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Characteristic of Mocaf Noodles with Sago Flour Substitution (*Metroxylon sago*) and Addition of Latoh (*Caulerpa lentillifera*)

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***Abstract*— Food can fulfill both functional needs that are beneficial for health and nutritional requirements. Using mocaf (modified cassava flour) has been studied to produce food-processed products with good sensory characteristics, such as dry noodles. Latoh, which is rich in phenolic content and antioxidant activity, can further enhance the functional properties of noodles in addition to serving as a binder. Additionally, the addition of sago starch can improve the texture of the noodles and serve as a source of dietary fiber. This study aimed to study the nutritional value and functional properties of mocaf noodles by adding sago starch and latoh. There were six formula with varying percentages of mocaf flour, including sago with a ratio of 60%:10% (M1), 50%:20% (M2), 40%:30% (M3), 30%:40% (M4), 20%:40% (M5), and 10%:60% (M6), each formula containing 2% latoh flour. The result showed that mocaf noodle contained ash content about 1.32-1,32%, protein content 3.9-4.37%, fat content 0.41-0.67%, carbohydrate content 82.39-83.43% and total calories 339-343 kcal/100g noodles. Formula M3 had higher antioxidant activity (6.6%) and total dietary fiber content (11,54%) compared to other samples. The resistant starch content of noodles ranged from 8.7-12.64% with starch digestibility ranging from 27.27-61.05%. In conclusion, incorporating 30% sago starch, 40% mocaf, and 2% latoh flour in a formula has been found to increase dietary fiber and decrease starch digestibility. This suggests that the formula has the potential to be developed as a functional food.**

***Keywords*— Noodle; mocaf; sago; latoh; substitution.**

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I. INTRODUCTION

Noodle consumption was high in some countries, such as about 41,450 million in China, 12.520 million in Indonesia, 6,730 million in India, 5,630 million in Japan, and 5,440 million in Vietnam, recorded in 2019 [1]. Dry noodles processing generally uses wheat flour for the basic ingredients. However, wheat availability is quite low in certain countries, including Indonesia, which needs to import about 10,664 tons in 2019 [2]. Indonesia has other potential carbohydrate sources that can be used as a substitute for wheat-based products, such as noodle products. Mocaf noodles have been previously developed by Al-Baarri *et al.* [3] studies, but no more specific studies have been carried out regarding their chemical and functional characteristics. Mocaf flour is made from fermented cassava flour. It was previously reviewed by Pandin *et al.* [4]. Mocaf is a modified starch product that has undergone a biochemical process by fermentation. In the fermentation process, lactic acid bacteria play an important role in modifying starch structure by producing enzymes that hydrolyze starch. Starch modification can improve the properties of the final product. Flour properties contribute to food quality, which is closely related to consumer preferences. This flour has been widely developed for the production of raw materials, replacing some of the use of wheat flour [3].

The addition of other ingredients in the mocaf noodle based products can be used with the aim of improving its quality. Besides being able to improve the characteristics of noodle products, sago starch has bioactive components in the form of total dietary fiber of 11.07% (8.73% soluble dietary fiber and 2.34% insoluble dietary fiber) and resistant starch of 10.58mg/100g [5], [6]. Sago starches serve as a binder on noodle products to increase texture. They contain an amylose of around 27% and an amylopectin level of about 73% [7]. Noodle formula with a high proportion of sago starch will increase the formation of resistant starch [5]. The availability of sago starch is very abundant; Zaman *et al*. [8] explains that sago starch's potential production can reach 6 – 7 million tons.

The addition of latoh flour also has the potential to be used in noodle products. Besides its functional properties, Latoh (*Caulerpa lentillifera*) has the ability as a binder. Latoh is an edible seaweed with good nutritional value and biological activity [9]. Latoh contains crude protein 20.54%, 37,66% carbohydrate, 1.42% crude lipid, and 21.98% crude fiber [10]. In addition, latoh also studied its antioxidant potential, with phenolic content of 2.04-5.47 mg GAE/g and flavonoid content 4.93 mg QE/g with antioxidant activity EC_{50} 2.20 mg/ml [11].

