11. Characteristics of non-gluten noodles from modified cocoyam (Xanthosoma sagittifolium) and porang (Amorphophallus oncophyllus)

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Characteristics of non-gluten noodles from modified cocoyam (*Xanthosoma sagittifolium*) and porang (*Amorphophallus oncophyllus*)

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PAPER

Abstract

Foods product were developed after the discovery of gluten-free flour. This study aimed to determine the proper formulation of dry noodles from different proportions of modified cocoyam flour and porang flour. In addition, the use of egg was evaluated in terms of physicochemical and organoleptic properties. The first factor was the proportion of modified cocoyam flour and porang flour (90%:10%, 85%:15%, and 80%:20%). The second factor was the addition of eggs (5%, 10%, and 15%). The result showed that the best formulation according to chemical, physical, and organoleptic parameters was made with modified cocoyam flour and porang flour, 85%:15%, with 10% eggs. This non-gluten-based formulation of noodles showed both high dietary fibers content derived from glucomannan (60.14%) and high protein content (12.75%).

Keywords: cocoyams tubers, eggs, modified flour, noodles, porang, soybean

Introduction

Noodles are long thin pieces of food made from flour, water, and eggs. Noodles usually cooked in soup or boiling water. Moreover, noodles are composed of wheat flour with a lot of gluten. Wheat flour should not be consumed by people who have certain digestive disorders. Hence, in this research, non-gluten flour was used. Non-gluten flour is obtained from tubers such as cocoyam (*Xanthosoma sagittifolium*). However, some limitations during production of noodles using non-gluten flour occurred. Therefore, other ingredients must be added to enhance the texture of noodles. Porang (*Amorphophallus oncophyllus*) flour is added to increase the texture elasticity of noodles.

Cocoyam is a commodity with an appreciable nutritional profile, high productivity, and better storability than other indigenous roots and tubers. In addition, cocoyam has the potential for sustainable food security. Cormels, flours, and starches could be explored in the snack and complimentary food industries by utilizing processing properties, ease of crop production, storability, and nutritional value (Boakye *et al.*, 2018).

The utilization of cocoyam flour as a substitute for wheat flour in production of noodles has physical and sensory limitations such as dull color, too much stickiness when added with water, very low solubility and swelling strength, and soft texture. Therefore, modification of flour is required to enhance the physical and sensory properties of noodles. The physical and sensory properties of noodles can be improved in several ways. One of them is by fermenting the flour using lactic acid bacteria (LAB). Fast-growing microbes produce pectin lytic and cellulolytic enzymes. These enzymes can destroy the tuber cell wall allowing the liberation of starch granules (Subagio, 2008). These conditions change the characteristics of flour, including increased viscosity, gelation ability, rehydration, and dissolving ability.

The tuber flour modified by fermentation method resulted in lower water content, brighter flour color, and higher amylose content compared to the ordinary cocoyam flour. The increase of amylose content in cocoyam flour impacts production of dry noodles. Starch with high amylose content can absorb water due to amylase, which can form hydrogen bonds that are greater than amylopectin (Hidayat *et al.*, 2007). Additionally, amylose plays a role in increased firmness compared to amylopectin. Therefore, the higher amylose content reduces the stickiness of noodles (Supriyadi, 2012).

Noodles from 100% modified cocoyam flour have less elastic properties of dough. Thus, the need for additional ingredients plays an essential role in the chewy texture of noodles. A binder can be added to obtain the rubbery texture of noodles. Moreover, binder can trap water to form an elastic and springy texture (Saha and Bhattacharya, 2010). In this case, porang flour and eggs were used as a binder.

Tubers of porang (*Amorphophallus oncophyllus*), or often called "iles-iles" in Indonesia, from the *Araceae* family, grow in a warm subtropical climate such as in East Asia, South China, Japan, and Indonesia (Ambarwati *et al.*, 2000). Porang flour contains high content of glucomannan (15–64% on a dry basis) (Faridah *et al.*, 2012) Therefore, porang flour can absorb water, form a gel (gelling agent), and increases the elasticity of noodles (Wang *et al.*, 2012).

