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The characteristics of noodles from fermented taro flour with the addition of cassava starch and xanthan gum

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Abstract

The purpose of the study was to determine the effect of adding cassava starch and xanthan gum to fermented taro flour noodles and to find the best combination of cassava starch, and xanthan gum, based on the characteristics of dried taro noodles. Fermented taro flour is made from slices of fermented taro tubers by soaking in water (1:2) for 24 hrs to reduce oxalate content, dried, and ground into flour. Fermented taro flour was added with cassava starch (0 and 10%) and xanthan gum (0; 0.25; 0.50; 0.75%). The dough was mixed with water and steamed. The pregelatinized dough was extruded into noodles and the noodles were dried. The addition of cassava starch and xanthan gum concentration and their interactions had a very significant effect ($p<0.01$) on moisture content, ash content, cooking time, cooked weight, a* value (redness or greenness), b* value (yellowness or blueness) of dried taro noodles. The addition of cassava starch increased cooking loss while xanthan gum decreased cooking loss. The lightness (L*) of dried taro noodles was affected only by the addition of cassava starch. The interaction of cassava starch and xanthan gum can improve the texture of taro noodles. This study concluded that taro flour with the addition of cassava starch and xanthan gum has the potential to be a gluten-free noodle ingredient. The best combination found to produce gluten-free fermented taro flour noodles is fermented taro flour with the addition of 10% cassava starch and 0.75% xanthan gum.

1. Introduction

Taro (*Colocasia esculenta*) has the potential as a source of carbohydrates and contains nutritional, bioactive, and antioxidant values (Simsek and Nehir, 2015; Arıcı *et al*., 2016). Taro starch granules are small in size between 1-5 meters resulting in a smooth gel texture, easy to digest, and a better mouthfeel (Simsek and Nehir, 2015; Alam *et al*., 2020) compared to yam and sweet potato starch. The use of taro tubers is limited because they contain oxalate and have a short shelf life. To reduce oxalate levels, fermentation is carried out, while to extend the shelf life and wider use, taro is processed into flour.

In addition to reducing the oxalate content of taro tubers by 64.35% (Indrastuti *et al*., 2021), natural fermentation also gives a distinctive flavor to food products. Research on the use of taro flour combined with rice flour and pigeon pea as well as banana starch and potato starch in noodles has been carried out (Kaushal and Sharma, 2014; Sonia *et al*., 2019). However, there has not been much research on the use of naturally fermented low-oxalate taro flour as a substitute for wheat flour in dried noodles.

Wheat flour contains gluten which consists of gliadin and glutenin (Sonia *et al*., 2019). Wheat-based noodles have a firmer, more elastic texture and lower solids loss due to gluten (Lu and Collado, 2019). Gluten-free noodles are an option for people with gluten intolerance, but they have the disadvantage of not being able to form a gluten network structure similar to noodles made of wheat flour (Li *et al*., 2020). This weakness can be overcome by modifying the noodle-making process.

Modifications to the process of making non-wheat noodles that have been carried out are pre-gelatinization treatment (Lubowa *et al*., 2020; Li *et al*., 2020), the addition of hydrocolloid gum arabic, CMC, and xanthan gum, which xanthan gum gives the best results) (Alam *et al*., 2020; Calle *et al*., 2020), and the use of both binders and pre-gelatinization (Kamsiati *et al*., 2021). According to Kamsiati *et al*. (2021), the use of a 10% cassava starch binder followed by pre-gelatinization by steaming for 20 minutes improved the quality of sorghum noodles due to

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the function of starch as a binder, but its effect on fermented taro noodles is not yet known.

The modification that is expected to overcome the problem is the combination of adding cassava starch as a binder and xanthan gum hydrocolloid. The next problem is the unknown effect of adding cassava starch and xanthan gum and the combination of the two on the characteristics (water content, ash, cooking properties, texture, and colour) of taro noodles. This study aimed to determine the effect of adding cassava starch and xanthan gum to the characteristics of dried taro noodles and determine the combination of fermented taro flour with the addition of cassava starch and xanthan gum that produces the best-dried taro noodles.

