ment	Color	Aroma	Taste	Chewi-ness	Overall
SP1	1.46^{a}	1.68^{a}	1.51^{a}	3.63^{cde}	2.21^{a}
SP2	2.59^{c}	2.34^{b}	2.35^{b}	3.84^{e}	2.64^{b}
SP3	3.00^{d}	2.49^{b}	2.79^{c}	3.81^{de}	3.05^{c}
SP4	3.78^{fg}	3.03^{cd}	3.69^{e}	3.03^{a}	3.74^{f}
SP5	3.81^{fg}	2.79^{c}	3.70^{e}	2.80^{a}	3.69^{f}
JP1	2.18^{b}	2.78^{c}	2.95^{c}	3.34^{b}	2.91^{c}
JP2	3.09^{d}	2.96^{cd}	3.30^{d}	3.48^{bc}	3.30^{d}
JP3	3.45^{e}	2.93^{c}	3.35^{d}	3.75^{de}	3.45^{de}
JP4	3.74^{f}	3.23^{d}	3.40^{d}	3.55^{bcd}	3.58^{ef}
JP5	3.98^{g}	3.21^{d}	3.55^{de}	3.56^{bcd}	3.69^{f}

Numbers followed by different lowercase letters in the same column show significant differences (P<0.05). Hedonic score 1. Dislike very much, 2. Dislike, 3. Somewhat like, 4. Like, 5. Very like.



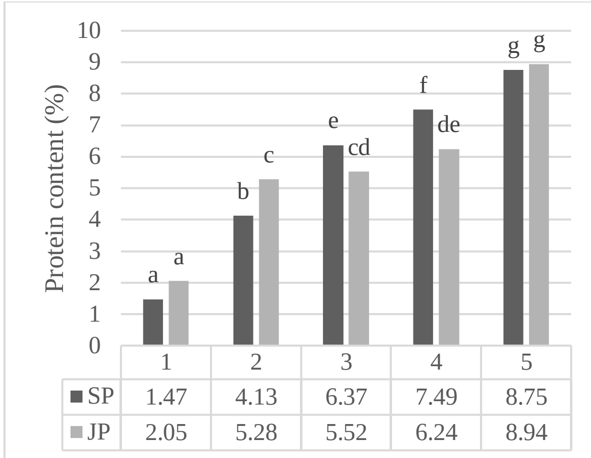
Different letters outside the end of data points indicate significant (P<0.05)

Figure 1. Moisture content of wet noodles from sago starch and sweet potato starch with mung bean flour substitution



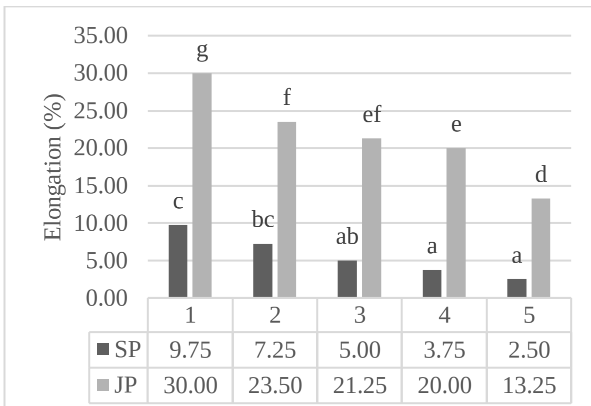
Different letters outside the end of data points indicate significant (P<0.05)

Figure 2. Ash content of wet noodles from sago starch and sweet potato starch with mung bean flour substitution



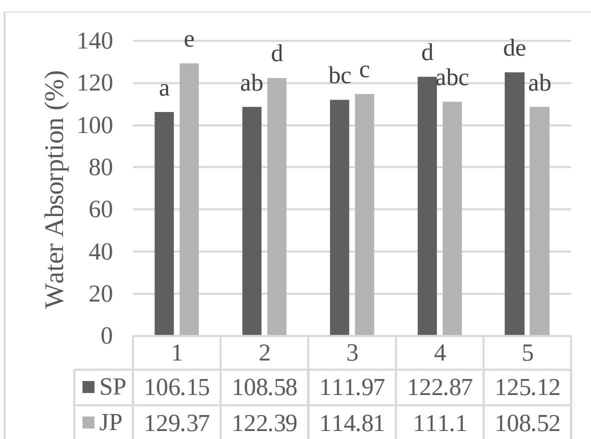
Different letters outside the end of data points indicate significant (P<0.05)

Figure 3. Protein content of wet noodles from sago starch and sweet potato starch with mung bean flour substitution



Different letters outside the end of data points indicate significant (P<0.05)

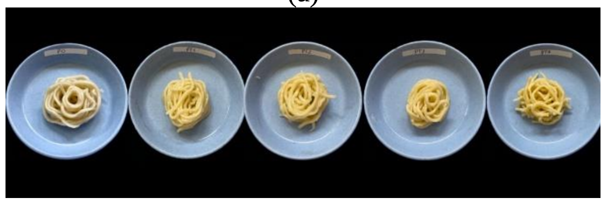
Figure 4. Elongation of wet noodles from sago starch and sweet potato starch with mung bean flour substitution



Different letters outside the end of data points indicate significant (P<0.05)

Figure 5. Water absorption of wet noodles from sago starch and sweet potato starch with mung bean flour substitution

(a)



(b)

Figure 6. Wet noodles made from starch and mung bean flour: (a) sago; (b) sweet potato