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The Effect of Different Stabilizers on the Characteristics of Gluten-Free Dried Noodle from Arrowroot and Mung bean Flour

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ABSTRACT

Dry noodles are one of the foods made from wheat flour. The availability of wheat in Indonesia does not match consumer demand, necessitating the use of alternative ingredients such as arrowroot flour and mung bean flour. The use of stabilizers like CMC, STPP, and Xanthan Gum is needed to improve the characteristics of dry noodles. This research aims to determine the effect of the proportion of arrowroot flour and mung bean flour with different types of stabilizers on the physicochemical and organoleptic characteristics of dry noodles. The experimental design used was a factorial CRD with two factors. Factor I was the proportion of arrowroot flour and mung bean flour and Factor II was the addition of different types of stabilizers. Data were analyzed using 5% ANOVA and 5% DMRT. There was a significant interaction ($p \leq 0.05$) on the moisture content, ash, protein, fat, starch, rehydration capacity, cooking loss, elasticity, and organoleptic characteristics of aroma, texture, and overall appearance. There were no significant differences in the organoleptic characteristics of color and taste. The best treatment was the proportion of arrowroot flour and mung bean flour (60:40) with the addition of CMC stabilizer, which resulted in dry noodles with the following characteristics: moisture 11.392%, ash 1.919%, protein 11.592%, fat 1.378%, starch 54.720%, rehydration capacity 110.266%, cooking loss 6.398%, elasticity 0.314 N, aroma 4.200, color 4.040, taste 3.800, texture 4.200, and overall appearance 4.160.

1. INTRODUCTION

1.1. *Research Background*

The main raw material for making noodles is wheat flour. However, in Indonesia, wheat is still imported due to unfavorable climatic conditions for growing wheat, the raw material for flour (Winarti et al., 2017). Consumer demand does not match the availability of wheat in Indonesia. Wheat imports in Indonesia increased from January to October 2023 compared to 2022. Wheat commodity imports during that period increased by 8.64%, or 8.57 million tons, compared to the same period the previous year, which was 7.88 million tons (BPS, 2023).

1.2. *Literature Review*

Arrowroot tuber (Maranta arundinaceae L.) is a tuber that has the potential to develop into food products, one of which is dried noodles (Thamrin and Pujilestari, 2016). Arrowroot tubers are beneficial for health because they are high in carbohydrates and rich in dietary fiber. The government also prioritizes the cultivation of arrowroot tubers because they can replace wheat flour (Litbang Pertanian, 2014). The advantages of arrowroot flour are its easily digestible starch content due to the presence of 24.64% amylose and 73.46% amylopectin, and a total starch content of 98.10% (Faridah et al., 2014). To enhance food diversification, local food ingredients with high protein content are needed because arrowroot flour does not contain gluten and has a low protein level (Adyana, 2017).

Mung beans are one of the local food ingredients with high protein content. According to data from the Central Bureau of Statistics in 2018, Central Java, East Java, and West Nusa Tenggara are the top three provinces in mung bean production in Indonesia, with East Java recording a production of 52,403 tons in 2017. Mung beans are rich in protein and starch, surpassing other types of beans, making them an ideal ingredient for dried noodles as they provide a chewy and elastic texture. Mung bean flour is also rich in calcium and phosphorus, which are important for bone health, and contains vitamins B1 and B2 (Rifani and Astuti, 2015). Mung bean flour is high in dietary fiber and contains 30-34% amylose and 66-70% amylopectin (Wahjuningsih et al., 2020).

Gluten-free dried noodle products will have poor texture and elasticity, so it is necessary to add different types of stabilizers. In this study, the effect of the proportion of flour and the addition of different types of stabilizers on gluten-free dried noodles made from arrowroot flour and mung bean flour will be examined to obtain good characteristics. These stabilizers are Carboxymethyl Cellulose (CMC), Sodium Tripolyphosphate (STPP), and Xanthan Gum. According to Arinachaque et al. (2023), stabilizers play a role in controlling water migration during cooking, making the dough more compact, less brittle, and less likely to break apart.