2. Materials and methods

2.1 Materials

The main ingredient, taro was purchased from the taro chips industry in the village of Jawa Tengah, Sungai Ambawang sub-district, Pontianak Indonesia. For analysis, chemical grade pro analysis (pa) was used. The taro used was black taro of local varieties. Black taro has a colour the base of the petiole is black, the shape of the corms cone, and the color of the corms flesh is white.

2.2 Preparation of taro flour

Taro tubers were cleaned, peeled, washed, and sliced into chips. The taro chips were fermented by soaking the taro tubers for 48 hrs at ambient temperature. The sliced tubers were dried at a drying temperature of 60°C for 12 hrs and ground into flour. The flour was sifted through an 80-mesh sieve and stored in a plastic bag.

2.3 Preparation of taro noodle

The making of taro noodles was carried out as follows; 200 g of taro flour, one part without the addition of cassava starch (0%) and the other part with 10% cassava starch added. 35% water and 0.3% salt were added to the flour mixture, including 0.25%; 0.5%; 0.75% xanthan gum. Control was made without the addition of xanthan gum, thus obtaining eight treatments which were repeated three times.

Taro noodle was prepared by blending the ingredients. Proportion taro flour and cassava starch (100:0 and 90:10 %) was mixed with 35% water, 0,3% salt, and xanthan gum (0; 0.25; 0.5; 0.75%). Control was made without the addition of cassava starch and xanthan gum, thus obtaining eight treatments which were repeated three times.

The mixture was stirred until homogeneous, put into a filter cloth and compacted, then steamed for 20 min. The dough was extruded to obtain wet taro noodles. Wet taro noodles were dried in a cabinet dryer at 60°C for 3 hrs to obtain dried noodles.

Parameters observed in dried noodles include wet basis (wb) moisture. Dry taro noodles were dried at a temperature of 105 °C until the weight was constant. The difference in weight before and after drying is the amount of water evaporated. Dry basis (db) ash content (AOAC, 2011), The colour of noodles was measured by determining Hunter lightness (L *), redness-greenness (a*), and yellowness-blueness (b*) values. Cooking time was determined as the time needed for a white spot in the middle of the noodles to disappear. Cooking loss analysis and cooked weight were determined as described by Kaur *et al*. (2015). About 10 g of dry taro noodles are cooked in 250 mL of boiling distilled water for 5 mins. Distilled water and noodles were separated. Distilled water was heated in an oven at 105°C until all the water had evaporated, and the remaining dry ingredients were weighed and calculated as cooking loss. Noodles that have been separated from distilled water were cooled and weighed as cooked weight. The texture was analyzed using a Texture Analyzer (Javaid *et al*., 2018) and microstructure using a Scanning Electron Microscope (SEM).

2.4 Analysis

Data were obtained from three replications of experiments and values were expressed as a mean ± standard deviation (SD). Observational data were analyzed using Completely Randomized Design (CRD) and processed using Minitab. If from the analysis results, there was a significant interaction effect, the DMRT test (5%) would be carried out, while if there was no interaction, the Least Significance Different (LSD) test (5%) would be carried out. The best treatment was chosen using an effectiveness index (de Garmo *et al*., 1994).

3. Results and discussion

3.1 Moisture content, ash content, and cooking quality dried taro noodles

Moisture content greatly affects the rheological, physical, chemical, processing, stability, and shelf-life characteristics of food (Li *et al*., 2018), including taro noodles. The moisture content of dried taro noodles is between 7.62 – 9.07% wb (Table 1). The moisture content of dried taro noodles in all treatments met the Codex Alimentarius Commission (2006) Standard for Instant Noodles (CXS 249-2006) which was a maximum of 10%.

Analysis of variance showed that the addition of

Table 1. Moisture, ash content, and cooking quality of dried taro noodles at different concentrations of cassava starch and xanthan gum.