The addition of porang flour improves the texture, elasticity, and flexibility of noodles. Porang flour increases the thickness of noodles, thus can be used as a substitute for thickening chemicals in noodles. Therefore, porang flour can be a gelling agent (Retnaningsih and Hartayani, 2005). Formation of gel occurs when dispersed in water, as hydrocolloids and water molecules are trapped in the complex structures through hydrogen cross-linking. This condition leads to hydration process (Citra *et al.*, 2012). Glucomannan is a soluble dietary fiber with high water but low calorie contents (Yang *et al.*, 2006).

Nugraheni and Puspitaningrum (2013) examined the positive effect of porang tuber (*Amorphophallus konjac* K. Koch) on the liver. The results demonstrated that administering porang tuber flour to rats at a dosage of 2000 mg/kg alters the levels of serum glutamic oxaloacetic transaminase and serum glutamic pyruvic transaminase as well as the liver histopathology images of Wistar male rats induced by paracetamol.

The eggs added in production of noodles create more resilient dough so that the noodles will not break easily. Moreover, the noodles turbidity during boiling will be prevented. The function of egg yolk is to accelerate water hydration. The egg white protein forms a layer that is strong enough to cause a better binding of water to noodles and increase suppleness (Diniyah *et al.*, 2017).

The addition of eggs at low concentrations does not meet the Indonesian National Standard for dry noodles. Therefore, they must be supplemented with other ingredients with high protein content. Soybean is a food with a high nutritional content. It is the best source of protein among nuts. The addition of soybeans to the noodles production is expected to meet the protein quality standards of non-gluten dry noodles (Widaningrum and Soekarto, 2005), and produce a better texture and noodles taste. For this reason, a fixed proportion of soybean flour (15%) is added to the dry noodles composition. This study aimed to determine the exact proportion between the use of modified cocoyam flour, porang flour, and egg on the noodles quality.

Methods

Raw material properties

Cocoyam tuber, porang flour, and soda ash were used as raw materials to produce dry noodles. Cocoyam tubers and porang flour were obtained from Sleman, Indonesia. *Lactobacillus plantarum* FNCC 0027 strain (Agricultural Product Technology Laboratory, Gadjah Mada University, Indonesia) was used for the fermentation method. Hydrochloric acid (Sigma Aldrich), sodium hydroxide (Merck), Fehling A, Fehling B, sulfuric acid, De Man, Rogosa and Sharpe (MRS) broth (Oxoid Ltd.), bromocresol green, boric acid (HO_3BO_3), distilled water, 95% alcohol, isopropyl alcohol, and aluminum sulfate were used as analysis materials.

Modified cocoyam and porang flour

Cocoyam flour was made based on the method of Rosida *et al.*, 2020. Cocoyam tubers were peeled, washed, and sliced for 0.5-cm thickness. Sliced tubers were soaked in 7.5% NaCl solution for 1 h to remove calcium oxalate in the tuber tissue, which can cause itching (Rozali *et al.*, 2021). Sliced tubers were washed with tap water until clean and drained. These were dried using a cabinet dryer at 60°C for 12 h. Dried tubers were ground using a grinding machine. Finely knotted tubers were sifted using 80-mesh sieves.

A suspension of 2500-g cocoyam flour and 7500-mL distilled water was fermented using 7% *Lactobacillus plantarum* FNCC 0027 starter for 96 h at room temperature (25 ± 2°C). The fermented products were washed with distilled water at a neutral pH. Fermented flour was dried at 60°C for 12 h. The modified cocoyam flour was analyzed for moisture, ash, protein (Association of Official Agricultural Chemists [AOAC], 2004), starch (Sudarmadji *et al.*, 1997), and amylose (International Rice Research Institute [IRRI], 1978). Cocoyam tubers and porang flour were obtained from Sleman, Indonesia. Similarly, porang flour was evaluated in terms of moisture, ash, protein (AOAC, 2004), starch (Sudarmadji *et al.*,1997), amylose (IRRI, 1978), and glucomannan (Widjanarko and Megawati, 2015).

Dry noodle production

Dry noodles were produced with the composition of modified cocoyam flour and porang flour (90%:10%, 85%:15%, or 80%:20%) and egg addition (5%, 10%, or 15%). Steps for dry noodles production are as follows: Modified cocoyam flour and porang flour (90%:10%, 85%:15%, or 80%:20%), soy flour (15%), soda ash (1%), and salt (2%) were mixed while adding water and egg (5%, 10%, or 15%) until it became an homogeneous dough. The dough was put into a noodle extruder machine. Noodles were steamed at 100°C for 5 min and dried using a cabinet dryer at 60°C for 7 h.