CMC forms a colloidal solution, has hygroscopic properties, and functions as a form-giver, providing texture and consistency. CMC acts as a leavening agent, and thickener, enhances water resistance, and maintains softness during the production of dried noodles (Hasibuan et al., 2015). According to research by Kartini & Putri (2018), in polymer molecules, CMC typically forms cross-links that trap solvent molecules within them, resulting in a rigid and pressure-resistant molecular structure. The hydrogen bonds in the starch chain are reinforced by these cross-links, causing amylose and amylopectin molecules to form hydrogen bonds with each other, making the gel more compact.

STPP has negatively charged polar phosphate groups. The hydrophilic nature of STPP's polar groups allows the phosphate fractions to dissolve in water molecules and bind with proteins. Gels can be formed by STPP due to its hydrophilic ions, which can cause a balance between insoluble and soluble states (Arisandy & Estiasih, 2016). According to research by Nursanty & Sugiarti (2018), the OH groups of amylose bind to the phosphate groups of STPP compounds, altering the properties of amylose. STPP can increase the number of phosphate groups replacing the OH groups in starch. With this substitution, the hydrogen bonds in starch weaken, allowing water to enter the starch granules (Mutmainah et al., 2015). Additionally, STPP can reduce amylopectin, increasing its solubility (Nursanty & Sugiarti, 2018).

Xanthan Gum is a polysaccharide with polar groups that allow water to form hydrogen bonds with hydroxyl groups (-OH) and can bind water up to 32,300±1100 grams of hydrogen per 100 grams of solid. Xanthan Gum's water-binding capacity can cause volume reduction and evaporation of water content, reducing the amount of free water that evaporates (Ramadhan et al., 2015). According to research by Wahyuningsih et al. (2015), Xanthan Gum can form films and adhesive interactions among gelatinized granules. These interactions can strengthen the amylose and amylopectin matrix, increasing the granules' robustness. During the drying process, the pores of the product become harder due to the increased granule robustness, resulting in a firmer product.

1.3. Research Objective

Previous research by Widyaningtyas & Susanto (2015) studied the effect of different types and concentrations of stabilizers on the characteristics of dried noodles using yellow sweet potato pasta. The study stated that the addition of stabilizers to dried noodles can make the gel matrix more compact and reduce the hollow structure, thereby maintaining the chewiness and firmness. This study aims to diversify arrowroot flour and mung bean flour into dried noodle products without using wheat flour to reduce wheat imports and to add different types of stabilizers to improve the characteristics of these dried noodles. It is hoped that the dried noodle products will have physicochemical and organoleptic characteristics that are acceptable to consumers.

2. MATERIALS AND METHODS

2.1 Materials

The tools used for making dried noodle products are a single-screw extruder, cabinet dryer, and steamer. The materials for making dried noodle products include Cap Burung brand arrowroot flour and Lingkar Organik brand mung bean flour, which are obtained from online stores, CMC, STPP, and Xanthan Gum, which are certified and obtained from online stores, salt, water, and eggs. The tools used to analyze physicochemical characteristics are an analytical balance, petri dishes, furnace, Kjeldahl flask, weighing bottles, water bath, condenser, Soxhlet apparatus, weighing bottles, and UV-Vis spectrophotometer. The materials for physicochemical analysis include Kjeldahl tablets, H2SO4, NaOH, HCl, distilled water, petroleum benzene, 95% ethanol, and CH_3COOH.

2.2 Research procedure

The research conducted is an experimental study using a Completely Randomized Factorial Design method with 2 repetitions. Factor I (A) is the proportion of arrowroot flour and mung bean flour:

A1 = 80% Arrowroot Flour : 20% Mung Bean Flour
A2 = 70% Arrowroot Flour : 30% Mung Bean Flour
A3 = 60% Arrowroot Flour : 40% Mung Bean Flour
Factor II (B) is the addition of different types of stabilizers:
B1 = 1% CMC Stabilizer
B2 = 0.75% STPP Stabilizer
B3 = 1% Xanthan Gum Stabilizer.

2.3 Process of Making Gluten-Free Dried Noodles

The process of making dried noodles is conducted using modifications from the research by Setiawati (2015), as follows: preparation of arrowroot flour and mung bean flour with proportions according to the treatments (80:20), (70:30), (60:40). Arrowroot flour and mung bean flour are mixed with additional ingredients: 20% water, 30% egg whites, and 1% salt. The dough is then mixed with different types of stabilizers according to the treatments (1% CMC, 0.75% STPP, 1% Xanthan Gum). The dough is compacted in a container and steamed for 5 minutes at a temperature of 100°C. The noodle dough is then shaped using a single screw extruder and dried using a cabinet dryer at 60°C.