Along with changes in the lifestyle of modern society and the increased risk of degenerative diseases, food with functional properties is very necessary. High-stress levels and an unbalanced diet result in a high risk of degenerative diseases. The development of functional food has a very important role in preventing and managing the risk of degenerative diseases. Nowadays, consumer behavior is not only focused on delicious taste and nutritious products, but they also consider the aspects of health. Noodle research grows sustainably to produce interesting and nutritious products with functional health benefits, including research by Chin *et al*. [12].

The development of food products contains dietary fiber, resistant starch, and other food products containing antioxidants. Dietary fiber and resistant starch have been studied to play a role in reducing the risk of degenerative diseases such as diabetes, and hypercholesterolemia, providing gastrointestinal health, and reducing the risk of colon cancer. Some of the mechanisms that support this theory are that the fermentation of dietary fiber and resistant starch in the colon can produce short chain fatty acids (SCFA), which provide benefits both for intestinal epithelial cells, have a good influence on glucose and lipid metabolism, besides that it is also a lack calorie food ingredient [13]. In addition, natural antioxidants have been suggested to have beneficial effects on health and various medical conditions such as neurodegenerative disease, cardiovascular disease, diabetes, and cancer. Much is attributed to its ability to scavenge reactive oxygen species (ROS) that counteract oxidative stress [14]. Given the significance of the above-mentioned future development of functional foods, this study aims to evaluate the nutritional value and functional properties of mocaf noodles substituted with sago starch and the addition of latoh.

II. MATERIALS AND METHOD

A. Materials

The raw material used is Mocaf flour obtained from local craftsmen in the Grobogan area, Indonesia. Sago starch and flour are obtained from local industries, while fresh latoh is obtained from the sea waters of Jepara regency, Indonesia. Preparation of latoh flour raw materials through the process of washing, sorting, soaking in water, drying at 50°C for 24 hours, and grinding of 60 mesh. Afterward, the flour was kept in the dark, dry, and closed container.

B. Noodle Preparation

The making of mocaf noodles is carried out with six formulas (Table I). Mixed flour ingredients and 2% latoh flour are added, then 30% water is added. The dough was steamed for 35 minutes, then formed using an extruder. Wet noodles were dried in a cabinet dryer at 50°C for 17 hours. The noodles are cooled and packaged for further analysis.

TABLE I
PERCENTAGE SUBSTITUTION OF RAW MATERIALS FOR MAKING MOCAF NOODLES

Code	Mocaf flour (%)	Sago starch (%)	Wheat flour(%)
M1	60	10	30
M2	50	20	30
M3	40	30	30
M4	30	40	30
M5	20	50	30
M6	10	60	30

C. Proximate Analysis

The proximate analysis consists of moisture content analysis, ash content, total protein content, and fat content according to AOAC [15]. The carbohydrate content is calculated based on different methods with the following equation:

$$Carbohydrate(\%) = 100\% - (\%water + \%protein + \%fat + \%ash) \quad (1)$$

D. Dietary Fiber

Dietary fiber content was analyzed using McCleary et al. [16]'s method. Petroleum ether was used to remove the fat from the dry sample for 15 minutes at room temperature, after which it was dried. An Erlenmeyer flask containing 1 g of fat-free sample was filled with a suspension after mixing 25 ml of 0.1 M phosphate buffer pH 6. The sample was wrapped with aluminum foil and given 0.1 ml of termamyl. The sample was heated to 100°C for 15 minutes before being cooled. The pH of the sample was raised to 1.5 by adding 4 M HCl after adding 20 ml of distilled water. Pepsin is added to the process and allowed to continue for 60 minutes while being covered, incubated at 40°C, and stirred. The pH was adjusted to 6.8 after the samples were added to 20 ml of distilled water. A 100 mg dose of pancreatin was added, sealed, and stirred for 60 minutes at 40°C. Subsequently, HCl was used to raise the pH to 4.5. The residue was filtrated using a crucible containing celite (dry weight). After that, the residue was cleaned using 2 x 10 ml of each distilled water, 95% ethanol, and acetone. After cooling, the residue was weighed after being dried at 105°C for around 12 hours to a constant weight. Ash was residual, which was heated to a temperature of 525°C, cooled, and weighed. The same process was used to get blank values but without using samples.