Experimental design

The experimental design was a completely randomized design with a factorial pattern that comprises two factors. Factor I comprised the three levels of the proportion of modified cocoyam flour and porang flour (90%:10%, 85%:15%, or 80%:20%), and factor II comprised the three levels of egg addition (5%, 10%, or 15%).

Dry noodles were analyzed for proximate composition such as moisture, ash content, protein content (AOAC, 2004), starch content (Sudarmadji *et al.*, 1997), rehydration (Ramlah, 1997), cooking loss (Subarna and Muhandri, 2013), elasticity (Ramlah, 1997), glucomannan level, and organoleptic properties (Wulandari *et al.*, 2008).

Dry noodles properties

Physical properties

Rehydration

The measurement of rehydration was conducted using the weighing method. Rehydration is the ability of noodles to absorb water after gelatinization. Measurements were made by (a) weighing 5 g of raw noodles, and (b) boiling for 4 min or until the noodles were completely gelatinized, and then weighing again. Rehydration was the percentage difference between (a) raw noodles and (b) gelatinized noodles.

Cooking loss test

Cooking loss was determined by boiling approximately 5 g of noodles in 150-mL water for 3 min and draining. Then noodles were dried at 100°C until their weight was constant. Other 5-g noodles were weighed for water content to calculate dry weight of the sample. The percentage of cooking loss was calculated based on the difference between dry weights of the sample before and after boiling divided by dry weight of the sample before boiling.

Elasticity

Elasticity was measured using a ruler. The cooked sample was placed on a ruler and measured (the initial length, P1); then it was pulled off until it broke and measured again (the final length, P2). Elasticity was calculated by the following formula: (P1 – P2/P1) × 100%.

Glucomannan levels using gravimetric method

The sample (25 g) and aluminum sulfate salt (2.5 g) were dissolved in 75-mL water 1:10 (w/v) with continuous stirring for 35 min. The precipitated samples were separated using a 2000-rpm centrifuge for 30 min. Supernatant was added with isopropyl alcohol in a ratio of 1:1 (v/v) with stirring until lumps were formed (Rhim and Wang, 2013; Yan *et al.*, 2012).

The lumps were filtered using a filter paper and dried at 60°C for 24 h and weighed. Glucomannan content was the percentage of the dry weight to the initial weight of the sample.

Organoleptic test

Food quality can be measured by three properties: chemical, physical, and sensory. Consumer acceptance is primarily determined by quality factors, especially organoleptic (Agustia *et al.*, 2019; Akonor *et al.*, 2017). Organoleptic properties are determined using the human senses: sight, smell, and taste (Chauhan *et al.*, 2018). The organoleptic properties of the dry noodle products tested in this study were color, taste, texture, and aroma. According to Friedman's test performed for the color, taste, and texture of non-gluten dry noodle products, there were significant differences ($X_{2count} \geq X_{2table}$). Panelists (n = 25) gave an assessment of color, taste, and aroma using the following evaluating scale: 5 = liked extremely, 4 = liked moderately, 3 = liked slightly, 2 = disliked moderately, and 1 = disliked extremely.

Data analysis

Data from all test parameters (except for ash content) were obtained and processed for variance analysis. Variance analysis was used to determine the interaction between each composition. Further tests were performed using Duncan's multiple range test (5%) if there were significant differences.

Results and Discussion

Raw material properties

Table 1 shows the characteristics of modified cocoyam flour (Rosida *et al*., 2020) and porang flour compared to the previous research (Arifin, 2001; Aryanti and Abidin, 2015; Kumoro *et al.*, 2018; dan Widjanarko, 2015). The differences between the raw materials in this study and previous studies were harvesting period, tuberose varieties, and flour production method. According to Table 1, porang flour based on the data of previous studies contained 12.32% of water, 3.9% of ash (Aryanti and Abidin, 2015), 24.6% of starch, 18.2% of amylose (Kilara, 1994), 3.42% of protein (Kumoro *et al*., 1994), and 63.49% of glucomannan (Widjanarko and Megawati 2015).