2.4 Analysis of Physical, Chemical, and Organoleptic Characteristics of Dried Noodles

The physical analysis includes rehydration capacity analysis (Romlah & Haryadi, 1997), cooking loss analysis (Subarna et al., 2014), and elasticity (tensile strength) using a rheometer (Kurniasari et al., 2015). Chemical analysis includes moisture content analysis (AOAC, 2005), ash content analysis (AOAC, 2005), protein content analysis (AOAC, 2005), fat content analysis (AOAC, 2005), carbohydrate content analysis (Rauf, 2015), starch content analysis (AOAC, 1995), and organoleptic testing using a hedonic test with 25 moderately trained panelists, assessing color, aroma, taste, texture, and overall appearance (Lasaji et al., 2023).

2.5 Data Analysis

The obtained data are then subjected to Analysis of Variance (ANOVA) and further tested using Duncan's Multiple Range Test (DMRT) at a significance level of 95%. Decision analysis to determine the best treatment is conducted using the De Garmo effectiveness test.

3. RESULT AND DISCUSSION

3.1 Chemical Characteristics of Gluten-Free Dried Noodles

3.1.1 Water Content

The analysis of variance indicates significant interactions ($p < 0.05$), with each treatment significantly affecting the moisture content of gluten-free dried noodles when varying the proportions of arrowroot flour and mung bean flour combined with different stabilizers. The average moisture content values for each treatment of gluten-free dried noodles are shown in **Table 1.**

Table 1. shows that the addition of CMC stabilizer increases the moisture content as the proportion of mung bean flour increases. This is because CMC binds to the polar hydrophilic protein groups, thereby trapping water and making it difficult to evaporate during drying. This finding is consistent with research by Azizah et al. (2021), which suggests that CMC tends to bind hydrophilic proteins and can trap water through polar amino acids. Materials with peptide-length polar chains become hydrophilic, leading to an increase in moisture content at the same heating temperature due to the high protein content.

Table 1. also demonstrates that adding STPP stabilizer decreases moisture content in the (70:30) proportion and increases it in the (60:40) proportion. This is because there is a decrease in starch content in the (70:30) proportion and an increase in protein content in the (60:40) proportion. The decrease in moisture content is attributed to STPP's hydrophilic polar groups, which allow its phosphate fraction to bind starch granules and maintain high water content. Therefore, the reduction in starch content reduces trapped water within the granules (Alfatina et al., 2022). The increase in moisture content is due to STPP preventing protein denaturation during drying and enhancing the ionic strength of proteins, thereby binding water and making it difficult to evaporate (Amahorseja et al., 2017).

Table 1. further indicates that the Xanthan Gum stabilizer decreases moisture content in the (70:30) proportion and increases it in the (60:40) proportion. This is because there is a decrease in starch content in the (70:30) proportion and an increase in protein content in the (60:40) proportion. According to Ramadhan et al. (2015), Xanthan Gum has hydroxyl groups that bind with starch and trap water in a complex matrix. The decrease in starch content leads to reduced moisture content due to decreased trapped water. Conversely, the increase in moisture content is attributed to Xanthan Gum binding nitrogen atoms in proteins and preventing denaturation during heating, thereby making it difficult for proteins to evaporate water (Zainuddin et al., 2020).

The moisture content of the dried noodles in this study ranges from 8.396% to 11.627%, meeting the requirements of SNI 8217-2015, which specifies a maximum moisture content of 13%.

3.1.2 Ash Content

The analysis of variance indicates significant interactions ($p < 0.05$), with each treatment significantly affecting the ash content of gluten-free dried noodles when varying the proportions of arrowroot flour and mung bean flour combined with different stabilizers. The average ash content values for each treatment of gluten-free dried noodles can be seen in **Table 1.**

Table 1. shows that adding CMC stabilizer decreases the ash content in the (70:30) proportion and increases it in the (60:40) proportion. This is because there is a decrease in starch content in the (70:30) proportion and an increase in protein content in the (60:40) proportion. The decrease in ash content in the (70:30) proportion is due to reduced CMC binding with starch, thereby reducing mineral binding. Conversely, the increase in ash content in the (60:40) proportion is due to increased CMC binding with protein, leading to increased mineral binding. According to Tinambunan et al. (2014), CMC contains sodium that binds with starch, and during heating processes, this interaction reduces minerals, resulting in low ash content.