E. Total Phenolic

Analysis of total phenolic compound refers to the Folin-Ciocalteau by Roy *et al.* [17]. 125 µl reagent folin Ciocalteu, 125 µl sample dilution, and 250 µl distilled water were put into the test tube. The mixture was shaken with vortex and waited for 5 minutes at room temperature. 125 µl Na_2CO_3 (7%) was added with 1 ml of distilled water. The mixture was shaken with a vortex and incubated at room temperature for 90 minutes. The total phenolic was determined using a spectrophotometer at λ 760 nm.

F. Antioxidant Activity

According to Sompong et al. [16], the antioxidant activity was measured based on the capacity to scavenge free radicals (percent RSA). 200 µl of sample or standard, combined with 1 ml of reagent DPPH 0.1 mM, then vortexed. After 60 minutes of incubation in a dark room, the solution was evaluated at its maximum wavelength of 515 nm.

G. Starch Digestibility

In vitro starch digestibility analysis was carried out referring to the method of Anderson *et al.* [18] with modifications. A total of 1 g of sample and 100 mL of distilled water were put into a 250 mL erlenmeyer. The Erlenmeyer flask was covered with aluminum foil and heated in a water bath until 90°C while continuously stirring, then cooled. The closed test tube was filled with 2 mL of the sample solution, 3 mL of distilled water, and 5 mL of pH 7 phosphate buffer solution. The tube was sealed and incubated at 37°C for 15 minutes. After adding the sample, 5 mL of -amylase enzyme solution (1 mg/mL in phosphate buffer solution pH 7) was added. After being incubated for 30 minutes, it was transferred into a sealed test tube containing 2 mL of DNS solution. The solution was cooled after heating for 12 minutes. The mixture was then vortexed after 10 mL of distilled water was added. The absorbance was measured at 520 nm of the sample solution and the control.

H. Resistant Starch

The resistant starch (RS) content analysis was modified by Miura *et al.* [19]. For 60 minutes, a solution containing 20 mg of pepsin was incubated with 100 mg of a sample at 40°C. The process was followed by the addition of a tris-maleate solution containing 40 mg of pancreatic amylase and a 16-hour incubation period at 37°C. After centrifuging the mixture, 45 minutes of amyloglucosidase incubation at 60 °C were spent on the residue. RS was determined using the glucose measurements and the calculation mg glucose x 0.9.

I. Statistical Analysis

One-way ANOVA was used to analyze the data with SPSS 23.00. Duncan's Multiple Range Test (DMRT) is then used to determine the significant difference at a significance level (α) of 0.05.

III. Results and Discussion

Numerous studies on the production of noodle products have been conducted to increase flavor variety, improve nutritional value, and develop new functional properties. Table II and Table III display the nutritional profile of mocaf noodles.

The data in Table II above is the average result of 3 replication. In the same column. various superscript characters show a significant difference ($p < 0.05$). Table II indicates that using less mocaf flour resulted in noodles with less protein.