Cassava starch (%)	Xanthan Gum (%)	Moisture (wb) (%)	Ash (db) (%)	Cooking time (s)	Cooked weight (%)	Cooking loss (%)
0	0.00	8.81±0.43^{b}	2.26±0.03^{e}	170.0±4.33^{a}	176.60±7.15^{ab}	7.11±0.65^{a}
	0.25	8.91±0.18^{b}	2.22±0.06^{de}	182.5±4.33^{b}	186.28±10.35^{bc}	
	0.50	8.83±0.36^{b}	2.27±0.04^{e}	192.5±4.33^{bc}	195.38±7.37^{cd}	
	0.75	8.74±0.23^{b}	2.16±0.04^{cd}	197.5±4.33^{c}	198.79±10.27^{cd}	
10	0.00	7.62±0.10^{a}	1.89±0.01^{a}	282.5±4.33^{d}	164.76±4.85^{a}	8.51±0.40^{b}
	0.25	7.94±0.30^{a}	2.04±0.04^{b}	322.5±7.50^{e}	167.51±6.72^{a}	
	0.50	8.87±0.06^{b}	2.15±0.08^{cd}	337.5±7.50^{f}	189.19±9.85^{bc}	
	0.75	9.07±0.13^{b}	2.10±0.04^{bc}	365.0±4.33^{g}	207.81±12.29^{d}	

Values are presented as mean±SD of triplicate analysis. Values with different superscripts within the same column are statistically significantly different ($p \leq 0.05$).

cassava starch and xanthan gum concentration and the interaction of the two factors had a significant effect ($p<0.01$) on the moisture content of taro noodles. In dried taro noodles without the addition of cassava starch, the addition of xanthan gum did not affect the moisture content of taro noodles, this is presumably the presence of fiber in taro flour which binds water, this is in accordance with the research of Milde *et al.* (2020) where the addition of xanthan gum did not affect the moisture content of the paste. Starch also has high carbohydrates that could bind water. The addition of starch is supposed to increase moisture content but the addition of 10% cassava starch with xanthan gum concentrations of 0 and 0.25% has a lower moisture content than the concentrations of 0.5 and 0.75%. Cassava starch contains higher amylose than taro flour (Table 2), so the mixture with 10% cassava starch contains higher amylose than without cassava starch. The higher amylose content in the mixture can reduce water absorption, according to Liu *et al*. (2021) noodles with high amylose can inhibit water absorption and swell due to the maintenance of starch granule structure. The high amylose content limits the level of swelling of starch and also results in a decrease in cooked weight (Table 1). In addition, starch with higher amylose content undergoes faster retrogradation than starch with lower amylose (Krystyjan *et al*., 2022). Retrogradation causes water syneresis and water evaporates more easily during drying. The moisture content of dried taro noodles with the addition of 10% cassava starch and 0.5 and 0.75% xanthan gum was higher, this was because of the interaction of cassava starch and xanthan gum as hydrocolloids had a high water-holding capacity. Increasing the concentration of hydrocolloids can convert free water into bound water (Maleki and Milani, 2013). According to Román-Brito *et al*. (2007), hydrocolloids produce a network that blocks water migration during drying. In noodles with cassava starch and xanthan gum with a concentration of 0.25%, it is suspected that amylose plays a greater role than xanthan gum. According to Krystyjan *et al*. (2022), structural changes in corn starch depend on the amylose content in the starch and the amount of hydrocolloid added to the mixture. The ash content of taro noodles ranges from 1.89 to 2.27% db (Table 1) and meets the Indonesian Dried Noodle Quality Standard (National Standardization Agency, 2015) which is a maximum of 3%. Analysis of variance showed that the addition of cassava starch and xanthan gum concentration and the interaction of the two factors had a very significant effect ($p<0.01$) on the ash content of taro noodles. The ash content is influenced by the mineral content in the raw material. The ash content of taro noodles without the addition of cassava starch was greater than that of taro noodles with the addition of cassava starch at the same xanthan gum concentration, this was due to the higher ash content of taro flour compared to cassava starch (Table 2). In taro noodles with 10% cassava starch, the greater the concentration of xanthan gum added, the greater the ash content. This is because xanthan gum has a higher ash content than cassava starch, taro flour, which is 7.60±0.05% (Ezera *et al*., 2019).

Table 2. Composition of taro flour and cassava starch.