Dry noodles' proximate properties

Water and ash contents of dry noodles

The water content of dry noodles ranged from 6.05% to 7.49%. The lowest water content was 6.05 % in dry noodles. This result was obtained with the modified cocoyam flour 90%, porang flour 10%, and 5% egg yolk. In contrast, the formulation of modified cocoyam flour of 90%, porang flour of 15%, and the addition of 15% egg yolk produced the highest water content (7.49%). Table 2 shows the relationship of the proportions of modified cocoyam flour, porang flour as well as the addition of eggs to the water content of noodles.

In addition, as shown in Table 2, the water content of noodles increases with the lower composition of modified cocoyam flour, the higher composition of porang flour, and more addition of egg yolk. This condition is caused by the presence of glucomannan, which is a water-soluble fiber. Similarly, more addition of eggs increases the water level of noodles. Eggs contain hydrophilic proteins. The absorption of water by proteins is related to the side-chain polar groups such as carbonyl, hydroxyl, amino, carboxyl, and sulfhydryl groups. This condition causes hydrophilic proteins to form hydrogen bonds with water (Kilara, 1994). These proteins bind water molecules by the formation of hydrogen bonds (Sari, 2017).

Glucomannan absorbs maximum water compared to other food fibers (Charoenrein *et al*., 2011). A previous study (Chan, 2011) confirmed this property, reporting that porang flour contains glucomannan and absorbs up to 200 times of water. If more porang flour is added, the holding capacity of water becomes greater, resulting in higher water content of dry noodles. Regarding the quality of dry noodles, Indonesia National Standard (SNI) stated that the maximum water content is 10%. In the present study, dry noodles in each category satisfied this standard (SNI No. 01-2974-1996).

Ash levels of dry noodles were found in the range 1.68–1.84%. The smaller modified cocoyam flour resulted in the higher porang flour proportion and ash content. The ash content of porang flour was 3.33%. It was higher than the modified cocoyam flour raw material, which was 1.08%. The higher the ash content, the higher the minerals contained in a food ingredient. It is because the ash content from mineral elements and chemical composition does not evaporate during the drying process.

The addition of eggs further increases the ash content in noodles. It is due to the mineral content of eggs (Juanda and Cahyono, 2000). A total of 1% of ash content is found in eggs (Muchtadi *et al.*, 2010). Egg yolk contains several minerals, especially phosphorus (P), manganese (Mn), iron (Fe), iodine (I), copper (Cu), calcium (Ca) and a small portion of zinc (Zn), which are more than those found in egg white. Maximum mineral component found in egg yolk is P, which binds phospholipids, especially lecithin. More than 60% of P in egg yolk is found in lecithin. On the other hand, egg white contains minerals such as chlorine (Cl), magnesium (Mg), potassium (K), sodium (Na), and sulfur (S) in higher proportion than found in egg yolk (Andriani *et al.*, 2015).

Table 1. Raw material properties according to previous studies.

Component	Modified cocoyam flour	Modified cocoyam flour data in the literature	Porang flour
Water content (%)	8.92 ± 0.023	8.28	11.10 ± 0.030
Ash (%)	1.076 ± 0.021	1.05	3.33 ± 0.171
Starch (%)	63.31 ± 0.247	76.74	24.82 ± 0.182
Amylose (%)	22.77 ± 0.164	26.28	19.74 ± 0.158
Protein (%)	3.09 ± 0.008	–	3.47 ± 0.005
Glucomannan (%)	–	–	60.14 ± 0.192

Table 2. Water content, protein, starch, and amylose level of each composition of modified cocoyam flour and porang flour with addition of egg.