Table 1. also indicates that adding STPP stabilizer decreases the ash content in the (70:30) proportion and increases it in the (60:40) proportion. The decrease in ash content in the (70:30) proportion is due to decreased phosphate binding of STPP with starch, reducing soluble nutrients. The increase in ash content in the (60:40) proportion is attributed to enhanced STPP binding with protein, thereby increasing soluble nutrients (Nugraha et al., 2017).

Table 1. further shows that adding Xanthan Gum stabilizer increases the ash content in the (70:30) proportion and decreases it in the (60:40) proportion. The increase in ash content in the (70:30) proportion is due to increased Xanthan Gum binding with protein, thereby enhancing mineral binding. Conversely, the decrease in ash content in the (60:40) proportion is due to decreased binding of Xanthan Gum's polar groups with starch, reducing mineral binding. According to Ramadhan et al. (2015), the high ash content in products with Xanthan Gum is due to its ash content, which includes minerals such as calcium, potassium, and sodium, ranging from 7-12%.

The ash content of the dried noodles in this study ranges from 1.699% to 2.130%, meeting the requirements of SNI 01-2974-1996 with a maximum ash content of 3%.

3.1.3 Protein Content

The analysis of variance shows significant interaction ($p < 0.05$), with each treatment significantly affecting the protein content of gluten-free dried noodles when varying the proportions of arrowroot flour and mung bean flour combined with different

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stabilizers. The average protein content values for each treatment of gluten-free dried noodles can be seen in **Table 1.**

Table 1. indicates that higher proportions of mung bean flour with different stabilizers increase the protein content in dried noodles because mung bean flour contains more protein than arrowroot flour. According to Akbar et al. (2020), the addition of stabilizing agents increases protein content with specific roles.

Table 1. shows that the proportion of arrowroot flour and mung bean flour with CMC results in dried noodles with higher protein content compared to STPP and Xanthan Gum. CMC binds and prevents protein precipitation by interacting with polar groups, thereby increasing the protein content of the product. According to Nelas et al. (2022), CMC prevents protein precipitation by the carboxyl groups of CMC interacting with the positive charges of protein.

Table 1. also shows that the addition of Xanthan Gum plays a role in binding protein, although its protein content is not as high as CMC. Xanthan Gum binds to nitrogen atoms in proteins and prevents denaturation during heating, thereby increasing the protein content (Zainuddin et al., 2020).

Table 1. indicates that STPP also plays a role in binding protein, although its protein content is lower compared to other stabilizers. STPP prevents protein denaturation during drying and enhances the ionic strength of proteins, resulting in increased protein content (Amahorseja, 2017).

The protein content of the dried noodles in this study ranges from 6.924% to 11.592%, with three treatments meeting the requirements for dried noodles according to SNI 8217-2015, which specifies a minimum protein content of 10%. These treatments are A3B1, A3B2, and A3B3.

3.1.4 Fat Content

Analysis of variance shows significant interaction ($p < 0.05$), with each treatment significantly affecting the fat content of gluten-free dried noodles when varying the proportions of arrowroot flour and mung bean flour combined with different stabilizers. The average fat content values for each treatment of gluten-free dried noodles can be seen in **Table 1.**

Table 1. indicates that higher proportions of mung bean flour with different stabilizers increase the fat content in dried noodles because mung bean flour contains more fat than arrowroot flour. According to Akbar et al. (2020), stabilizing agents have varying abilities to bind fats through hydrophobic groups, trapping fats in the product.

Table 1 shows that the proportion of arrowroot flour and mung bean flour with STPP results in dried noodles with lower fat content compared to CMC and Xanthan Gum. STPP binds starch with its ionic phosphate groups, thereby enhancing the product's ability to bind fats in materials (Yuliani et al., 2022).

Table 1 also shows that the addition of CMC also plays a role in fat binding, although its fat content is not as low as STPP. CMC has lipophilic groups that bind non-polar fats, thereby enhancing the product's ability to bind fats in materials. This is supported by the findings of Hartatik & Damat (2017), suggesting that the higher fat content with CMC addition is due to CMC molecules having lipophilic groups that can bind oil or other non-polar materials.