	Taro Flour [a]	Cassava starch
Water (%)	9.99±0.12	13.49
Ash (%)	1.09±0.05	0.29
Ca oxalate (mg/100 g)	412.07±31.30	ND
Acid oxalate (mg/100 g)	383.10±45.54	ND
Amylose (%)	13.94±0.13	17.67
L* (Lightness)	91.84±0.27	95.20
a* (Redness-Greenness)	1.31±0.05	-1.33
b* (Yellowness-Blueness)	5.65±0.17	1.53

[a] Indrastuti *et al*. (2020), nd: not detected.

The cooking quality of taro noodles consists of cooking time, cooked weight, and cooking loss. According to Hormdok and Noomhorm (2007), cooking time and cooking loss are factors that determine the quality of rice noodles. Good noodles have a short cooking time and a small cooking loss value. Insufficient cooking time usually results in noodles that are hard and coarse in texture, but too long cooking time results in noodles that are too soft and sticky (Hormdok and Noomhorm, 2007). Analysis of variance showed that the addition of cassava starch, xanthan gum concentration, and the interaction of the two factors had a very significant effect ($p<0.01$) on the cooking time and cooked weight of taro noodles (Table 1).

Cooking time is the time it takes for noodles to gelatinize in boiling water. During cooking, starch swells when it comes into contact with hot water, some granules gelatinize and become part of the pasta structure, while others are leached to the medium along with amylose chains, resulting in an undesirable sticky pasta surface and turbid cooking water (Palavecino *et al*., 2017). Cooking time ranges from 170 – 365 s while taro noodles mixed with rice and pigeon pea according to Kaushal and Sharma (2014) are between 310-395 s. The quality of instant noodles can be assessed by evaluating the cooking time which should be less than 360 s at 80°C (Javaid *et al*., 2018). The greater the addition of cassava starch and the concentration of xanthan gum, the longer the cooking time.

Taro noodles with the addition of 10% cassava starch had a higher cooking time at the same xanthan gum concentration. This is in accordance with the research of Sonia *et al*. (2019) which stated that higher starch addition would increase the cooking time. Starch has a higher pasting temperature which will be more resistant to swelling and breakdown of starch granules (Kaur and Singh, 2005) than flour.

The addition of hydrocolloids can increase the cooking time due to the limited moisture content contained in the starch granules. The hydrophilic groups in xanthan gum (containing many hydroxyl groups) bind water. Starch competes with xanthan gum to obtain the water needed in the gelatinization process. As a result, the time required for starch to fully gelatinize becomes longer. According to Sonia *et al*. (2019), xanthan gum is stable under hot conditions, this condition can delay starch granules from swelling (Kaur *et al*., 2015).

The cooked weight of taro noodles ranged from 176.60 – 207.81%. this is in accordance with the research of Marti *et al*. (2015), where the cooked weight of pasta is between 1.5 - 2 times the dried weight. The cooked weight of noodles is affected by water absorption. Water absorption comes from the outside to the inside of the noodles, otherwise, the transfer of ingredients can take place from pasta to water during cooking (cooking loss). The more concentration of xanthan gum added to the two additions of cassava starch, the greater the cooked weight of the noodles. This indicates that the hydrophilic groups in xanthan gum increase water binding, thereby increasing the swelling capacity of starch granules (Jang *et al*., 2015).

Cooking loss is dried solids lost to cooking water expressed in percent and is an indicator of the resistance of noodles to cooking (Marti *et al*., 2015). According to Chinese and Thai standards for rice noodles, the cooking loss should be less than 10% and 9%, respectively (Wandee *et al*., 2015). Cooking loss in all treatments was below 9%, which means good quality taro noodles.

Analysis of variance showed that the addition of cassava starch and xanthan gum had a very significant effect ($p<0.01$) on the cooking loss of taro noodles, but there was no interaction between the two. High cooking loss is undesirable because it represents high starch solubility, resulting in cloudy cooking water, low cooking tolerance, and a sticky feeling in the mouth (Kaushal and Sharma, 2014). The addition of 10% cassava starch showed a higher cooking loss than without the addition of cassava starch (0%), this was because the higher amylose content in cassava starch than in taro flour (Table 1) caused amylose leaching.