TABLE II
Moisture, Ash, Protein and Fat Content of Mocaf Noodles with Sago Starch Substitution and the Addition of Latoh

Code	Content			
	Moisture Content (%)	**Ash Content (%)**	**Protein Content (%)**	**Fat content (%)**
M1	10.85 ± 0.22^{a}	1.72 ± 0.04^{a}	4.37 ± 0.00^{a}	0.67 ± 0.00^{a}
M2	11.11 ± 0.10^{a}	1.77 ± 0.16^{a}	4.22 ± 0.04^{b}	0.41 ± 0.01^{b}
M3	10.95± 0.52^{a}	1.68 ± 0.01^{a}	4.35 ± 0.06^{ab}	0.61 ± 0.08^{ab}
M4	10.98 ± 0.07^{a}	1.59 ± 0.03^{ab}	3.97 ± 0.11^{c}	0.53 ± 0.11^{ab}
M5	10.83 ± 0.29^{a}	1.39 ± 0.09^{bc}	4.06 ± 0.03^{c}	0.60 ± 0.12^{ab}
M6	10.83 ± 0.21^{a}	1.32 ± 0.09^{c}	3.91 ± 0.00^{c}	0.49 ± 0.03^{ab}

This fact was related to the protein content of mocaf flour by 1.21%, higher than the protein content of sago starch, which is 0.54%. The protein level of latoh flour is 8.68%. The protein level of latoh flour is 8.68%. The raw material's protein content affects the noodles' characteristics. Mudgal and Singh [20] study the functional properties of noodle non wheat based on the raw material's protein content. Zhou *et al.* [21] studied that flour with low protein content produces noodles with low hardness. Another study by Chin *et al*. [12] showed that the protein content of noodles with the addition of surimi had a higher protein content of 7.82-18.11%, while the other content was moisture of 62.58-64.65%, ash content of 1.39-1.69% and fat content of 3.27-5.15%. The rheological properties of the product are influenced by the protein matrix and the starch material, as well as the interaction between the two. The granules' particle size affects the dough's elasticity of the dough, but the water-binding capacity of different starches can also have a greater influence. Increasing the proportion of smaller granules improves the elasticity character of the dough. Surface characteristics of starch granules and protein-starch interactions are responsible for the differences in linear viscoelastic behaviors of flour doughs [22].

TABLE III
Carbohydrate and Total Calories of Mocaf Noodles with Sago Starch Substitution and the Addition of Latoh

Code	Content	
	Carbohydrate (%)	**Total Calories (kcal/100g)**
M1	82.39 ± 0.18^{b}	341.95 ± 0.67^{ab}
M2	82.49 ± 0.23^{b}	339.35 ± 0.98^{b}
M3	82.42 ± 0.51^{b}	341.38 ± 2.45^{a}
M4	82.93 ± 0.18^{ab}	340.97 ± 0.77^{ab}
M5	83.12 ± 0.48^{ab}	342.83 ± 0.85^{a}
M6	83.43 ± 0.28^{a}	342.43 ± 1.31^{ab}

The data is the average result of 3 replication. In the same column. various superscript characters showed a significant difference ($p < 0.05$).

The carbohydrate content of noodles with mocaf and sago flour substitution was not significantly different. The overall formula showed that M2 formula was the lowest compared to other formulas (Table III), and this finding might be due to M2 formula's lower fat content. Noodles can provide roughly 15% of the calories that Indonesian adults need. The calorie content of noodles in this study (339-342 kcal/100g) was lower than the wheat noodles studied by Bayomy *et al.* [23] (40.1 kcal/100g) but ranged in the total calorie value of noodles with lentils and chickpeas based. The carbohydrate content of wheat noodles is about 81.49%, while the carbohydrate content of lentil-based noodles and chickpea-based noodles ranges from 74-78% [23].

TABLE IV
STARCH CONTENT OF MOCAF NOODLES

Code	Content		
	Amylosa (%)	Amylopectin (%)	Starch Total (%)
M1	18.86 ± 0.04^{c}	55.99 ± 0.04^{b}	76.86 ± 0.00^{c}
M2	19.90 ± 0.02^{b}	56.13 ± 0.13^{b}	76.03 ± 0.11^{b}
M3	18.19 ± 0.09^{d}	59.02 ± 0.09^{a}	77.21 ± 0.00^{a}
M4	21.64 ± 0.02^{a}	43.96 ± 0.13^{e}	65.59 ± 0.11^{f}
M5	21.68 ± 0.04^{a}	44.67 ± 0.18^{d}	66.35 ± 0.22^{e}
M6	21.62 ± 0.04^{a}	45.63 ± 0.17^{c}	67.25 ± 0.22^{d}

The data is the average result of 3 replication. In the same column. various superscript characters showed a significant difference (p 0.05).