Table 1 indicates that the addition of Xanthan Gum also plays a role in fat binding, with the highest fat content compared to other stabilizers. The gel matrix formed by Xanthan Gum during gelatinization allows fats to be trapped within it, thereby increasing the fat content (Wahyuningsih et al., 2015).

3.1.5 Starch Content

Analysis of variance shows significant interaction ($p < 0.05$), with each treatment significantly affecting the starch content of gluten-free dried noodles when varying the proportions of arrowroot flour and mung bean flour combined with different stabilizers. The average starch content values for each treatment of gluten-free dried noodles can be seen in **Table 1.**

Table 1 shows that higher proportions of mung bean flour with different stabilizers lead to a decrease in starch content because mung bean flour has lower starch content compared to arrowroot flour. This is consistent with research by Pratama & Nisa (2014) indicating that higher concentrations of mung bean flour result in decreased starch content in dried noodles due to its predominantly simple sugar carbohydrates.

Table 1 indicates that the proportion of arrowroot flour and mung bean flour with STPP results in dried noodles with higher starch content compared to CMC and Xanthan Gum. STPP binds starch molecules through its phosphate groups, strengthening phosphate bonds and reducing starch loss during heating, thus improving the interaction of STPP with starch and the starch content of the product (Setiyoko & Yuliani, 2021).

Table 1 also shows that the addition of CMC plays a role in maintaining starch content, although not as strongly as STPP. CMC can maintain the starch matrix in dried noodles and prevent starch loss due to heating, resulting in reduced interaction of CMC with starch and lower starch content of the product due to the low starch content of the raw materials used (Kartini & Putri, 2018).

Table 1 further indicates that the addition of Xanthan Gum also plays a role in maintaining starch content, although its starch content is the lowest compared to other stabilizers. Xanthan Gum binds dough through its hydroxyl groups interacting with starch and reducing starch loss due to heating, thus resulting in reduced interaction of Xanthan Gum with starch and the starch content of the product due to the low starch content of the raw materials used (Efendi et al., 2023).

Table. 1 The results of the analysis of the chemical characteristics of gluten-free dried noodles

Treatment		Water Content (%)	Ash (%)	Protein (%)	Fat (%)	Starch (%)
Arrowroot flour : Mungbean Flour (%)	Type of Stabilizer					
80:20	CMC	9.588±0.045^{c}	1.905±0.010^{de}	8.060±0.014^{c}	1.006±0.011^{d}	64.793±0.028^{g}
	STPP	9.945±0.016^{d}	2.078±0.029^{g}	6.924±0.045^{a}	0.789±0.005^{a}	67.717±0.094^{h}
	Xanthan Gum	9.872±0.006^{d}	1.699±0.021^{a}	7.463±0.016^{b}	0.911±0.019^{c}	56.017±0.040^{d}
70:30	CMC	9.707±0.014^{c}	1.820±0.010^{b}	9.172±0.016^{d}	1.163±0.006^{e}	60.499±0.088^{e}
	STPP	8.567±0.107^{b}	1.859±0.006^{c}	9.343±0.013^{e}	0.830±0.022^{b}	63.173±0.042^{f}
	Xanthan Gum	8.396±0.120^{a}	2.130±0.008^{h}	9.514±0.017^{f}	1.304±0.008^{g}	53.064±0.040^{b}
60:40	CMC	11.392±0.008^{e}	1.919±0.009^{ef}	11.592± 0.015^{g}	1.378±0.034^{h}	54.270±0.040^{c}
	STPP	10.000±0.016^{d}	1.940±0.006^{f}	10.871±0.015^{h}	1.238±0.008^{f}	56.073±0.070^{d}
	Xanthan Gum	11.627±0.008^{f}	1.883±0.006c^{d}	11.053±0.016^{i}	1.418±0.010^{i}	49.503±0.081^{a}

Description: values accompanied by different letters indicate significant differences ($p \leq 0.05$)

3.2 Physical Characteristics of Gluten-Free Dried Noodles

3.2.1 Rehydration Capacity

Analysis of variance shows significant interaction ($p < 0.05$), with each treatment significantly affecting the rehydration capacity of gluten-free dried noodles when varying the proportions of arrowroot flour and mung bean flour combined with different stabilizers. The average rehydration capacity values for each treatment of gluten-free dried noodles can be seen in **Table 2.**

Table 2 shows that the addition of CMC stabilizer increases the rehydration capacity with increasing proportions of mung bean flour. This is because the carboxyl groups of CMC can bind to hydrophilic protein groups, thereby absorbing and retaining water in the product during boiling, especially with a high amount of bound protein groups (Azizah et al., 2021).