The cooking loss of taro noodles at a concentration of xanthan gum of 0.25% was greater than the concentration of xanthan gum of 0%, but at concentrations of xanthan gum of 0.50 and 0.75%, the cooking loss decreased again (Table 3). The increased cooking loss implies that the xanthan gum concentration of 0.25% forms a weak overall network structure that allows the leaching of the solids during cooking. This is reinforced by the increased moisture content and water absorption at a concentration of 0.25% xanthan gum. According to Milde *et al*. (2020), low concentrations of xanthan gum were not sufficient to form a network, which was reflected in the high cooking loss.

Table 3. Cooking loss of dried taro noodles at different concentrations of xanthan gum.

Xanthan Gum (%)	Cooking loss (%)
0	8.03 ± 0.78^{c}
0.25	8.34 ± 0.72^{d}
0.50	7.63 ± 0.66^{b}
0.75	7.24 ± 1.13^{a}

Values are presented as mean±SD of triplicate analysis. Values with different superscripts within the same column are statistically significantly different ($p \leq 0.05$).

Cooking loss decreased in taro noodles with xanthan gum concentrations of 0.5 and 0.75%. this is in accordance with the research of Milde *et al*. (2020)

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wherein adding xanthan gum to the formulation will help in the formation of a stronger network so that the starch granules will be trapped. At concentrations of 0.50 and 0.75%, a strong three-dimensional network is formed to prevent amylose from diffusing out.

3.2 Colour characteristic of taro noodle

Colour is one of the characteristics that influence consumer decisions to buy or consume food products (Kaushal and Sharma, 2014). Visual assessment plays an important role in evaluating noodle quality (Zhou *et al*., 2015). Analysis of variance showed that the addition of cassava starch had a very significant effect (p<0.01) on the lightness (L*) of taro noodles, while the concentration of xanthan gum had no significant effect on the brightness of taro noodles (Table 4). The addition of 10% cassava starch causes the colour of taro noodles to be brighter than without the addition of cassava starch (0%). taro tubers contain polyphenol molecules and the enzyme polyphenol oxidase (PPO) (Aboubakar *et al*., 2012), which causes the browning process when steaming, while cassava starch is lighter in colour than taro flour (Table 2). The results of the lightness of taro noodles are in accordance with the research of Javaid *et al*. (2018) in which cassava starch, potato, and modified starch were used to lighten the colour of noodles.

The addition of xanthan gum did not have an effect on the lightness of taro noodles, and this was different from the results of several researchers (Javaid *et al*., 2018; Milde *et al*., 2020) which showed that the addition of xanthan gum made the colour of the noodles lighter (increasing the L* value). This is presumably because cooked taro flour has a low lightness so the addition of xanthan gum does not affect the brightness.

Analysis of variance showed that the interaction of the addition of cassava starch and the concentration of xanthan gum had a significant effect (p<0.05) on the values of a* and b* (Table 4). The results showed that the greater the concentration of xanthan gum, the red a* value of the noodles, except for noodles without xanthan gum and cassava starch. The value of b* on the addition of 0% cassava starch, the greater the concentration of xanthan gum, the value of b* decreased. At the addition of 10%, the greater the concentration of xanthan gum, the value of b* increased. The mean a* value for the high noodle sample can be ascribed to the positive relationship between water absorption and noodle lightness. Noodles with xanthan gum combined have a greener and more yellow colour (Javaid *et al*., 2018).

3.3 Texture properties of taro noodles

The noodle texture is one of the important characteristics that determine noodle quality and consumer acceptance (Milde *et al*., 2020). Several texture parameters of cooked taro noodles are presented in Table 5. Analysis of variance showed that the addition of cassava starch and xanthan gum and the interaction of the two factors had a very significant effect (p<0.01) on hardness (firmness), adhesiveness, cohesiveness and chewiness, while the addition of cassava starch and xanthan gum had no effect on springiness.