Formula composition					
Modified cocoyam flour and porang flour (%)	Egg (%)	Water content (%)	Protein (%)	Starch (%)	Amylose (%)
	5	6.05ᵃ ± 0.10	12.23ᵃ ± 0.01	65.32ᵉ ± 0.84	23.50ᶠ ± 0.05
90:10	10	6.35ᵃ,ᵇ ± 0.22	12.93ᵇ ± 0.02	64.45ᵈ ± 0.76	23.14ᵉ ± 0.11
	15	7.14ᵈ ± 0.12	13.65ᶜ ± 0.01	64.03ᵈ ± 0.24	22.79ᶜ,ᵈ ± 0.12
	5	6.57ᵇ,ᶜ ± 0.19	12.55ᶜ ± 0.03	64.13ᵈ ± 0.07	23.14ᵉ ± 0.04
85:15	10	6.78ᶜ ± 0.19	13.22ᵈ ± 0.02	63.16ᵇ,ᶜ ± 0.10	22.67ᶜ ± 0.08
	15	6.71ᵇ,ᶜ ± 0.34	14.19ᵉ ± 0.08	62.59ᵇ ± 0.16	22.14ᵇ ± 0.18
	5	6.77ᶜ ± 0.24	12.87ᶠ ± 0.07	63.86ᶜ,ᵈ ± 0.63	22.91ᵈ ± 0.04
80:20	10	7.16ᵈ ± 0.13	13.53ᵍ ± 0.02	62.76ᵇ ± 0.10	22.26ᵇ ± 0.14
	15	7.49ᵈ ± 0.20	14.49ʰ ± 0.01	60.98ᵃ ± 0.27	21.45ᵃ ± 0.16

Products from animals contain high ash content because it contains several minerals such as Ca, Fe, and P. The heating process also affects the amount of ash content in the product produced. The drying process causes the decomposition of water molecular bonding components. Moreover, drying process increases sugar, fat, and minerals, thereby increasing ash content. The ash content should be only 3% according to the quality standard of dry noodles. In the present study, dry noodles in each category satisfied this standard (SNI No. 01-2974-1996).

Protein content

The protein content of dry noodles was 12.23–14.49%. The proportions of modified cocoyam flour of 90% and porang flour of 10% with an egg addition of 5% produced the lowest protein content (12.23%) whereas the proportions of modified flour of 80% and porang flour of 20% with an egg addition of 15% produced the highest protein content (14.49%). Table 2 shows the relationship of the proportions of modified cocoyam flour, porang flour as well as the addition of egg to the protein content of noodles.

Moreover, the smaller proportion of modified cocoyam flour, the higher proportion of porang flour, and the addition of eggs increased the protein content of dry noodles (Table 2). It was due to the higher protein content in porang flour than in modified cocoyam flour, thereby increasing the protein content of dry noodles. The protein content of raw material in porang flour was higher (3.47%) than the protein content of modified cocoyam flour (3.09%).

Similarly, the addition of more eggs increased protein level in dry noodles. According to Muchtadi *et al.* (2010), eggs have 12.7% of protein.

The egg added in the manufacture of dry noodles improves the quality of noodle protein and creates a more resilient dough (Astawan, 2008). Moreover, addition of soy flour to dry noodles increases protein content because soybean is a good source of protein. A total of 41.7% of protein is found in soybean. According to the quality standard of dry noodles, the standard protein content must be at a minimum of 8%. In this study, the dry noodles in each category satisfied this standard (SNI number 01-2974-1996).

Starch content

The starch content of dry noodles ranged from 60.98% to 65.32%. The proportions of modified cocoyam flour of 80% and porang flour of 20% with an egg addition of 15% produced minimum starch content (60.98%) whereas the proportions of modified cocoyam flour of 90% and porang flour of 10% with an egg addition of 5% produced maximum starch content (65.32%). Table 2 shows the relationship of the proportions of modified cocoyam flour, porang flour as well as the addition of eggs to the starch content of dry noodles.

Furthermore, the smaller proportion of modified cocoyam flour, the higher proportion of porang flour, and the addition of eggs decreased starch level in noodles (Table 2). This was because the starch level in porang flour was less than that in modified cocoyam flour. The starch level of dry noodles decreased by increasing the proportion of porang flour. Similarly, more eggs decreased starch levels in dry noodle products because eggs did not contain starch.

The starch content in modified cocoyam flour was 63.31%. It was higher than in porang flour (24.82%); hence, the lower proportion of modified cocoyam flour in noodle production reduced its starch content.

Amylose content

Amylose levels of dry noodles ranged from 21.45% to 23.50%. The proportions of modified flour of 80% and porang flour of 20% with an egg addition of 15% produced the lowest amylose content (21.45%) whereas the proportions of modified cocoyam flour of 90% and porang flour of 10% with an egg addition of 5% produced the highest amylose content (23.50%). Table 2 shows the relationship of the proportions of modified cocoyam flour, porang flour as well as the addition of eggs to the amylose content of noodles. These results indicated that the smaller proportion of modified cocoyam flour, the higher proportion of porang flour, and the addition of eggs resulted in the lower level of amylose in noodles.