Table 2 indicates that the addition of STPP stabilizer decreases the rehydration capacity at the proportion of (70:30) and increases it at (60:40). This is due to the decrease in starch content at (70:30) and the increase in protein content at (60:40). The decrease in rehydration capacity at (70:30) is caused by the polar nature of STPP, which binds to starch and facilitates water absorption into the granules. The more starch binds to phosphate compounds, the more cross-linking of starch-phosphate bonds occurs, enhancing water penetration into the starch granules during boiling (Yuliani et al., 2022). Meanwhile, the increase in rehydration capacity at (60:40) is attributed to STPP preventing protein denaturation during drying and enhancing the ionic strength of proteins, thereby increasing protein content and water absorption through protein groups (Amahorseja, 2017).

Table 2 also shows that the addition of Xanthan Gum increases the rehydration capacity at (70:30) and decreases it at (60:40). This is because of the increased protein content at (70:30) and the high interaction of proteins and fats with Xanthan Gum at (60:40). The increase in rehydration capacity at (70:30) is due to the hydroxyl groups of Xanthan Gum binding with proteins and forming a complex matrix that binds water through hydrogen bonding during boiling, thus enhancing rehydration capacity (Efendi et al., 2023). The decrease in rehydration capacity at (60:40) is caused by hydroxyl group interactions with the high protein and fat content of the product, forming a layer on starch granules that delays gelatinization. This delay results in smaller starch granules that do not form a gel, inhibiting water absorption during boiling (Karneta et al., 2014).

3.2.2 Cooking Loss

Analysis of variance indicates significant interaction ($p < 0.05$), with each treatment significantly influencing the cooking loss of gluten-free dried noodles when varying the proportions of arrowroot flour and mung bean flour combined with different stabilizers. The average cooking loss values for each treatment of gluten-free dried noodles can be seen in **Table 2.**

Table 2 shows that the addition of CMC stabilizer increases cooking loss at the (70:30) proportion and decreases it at the (60:40) proportion. This occurs due to the reduction in starch content at (70:30) and the increase in protein content at (60:40). The increase in cooking loss at (70:30) is attributed to weakened cross-linking of CMC with starch granules during heating, coupled with reduced starch content, leading to weakened hydrogen bonds in the starch chain and formation of a weak gel structure, resulting in solids loss during cooking (Azizah et al., 2021). The decrease in cooking loss at (60:40) is due to strong cross-linking between carboxyl groups of CMC and polar protein groups, maintaining the integrity of starch solids to resist dissolution during boiling, thus reducing cooking loss (Monica et al., 2018).

Table 2 indicates that the addition of STPP stabilizer increases cooking loss with increasing proportions of mung bean flour. This is because of the weakened interaction of STPP with starch granules during heating, alongside a decrease in starch content. Reduced starch content diminishes cross-linking between phosphate groups and starch molecules, compromising granule integrity. This makes starch granules susceptible to breakage during boiling, resulting in more soluble amylose and significant solid loss (Setiyoko & Yuliani, 2021).

Table 2 also shows that the addition of Xanthan Gum stabilizer increases cooking loss with increasing proportions of mung bean flour. This is due to weakened interaction of Xanthan Gum with starch granules during heating, leading to reduced starch content. Low starch content weakens hydroxyl group interactions with starch and other groups, causing increased starch loss during cooking (Lubis et al., 2018).

3.2.3 Elasticity

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Analysis of variance indicates significant interaction ($p < 0.05$), with each treatment significantly influencing the elasticity of gluten-free dried noodles when varying the proportions of arrowroot flour and mung bean flour combined with different stabilizers. The average elasticity values for each treatment of gluten-free dried noodles can be seen in **Table 2.**

Table 2 shows that the addition of a CMC stabilizer increases elasticity with increasing proportions of mung bean flour. This is because carboxyl groups of CMC can bind to polar hydrophilic protein groups, absorbing and trapping water during boiling, thereby enhancing noodle elasticity. Additionally, longer peptide bonds require greater energy to break, and higher protein content contributes to greater elasticity (Azizah et al., 2021).