The starch content of mocaf noodles formula M1-M6 is shown in Table IV. Mocaf noodle had a starch content of 65.59-77.21% with amylose content of 18.19-21.68% and amylopectin 43.96-59.02%. The 40-60% sago flour substitution proportion resulted in higher amylose content and lower amylopectin ($p<0.05$) than the 10-30% sago flour substitution formula. Sago starch contains 39.69% high amylose and low amylopectin 42.05%, whereas mocaf flour contains 22.48% amylose and 77.52% amylopectin [3] [22]. The high amylose content in the M4-M6 formula is related to the high amylose content in sago starch. Amylose content affects the texture of rice. High-amylose rice tends to be firm. The higher the amylose content, the higher the resistant starch content. Amylose had a linear structure on a compact matrix, which made it less accessible to enzymes [24].

Apart from being a source of nutritional fulfillment, many noodle products have also been formulated as food products that can provide good benefits for health. Table V shows the total phenolic content and antioxidant activity of mocaf noodles in the M1-M6 formula. Mocaf Noodles M3 with the formula 40% mocaf flour, 30% sago starch, 30% wheat and 2% latoh had the highest antioxidant activity of 6.6% with a total phenolic content of 0.026%.

TABLE V
TOTAL PHENOLIC CONTENT (%) AND ANTIOXIDANT ACTIVITY (%) MOCAF NOODLES WITH ADDITION OF LATOH

Sample	Content	
	Total Phenolic (%)	Antioxidant Activity (%)
M1	0.027 ± 0.00^{a}	4.69 ± 0.15^{c}
M2	0.028 ± 0.00^{a}	5.73 ± 0.08^{b}
M3	0.026 ± 0.00^{b}	6.60 ± 0.08^{a}
M4	0.024 ± 0.00^{c}	6.00 ± 0.15^{b}
M5	0.022 ± 0.00^{d}	4.42 ± 0.23^{c}
M6	0.021 ± 0.00^{e}	2.35 ± 0.08^{d}

The data is the average result of 3 replication. In the same column, various superscript characters showed a significant difference (p 0.05).

Antioxidants are commonly found as food additives but also naturally in plants. Considering they play a role in intricate metabolic and signaling processes. Antioxidants are important for both animal and plant life. Antioxidants' function in preventing oxidative stress in the body, play a role as anti-inflammatory, anti-adipogenic, anti-diabetic, urinary tract infections, coronary heart, stomach ulcers, dental diseases, and various cancers [25], [26]. Polyphenols, often known as phenolic compounds, do the secondary metabolism of plants and produce a broad class of metabolites. They play a significant part in the defense against plant diseases and have one or more hydroxyl groups linked to the benzene ring. Phenolic compounds react with different free radicals as antioxidants. Either hydrogen atom transfer, single electron transfer, sequential proton loss electron transfer, or transition metal chelation are the mechanisms of antioxidant action involved [27], [28]. Latoh flour contains phenolic compounds and antioxidant activity of 0.03% and 55.79%, respectively. Thereby contributing to the phenolic and antioxidant content of mocaf noodles.

Dietary fiber content starch digestibility and resistant starch are shown in Fig. 1. Mocaf noodles formula M1-M6 has a dietary fiber content of 3.55-11.54%. Formula M3 had significantly higher dietary fiber content ($p>0.05$) than other treatments, with soluble dietary fiber 4.54% and insoluble dietary fiber 7%. Dietary fiber is much desired in the development of functional foods. Azkia *et al.* [29] also studied the dietary fiber content of noodles based on soghum, sago, and mung bean flour containing a total of 13.16% dietary fiber, in the form of 4.2% soluble dietary fiber and 9.46% insoluble dietary fiber.