This was because the amylose content in porang flour was less than that in the modified cocoyam flour. Therefore, the amylose content of dry noodles decreased by increasing the proportion of porang flour. Similarly, the addition of more eggs decreased the amylose levels of dry noodles.

The amylose content of modified cocoyam flour was 22.77%. It was higher than that of porang flour (19.74%). The high content of amylose in modified flakes was due to the activity of enzymes produced during fermentation. Therefore, the breakdown of amylopectin branch chain in α-1,6 glycosidic bonds caused the formation of new amylose.

The LAB has amylolytic properties that produce amylase and pullulanase enzymes. These enzymes hydrolyze starch. The release of amylopectin by pullulanase enzyme produces a straight-chain glucose polymer, which is amylose with a smaller degree of polymerization (Asha *et al.*, 2013). This pullulanase enzyme can be used to degrade glycosidic α-1,6 branch bonds to amylopectin and produce high amylose (Chen *et al.*, 2010).Microbes that produce pullulanase enzyme can break down high amounts of amylopectin into simple sugars, resulting in higher amylose concentrations of flour (Akbar and Yunianta, 2014).

Low amylose content in porang flour and high protein content in eggs cause the gel structure to form weakly. Additionally, these conditions cause higher dissolved solids, stickiness, and inelasticity in dry noodles. Amylose plays an important role in the gelatinization process and the character of starch paste (Rahim, 2007).

Physical properties

Rehydration

The rehydration of noodles ranged from 114.56% to 120.46%. The proportions of modified cocoyam flour of 90% and porang flour of 10% with the egg addition of 5% produced the lowest rehydration (114.56%) whereas the proportions of modified cocoyam flour of 80% and porang flour of 20% with the egg addition of 15% produced the highest rehydration (120.46%). The relationship of the proportions of modified cocoyam flour, porang flour as well as the addition of eggs to the rehydration of dry noodles is presented in Table 3.

The less proportion of modified cocoyam flour, the more proportion of porang flour, and the addition of eggs increased the rehydration of noodles (Table 3). These conditions show that porang flour contains glucomannan, which has high water absorption properties. Similarly, the addition of more eggs increased rehydration. It is indicated by lecithin in egg yolks that are hydrophilic. Moreover, the addition of eggs causes higher water absorption.

Lambrecht *et al.* (2014) reported that lecithin in egg yolks have polar and nonpolar groups. The polar group contains phosphate ester, which is hydrophilic and tends to dissolve in water. The nonpolar group contains fatty acid ester, which is lipophilic and tends to dissolve in fat or oil. It is supported by a previous study (Winarno, 2004) that reported that the use of eggs for non-gluten noodles accelerate hydration time. The presence of polar and nonpolar groups of egg yolk determines the water absorption rate and noodles' elasticity.

A previous study (Chan, 2011) revealed that porang flour has a high content of glucomannan. It absorbs up to 200 times of water and inhibits syneresis. Water-soluble polysaccharides increase the water absorption capacity of the product. Therefore, increased proportion of porang flour increases the rehydration of noodles (Faridah and Widjanarko, 2014). Glucomannan comprises monomer α,β-1,4-mannose and α-glucose. Glucomannan in iles-iles tubers strengthens the gel, improves texture, and increases thickness (Sande *et al.*, 2009).

The rehydration of dry noodles with cocoyam flour and the addition of mung bean flour ranged from 138.26% to 145.01% (Kartini and Widya, 2018). Difference in the rehydration of dry noodles is caused by different starch content, protein content, and processing activities.

Cooking loss

The cooking loss value ranged from 8.22% to 9.58%. The proportions of modified cocoyam flour of 90% and porang flour of 10% with the egg addition of 15% produced the lowest cooking loss value (8.22%) whereas the proportions of modified cocoyam flour of 90% and porang flour of 10% with the egg addition of 5% produced the highest cooking loss value (9.58%). The relationship

Table 3. Rehydration, cooking loss, and elasticity of each composition of modified cocoyam flour and porang flour with addition of egg.