Table 2 indicates that the addition of STPP stabilizer decreases elasticity at the (70:30) proportion and increases it at the (60:40) proportion. This is due to reduced starch content at (70:30) and increased protein content at (60:40). The decrease in elasticity at (70:30) is caused by STPP binding to starch granules, weakening hydrogen bonds, trapping water, and making the noodles elastic. Lower starch content reduces phosphate group substitutions, thereby decreasing noodle elasticity (Faisal et al., 2023). Conversely, increased elasticity at (60:40) is due to STPP preventing protein denaturation, increasing protein ion strength, enhancing water binding capacity, and making noodles more elastic (Amahorseja, 2017).

Table 2 shows that the addition of Xanthan Gum stabilizer increases elasticity at the (70:30) proportion and decreases it at the (60:40) proportion. This is because protein content increases at (70:30) and high interactions of protein and fat with Xanthan Gum at (60:40). The increased elasticity at (70:30) is attributed to hydroxyl groups of Xanthan Gum binding to proteins, forming a complex matrix with hydrogen bonds that trap water during boiling, thereby increasing noodle elasticity (Efendi et al., 2023). The decrease in elasticity at (60:40) is caused by hydroxyl group interactions with proteins and fats, forming layers on starch granules that delay gelatinization, resulting in small granules that do not form gel and hinder water absorption during boiling, thus reducing noodle elasticity (Karneta et al., 2014).

Table 2. The results of the analysis of the physical characteristics of gluten-free dried noodles

Treatment		Rehydration Capacity (%)	*Cooking Loss* (%)	Elastisitasity (N)
Arrowroot flour : Mungbean Flour (%)	**Type of Stabilizer**			
80:20	CMC	91.935±0.024[b]	6.523±0.028[a]	0.267±0.003[b]
	STPP	121.491±0.689[i]	7.392±0.045[d]	0.335±0.004[h]
	Xanthan Gum	99.083±0.054[d]	6.777±0.059[b]	0.286±0.001[d]
70:30	CMC	107.886±0.052[f]	7.915±0.033[e]	0.297±0.001[e]
	STPP	96.075±0.054[c]	7.519±0.065[d]	0.280±0.004[c]
	Xanthan Gum	115.298±0.062[h]	7.060±0.080[c]	0.323±0.001[g]
60:40	CMC	110.266±0.051[g]	6.398±0.083[a]	0.314±0.002[f]
	STPP	105.521±0.074[e]	8.417±0.087[f]	0.293±0.002[e]
	Xanthan Gum	87.413±0.129[a]	8.912±0.053[g]	0.254±0.004[a]

Description: values accompanied by different letters indicate significant differences ($p \leq 0.05$)

3.3 Organoleptic Characteristics of Gluten-Free Dried Noodles

3.3.1 Aroma

The Friedman test results indicate that the proportions of arrowroot flour and mung bean flour with different stabilizer additions significantly affect ($p \geq 0.05$) the liking scores for the aroma of gluten-free dried noodles produced. The average liking scores for the aroma of gluten-free dried noodles for each treatment can be seen in **Table 3.**

Table 3 shows that the proportion of arrowroot flour and mung bean flour (60:40) with CMC addition produces the best aroma due to the high content of mung bean flour. Meanwhile, the proportion (80:20) with Xanthan Gum produces the lowest aroma score due to the low content of mung bean flour. This is because mung bean flour tends to have a distinctive sweet and pleasant aroma, whereas arrowroot flour does not contribute to aroma during processing (Maylanti et al., 2022).

3.3.2 Color

The Friedman test results indicate that the proportions of arrowroot flour and mung bean flour with different stabilizer additions do not significantly affect ($p \geq 0.05$) the liking scores for the color of the gluten-free dried noodles produced. The average liking scores for the color of gluten-free dried noodles for each treatment can be seen in **Table 3.**

Table 3 shows that the addition of stabilizers to the proportions of arrowroot flour and mung bean flour does not influence the color of the dried noodles. According to the panelists, the noodle colors are nearly identical, making them difficult to distinguish.