The interaction of cassava starch and xanthan gum increased the hardness of taro noodles. Hardness is influenced by amylose content, higher amylose content in cassava starch than taro flour (Table 2) can increase the hardness of taro noodles. Kamsiati *et al*. (2021) reported that amylose would bind to each other to form a matrix which would increase the hardness of the resulting noodles. Xanthan gum can form a network like gluten. In taro noodles without the addition of xanthan gum, the noodles break easily even before cooking. According to Larrosa *et al*. (2013), xanthan gum resembles the elastic texture of gluten and increases the hardness of taro noodles.

The addition of cassava starch and the concentration of xanthan gum were negatively correlated with adhesiveness. The addition of cassava starch and the higher concentration of xanthan gum caused a decrease in adhesiveness, this indicated that the noodles had lower adhesion. According to Javaid *et al*. (2018), adhesiveness

Table 4. L*, a*, b* colour of dried taro noodles at different concentrations of cassava starch and xanthan gum.

Cassava starch (%)	Xanthan Gum (%)	L* (Lightness)	a* (Redness-Greenness)	b* (Yellowness- Blueness)
0	0.00	53.68±1.12[a]	9.06±0.40[b]	16.69±0.59[c]
	0.25		8.38±0.21[a]	15.37±0.15[a]
	0.50		8.55±0.29[ab]	15.52±0.45[a]
	0.75		8.69±0.26[ab]	15.46±0.24[a]
10	0.00	57.00±1.32[b]	8.26±0.20[a]	15.54±0.12[a]
	0.25		8.49±0.36[ab]	15.80±0.48[ab]
	0.50		9.02±0.27[b]	16.37±0.16[bc]
	0.75		8.72±0.39[ab]	16.49±0.39[bc]

Values are presented as mean±SD of triplicate analysis. Values with different superscripts within the same column are statistically significantly different (p≤0.05).

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Table 5. Texture analysis of dried taro noodles at different concentrations of cassava starch and xanthan gum

Cassava starch (%)	Xanthan Gum (%)	Hardness (kg)	Adhesiveness (kg.s)	Springiness	Cohesiveness	Chewiness
0	0.00	3.79±0.14[a]	-0.08±0.01[e]	3.00±1.00[a]	0.55±0.01[a]	2.09±0.04[a]
	0.25	5.17±0.42[bc]	-0.09±0.01[e]	2.99±1.00[a]	0.59±0.01[b]	3.03±0.28[b]
	0.50	5.70±0.37[cd]	-0.12±0.00[d]	2.98±0.99[a]	0.65±0.01[c]	3.70±0.30[c]
	0.75	4.88±0.22[b]	-0.15±0.01[c]	2.96±0.99[a]	0.65±0.02[c]	3.13±0.09[b]
10	0.00	6.00±0.33[d]	-0.19±0.01[ab]	2.98±0.99[a]	0.56±0.03[ab]	3.35±0.36[bc]
	0.25	7.26±0.25[e]	-0.19±0.01[b]	2.99±1.00[a]	0.66±0.01[c]	4.74±0.20[d]
	0.50	8.83±0.23[f]	-0.19±0.02[ab]	2.99±1.00[a]	0.64±0.01[c]	5.61±0.20[e]
	0.75	8.89±0.42[f]	-0.20±0.01[a]	2.99±1.00[a]	0.67±0.02[c]	5.91±0.34[e]

Values are presented as mean±SD of triplicate analysis. Values with different superscripts within the same column are statistically significantly different ($p \leq 0.05$).

is related to the number of starch granules that come out of the noodle matrix into the water during cooking and cover the surface of the product. The lower the cooking loss, the fewer starch granules would leach out of the noodles to cover the product. Thus, resulting in noodles with lower adhesion

Springiness was not affected by the addition of cassava starch and xanthan gum concentration. The addition of cassava starch and the greater the concentration of xanthan gum, the higher the cohesiveness. This is in accordance with the research of Javaid *et al*. (2018) and Milde *et al*. (2020) where the addition of xanthan gum can increase cohesiveness; so that the leaching of amylose into the water during cooking is less.

Chewiness is a combination of three texture parameters hardness, cohesiveness, and springiness. In this study, chewiness increased with the addition of cassava starch and xanthan gum. This is due to lower solids loss, resulting in increased hardness and cohesiveness, while springiness has not been affected.