Formula composition				
Modified cocoyam flour and porang flour (%)	Egg (%)	Rehydration (%)	Cooking loss (%)	Elasticity (%)
	5	114.56[a] ± 0.11	9.35[a] ± 0.04	9.30[a] ± 0.11
90:10	10	115.29[b] ± 0.18	8.72[b] ± 0.02	10.47[b] ± 0.12
	15	115.86[c] ± 0.07	8.22[b] ± 0.02	11.50[c] ± 0.35
	5	116.38[d] ± 0.15	9.47[c] ± 0.11	10.43[b] ± 0.14
85:15	10	117.64[e] ± 0.14	8.75[c] ± 0.01	11.67[c] ± 0.08
	15	117.91[f] ± 0.08	8.39[c] ± 0.02	12.70[d] ± 0.30
	5	118.35[g] ± 0.13	9.58[d] ± 0.03	13.74[e] ± 0.18
80:20	10	119.44[h] ± 0.20	8.76[e] ± 0.01	13.85[e] ± 0.09
	15	120.46[i] ± 0.07	8.43[f] ± 0.01	14.66[f] ± 0.25

of the proportions of modified cocoyam flour, porang flour as well as the addition of eggs to the cooking loss of noodles is presented in Table 3.

Our results demonstrated that the less proportion of modified cocoyam flour, the more proportion of porang flour, and the addition of eggs increased the value of cooking loss. It was due to less amount of amylose in porang flour. However, addition of more egg decreased the cooking loss value. It was due to the presence of protein in eggs that made dough more compact.

Porang flour has lower amylose content (19.74%) than modified cocoyam flour (22.77%). Setyani *et al.* (2017) stated that the loss of solids because of cooking loss in noodles is influenced by the presence amylose content in the raw materials used. The higher the amylose content, the stronger the gel structure formed. Therefore, the smaller total loss of solids happens in noodle strands during the cooking process.

Owing to the addition of eggs, the higher value of cooking loss decreased in non-gluten dry noodles. It was due to egg protein enhancing the noodle mixture compact and reducing water turbidity during cooking. Reza *et al.* (2008) stated that the higher the level of egg concentration added, the less the cooking loss in dried noodles, because eggs make the dough compact. If the noodle mixture is more compact, less solid is lost during cooking. Eggs use in gluten-free products reduces cooking loss (Jayadi, 2019). Egg protein (albumin) produces a thin and strong layer on the surface of noodles. The coating is effective in reducing water turbidity during cooking. The higher cooking loss resulted in more undesirable dry noodle products. A higher cooking loss causes water turbidity during cooking and the noodles leave a feeling of stickiness in the mouth (Uba'idillah, 2015).

Elasticity

The elasticity of noodles ranged from 9.30% to 14.66%. The proportions of modified cocoyam flour of 90% and porang flour 10% with the egg addition of 5% produced the lowest elasticity value (9.30%) whereas the proportions of modified cocoyam flour of 80% and porang flour of 20% with the egg addition of 15% produced the highest elasticity value (14.66%). Table 3 presents the relationship of the proportions of modified cocoyam flour, porang flour as well as the addition of eggs to the noodles elasticity.

Our results showed that the less proportion of modified cocoyam flour, the more proportion of porang flour, and the addition of eggs increased noodles' elasticity (Table 3). Porang flour contains glucomannan compounds, which form an elastic gel to hold water strongly. Similarly, the addition of eggs increased noodles' elasticity. Egg white forms a strong layer or strong adhesion and enhances the texture of dry noodles.

Moreover, the less proportion of modified cocoyam flour the more proportion of porang flour result in the higher elasticity of noodles. This is because porang flour contains glucomannan compounds, which form an elastic gel and hold water. The formation of hydrocolloid gel occurs due to the formation of a mesh or a three-dimensional gel matrix network by a primary molecule. The primary molecule extends to the entire volume of gel formed by trapping an amount of water, thus making noodles' texture more elastic (Winarno, 2004). The gel in porang flour contains 99.90% water and has special properties such as solidity and especially elasticity.

The elasticity of noodles prepared from kimpul flour, tapioca, and tempeh flour ranged from 20.00% to 43.33% (Kustanti *et al.*, 2013). The difference in the elasticity value of dry noodles was due to the content of amylose, amylopectin, and binder in different flours. Additionally, different processing activities cause differences in elasticity.