3.3.3 Taste

The Friedman test results indicate that the proportions of arrowroot flour and mung bean flour with different stabilizer additions do not significantly affect ($p \geq 0.05$) the liking scores for the taste of the gluten-free dried noodles produced. The average liking scores for the taste of gluten-free dried noodles for each treatment can be seen in **Table 3.**

Table 3 shows that the addition of stabilizers to the proportions of arrowroot flour and mung bean flour does not influence the taste of the dried noodles. According to the panelists, the noodle tastes are nearly identical, making them difficult to distinguish.

3.3.4 Texture

The Friedman test results indicate that the proportions of arrowroot flour and mung bean flour with different stabilizer additions significantly affect ($p < 0.05$) the liking scores for the texture of the gluten-free dried noodles produced. The average liking scores for the texture of gluten-free dried noodles for each treatment can be seen in **Table 3.**

Table 3 shows that the proportions of arrowroot flour and mung bean flour (70:30) with Xanthan Gum produce the best texture due to sufficient water absorption and elasticity, making the noodles resistant to breaking and not excessively chewy. Conversely, the proportions (60:40) with Xanthan Gum resulted in the worst texture due to low water absorption and insufficient elasticity, causing the noodles to break easily and be somewhat hard, which was less preferred by the panelists. According to Agustiana et al. (2020), good noodles have a slightly chewy texture that is not easily broken. This texture comes from the starch and protein content that can bind water during cooking.

3.3.5 Overall Appearance

The Friedman test results indicate that the proportions of arrowroot flour and mung bean flour with different stabilizer additions significantly affect ($p < 0.05$) the liking scores for the overall appearance of the gluten-free dried noodles produced. The average liking scores for the overall appearance of gluten-free dried noodles for each treatment can be seen in Table 3.

Table 3 shows that the proportions of arrowroot flour and mung bean flour (70:30) with Xanthan Gum produce noodles with the best appearance because the aroma, color, taste, and texture are liked by the panelists. Conversely, the proportions (80:20) with Xanthan Gum result in the lowest appearance scores because they are less preferred by the panelists. According to Syahbuddin et al. (2014), good noodles should meet criteria such as not having a sour smell, not being slimy, having a bright yellow color, being slightly chewy in texture, and not easily breaking.

Table 3. The results of the analysis of the organoleptic characteristics of gluten-free dried noodles

Treatment		**Aroma**	**Color**	**Plavour**	**Texture**	**Overall**
Arrowroot flour : Mungbean Flour (%)	**Stabilizer**					
80:20	CMC	3.200	4.080	3.560	3.240	3.400
	STPP	3.080	3.840	3.600	3.280	3.280
	Xanthan Gum	3.080	3.880	3.640	3.560	3.160
70:30	CMC	3.280	3.960	3.800	3.960	3.800
	STPP	3.160	3.920	3.760	3.360	3.440
	Xanthan Gum	3.680	4.200	4.080	4.320	4.360
60:40	CMC	4.200	4.040	3.800	4.200	4.160
	STPP	3.480	3.640	3.920	3.720	3.280
	Xanthan Gum	3.360	3.400	3.840	3.120	3.320

Description: values accompanied by different letters indicate significant differences ($p \leq 0.05$)

4 CONCLUSION

There is a significant interaction between the treatments of arrowroot flour and mung bean flour proportions and the addition of different stabilizers on the physicochemical characteristics of dried noodles, including moisture content, ash content, protein content, fat content, starch content, rehydration ratio, cooking loss, and elasticity. There are significant differences in the sensory characteristics of aroma, texture, and overall appearance. However, there are no significant differences in the sensory characteristics of color and taste.

The analysis indicates that the best treatment is with a proportion of 60% arrowroot flour and 40% mung bean flour, supplemented with CMC stabilizer. The characteristics obtained include moisture content of 11.392%, ash content of 1.919%, protein content of 11.592%, fat content of 1.378%, starch content of 54.720%, rehydration ratio of 110.266%, cooking loss of 6.398%, elasticity of 0.314 N, aroma score of 4.200, color score of 4.040, taste score of 3.800, texture score of 4.200, and overall appearance score of 4.160.

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