3.4 Selection of the best treatment taro noodles

Determination of the best treatment for taro noodles was done using the effectiveness index method (de Garmo, 1994). This method was carried out on the parameters of moisture content, ash, cooking properties (cooking time, cooked weight, cooking loss) texture (hardness/firmness, adhesiveness, springiness, cohesiveness, and chewiness), colour (L*, a*, b*). Calculations showed that the best treatment for taro noodles was obtained from the addition of 10% cassava starch and 0.75% xanthan gum with characteristics moisture content 9.07±0.13%, ash content 2.10±0.04%, cooking time 365±4.44 s, cooked weight 207.81±12.29%, cooking loss added 10% cassava starch 8.51±0.40%, cooking loss added 0.75% xanthan gum 7.24±1.13%, L* value 57.00±1.32, a* value 8.72±0.39, b* value 16.49±0.39, hardness 8.89±0.42 kg, adhesiveness -0.20±0.01 kg.s, springiness 2.99±1.00, cohesiveness 0.67±0.02, and chewiness 5.91±0.34.

3.5 Microstructure

The microstructure of dried taro noodles without the addition of xanthan gum (Figures 1a and 1c) showed a cross-sectional structure of noodles with coarser pores than dried taro noodles with the addition of xanthan gum (Figures 1b and 1d). The addition of xanthan gum will help in the formation of a stronger three-dimensional network, thereby preventing amylose from diffusing out. This is also evidenced by a decrease in cooking loss and an increase in hardness in noodles with the addition of 0.75% xanthan gum. Susanna and Prabhasankar (2013) observed the effect of adding xanthan gum in gluten-free pasta from soy flour, channa flour, sorghum flour, and Whey Protein Concentrate (WPC) showing a fine structure which has an impact on reducing cooking loss during cooking. The addition of 10% cassava starch resulted in a smoother dried noodle surface (Figures 1c and 1d) than without the addition of cassava starch (Figures 1a and 1b) at the same xanthan gum concentration, this is because cassava starch contains higher amylose. According to a report by Lu and Collado (2019), amylose plays a role in making starch networks in noodles. SEM image at a magnification of 5000 times (1e-f) shows the micropores formed in dried taro noodles with the addition of xanthan gum are more uniform than without the addition of xanthan gum. Likewise, Javaid *et al*. (2018) reported that the addition of xanthan gum caused the micro-porous structure in potato instant noodles to be responsible for the reduction in cooking loss.

4. Conclusion

The addition of cassava starch and xanthan gum concentration and their interactions had a very significant effect ($p<0.01$) on moisture content, ash content, cooking time, cooked weight, reddish colour (a*), yellowish colour (b*) of dried taro noodles. The