Organoleptic test

Table 4 shows the mean organoleptic value of dry noodle products. Our results showed that the proportion of modified cocoyam flour and porang flour (90%:10%) with the egg addition of 10% produced dry noodles with the highest level of color preference (brown). Additionally, the proportion of modified cocoyam flour and porang flour (90%:10%) with the egg addition of 15% produced dry noodles with the lowest level of color preference (blackish brown).

The color of dry noodles was brown to blackish brown, obtained from the modified cocoyam flour and porang flour. The color of cocoyam flour was white whereas the porang flour was brown. An increase in the proportion of porang flour decreased the level of panelist acceptance of color in dry noodles. The color change in dry noodles occurred because of the addition of porang flour; hence, if more proportion of porang flour was added, then the color of the dry noodles produced increasingly turned brown. Porang flour color tends to be brown, and if applied to the product, a darker color is produced (Sumarwoto, 2007). Hence, the addition of more porang flour produced less liked colors.

Table 4 shows that the panelists liked the aroma of noodles prepared with the modified cocoyam flour and porang flour formulation (90%:10%) with the egg addition of 5%. Owing to the 15% addition of egg, the aroma of noodles produced with the modified cocoyam flour and porang flour formulation (80%:20%) was similar to that of porang. Porang flour is light brown with a distinctive odor like that of a fish; hence, with a higher proportion of porang flour, the noodles smell fishier (Sumarwoto, 2005).

Moreover, the panelists' preference for the taste of noodles tended to be high in the proportion of modified cocoyam flour and porang flour (90%:10%) with the egg addition of 5%, which was 153.5% (Table 4). The taste of dry noodles tended to decrease with the addition of more eggs (Biyumma *et al.*, 2017). The use of eggs caused a savory taste to noodles due to the presence of lecithin in egg yolk, but the panelists did not like the excessive use of eggs because it made noodles too rancid (a fishy smell).

As shown in Table 4, the level of texture preference for dry noodles was obtained from the proportion of modified cocoyam flour and porang flour (85%:15%). Moreover, the egg addition of 5% was the most preferred composition to meet the preference of consumers. The higher proportion of porang flour and eggs decreased the preference level of panelists for the texture of dry noodles.

Starch has a high amylose content and hydrogen bond strength because of the large number of straight chains in granules. Therefore, it requires more energy for gelatinization and making the noodles chewier (Smith, 1982). Since porang flour has a low amylose content (19.7%), its addition to dry noodles reduces the texture value. Additionally, the more the proportion of porang flour and eggs used, the higher the softness of noodles that have been rehydrated.

The level of softness of dry noodles is determined by the presence of glucomannan hydrocolloids in porang flour. It absorbs up to 200 times water of its weight. An increase in porang flour increases the noodle water content and produces softer noodles (Citra *et al.*, 2012).

Egg yolk causes more water absorption. Additionally, egg white has crystallization control power because of albumin. It prevents water evaporation and makes the dough softer

Table 4. Organoleptic values.

Formula composition		Score			
Proportion of modified cocoyam flour and porang flour (%)	Egg addition (%)	Color	Aroma	Taste	Texture
90:10	5	3.28	3.08	3.12	3.16
	10	3.28	3.00	2.96	3.04
	15	3.04	2.64	2.72	2.68
85:15	5	3.20	3.04	3.04	3.12
	10	3.20	2.96	3.00	3.04
	15	2.76	2.60	2.52	2.72
80:20	5	3.00	3.00	2.88	2.88
	10	2.96	2.88	2.68	2.76
	15	2.48	2.48	2.56	2.52

with higher moisture (Risti and Arintina, 2013). Both of these properties might lead to the usage of additional eggs, resulting in softer dry noodles, which the panelists disliked.

Conclusion

The proportion of modified cocoyam flour to porang flour determined the texture of non-gluten noodles. The high content of amylose induced a degrading enzyme activity during fermentation. It led to the breakdown of the amylopectin branch chain in α-1,6 glycosidic bond, resulting in new amylose and noodles texture. The best chemical, physical, and organoleptic parameters were obtained for noodles produced with 85:15 modified cocoyam flour and porang flour formulation with 10% egg addition. This formulation was chosen based on the organoleptic tests which were quite good (most preferred) than all other compositions.

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11. Characteristics of non-gluten noodles from modified cocoyam (Xanthosoma sagittifolium) and porang (Amorphophallus oncophyllus)

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