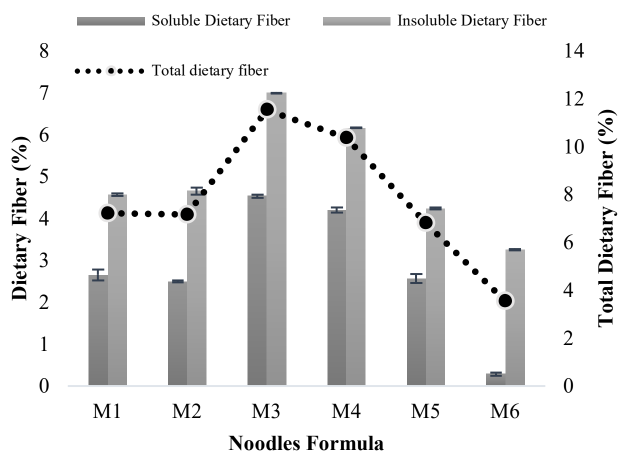

Fig. 1 Soluble, insoluble and total dietary fiber content (%).

Dietary fiber consists of indigestible forms of carbohydrates, usually polysaccharides derived from plant foods. Dietary fiber intake is associated with overall metabolic health (including insulin sensitivity) and various other pathologies, including cardiovascular disease, colon health, intestinal motility, and risk of colorectal carcinoma [30], [31]. Soluble dietary fiber increases transit time by delaying gastric emptying and also slows glucose absorption, while non-viscous soluble fiber acts as a substrate for microbial fermentation in the colon. Meanwhile, insoluble dietary fiber generally increases fecal bulk and bile acid extraction, and decreases intestinal transit time [32]. Resistant starch (RS) is a form of starch that is resistant to digestion in the small intestine. Due to this, it is also categorized as a form of dietary fiber. The RS diet was studied to have good benefits in managing the risk of diabetes, namely through glycemic control. In the colon, RS can be fermented to create short-chain fatty acids that have a satiety effect. This is additionally advantageous for colon health [33], [34]. Fig. 2 shows RS content in noodle mocaf sample of about 8.70-11.98%. This result is lower than previous studies on sorghum, sago, and mung bean flour-based noodles [29]. Different formulas of raw material for making noodles could affect dietary fiber and resistant starch content.

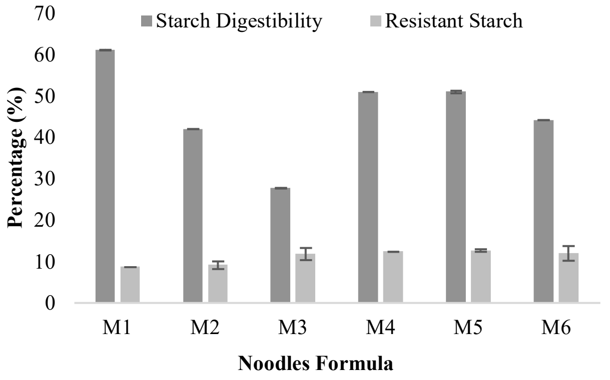

Fig. 2 Starch digestibility and resistant starch content (%).

IV. CONCLUSION

Improvement of functional properties of dry noodle products needs to be continuously developed, one of which is using local food ingredients. Given that mocaf noodles contain antioxidant activity, good dietary fiber, and low starch digestibility, adding sago and latoh can potentially boost the functional qualities of dry noodles. Mocaf noodles M3 with the formula 40% mocaf flour, 30% wheat and 2% latoh had the highest antioxidant activity of 6.6% with a total phenolic content 0.026%. In comparison to other treatments, Formula M3 had significantly more dietary fiber, including soluble dietary fiber at 4.54%, insoluble dietary fiber at 7%, and starch digestibility at 27.74%. Considering the many advantages of dietary fiber, these qualities can be developed to reduce oxidative stress and prevent diabetes.

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