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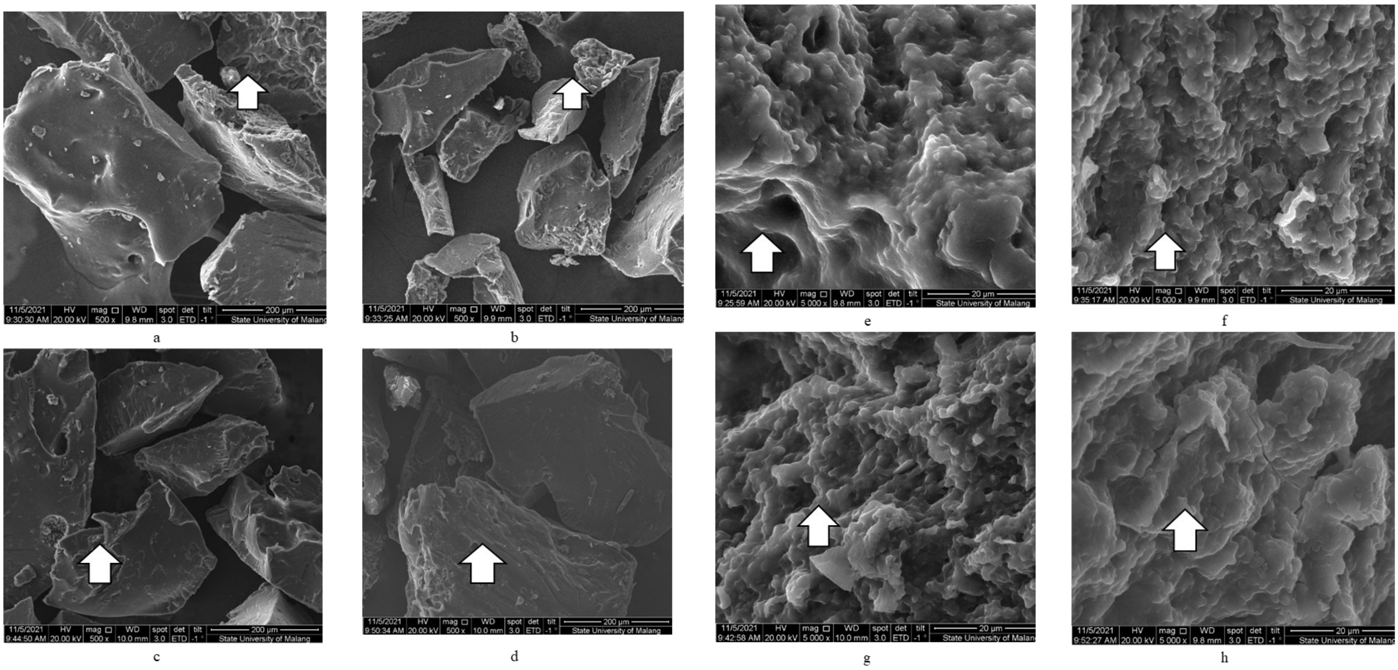

Figure 1. Scanning electron microscopy images of dried taro noodles (a) cassava starch 0% and xanthan gum 0% at 500× magnification, (b) cassava starch 0% and xanthan gum 0.75% at 500× magnification, (c) cassava starch 10% and xanthan gum 0% at 500× magnification, (d) cassava starch 10% and xanthan gum 0.75 % at 500× magnification, (e) cassava starch 0% and xanthan gum 0% at 5000× magnification, (f) cassava starch 0% and xanthan gum 0.75% at 5000x magnification, (g) cassava starch 10% and xanthan gum 0% at 5000× magnification, (h) cassava starch 10% and xanthan gum 0.75 % at 5000× magnification.

addition of cassava starch and xanthan gum concentration had a very significant effect on cooking loss but there was no interaction between treatments. The brightness (L*) of dried taro noodles was affected only by the addition of cassava starch. The addition of 10% cassava starch and xanthan gum can increase hardness, cohesiveness, and chewiness, reduce adhesiveness but not affect the springiness of taro noodles. This study can conclude that taro flour with the addition of cassava starch and xanthan gum has the potential as gluten-free noodles. The best treatment was taro noodles with the addition of 10% cassava starch and 0.75% xanthan gum. characteristics moisture content 9.07±0.13%, ash content 2.10±0.04%, cooking time 365±4.44 s, cooked weight 207.81±12.29%, cooking loss added 10% cassava starch 8.51±0.40%, cooking loss added 0.75% xanthan gum 7.24±1.13%, L* value 57.00±1.32, a* value 8.72±0.39, b* value 16.49±0.39, hardness 8.89±0.42 kg, adhesiveness -0.20±0.01 kg.s, springiness 2.99±1.00, cohesiveness 0.67±0.02, and chewiness 5.91±0.34. This noodle had moisture content, ash content, cooking time, cooked weight, cooking loss added 10% cassava, cooking loss added 0.75% xanthan gum, L* value, a* value, b* value, hardness, adhesiveness, cohesiveness and chewiness of 9.07±0.13%, 2.10±0.04%, 365±4.44 s, 207.81±12.29%, 8.51±0.40%, 7.24±1.13%, 57.00±1.32, 8.72±0.39, 16.49±0.39, s 8.89±0.42 kg, -0.20±0.01 kg.s, 2.99±1.00, 0.67±0.02, 5.91±0.34.

Conflict of interest

The authors declare no conflict of interest.

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