Gluten-free instant noodles based on mocaf flour

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Abstract. Background: Noodles are commonly made from wheat flour, which is an imported commodity. New innovation is needed by developing local food ingredients to make noodles. Mocaf exhibits properties such as viscosity, gelatinization, dehydration power, and solubility similar to wheat flour, so it can be used as a substitute ingredient in the developing of food products based on wheat flour. This study aims to develop gluten-free instant noodles using mocaf (modified cassava flour). Methods: The experimental design used a completely randomized design with five variations of rice flour and sago flour. Five noodle formulas were tested for their physical and sensory properties. The most favorable formula was analyzed for its nutritional content. Each treatment was set in duplicates, while analyses were performed in three replicates. All statistical analyses were performed with SPSS 23. Results: The most favorable formula was Mo4, which contains 6.15% water, 2.65% ash, 14.7% fat, 74.60% carbohydrate, 526 kcal total energy, 0.95% total sugar, 0.06% trans fat, and 4.12% dietary fiber. Conclusions: The preferred noodle contains 4.12% of dietary fiber, thus qualifying as a good source of dietary fiber. This noodle can become an alternative healthy food for individuals with gluten intolerance.

1 Introduction

Increasing population and life activities, changes in the lifestyle of Indonesian people, encouraging people to want something practical, easy, and instant to eat. Thus, Indonesian people already started to consume instant food a long time ago as an alternative choice to meet daily food needs to replace staple food. An instant food that is very popular and has the potential to be an alternative substitute for staple foods such as rice is instant noodles. Instant noodles are a very fast food interested in many Indonesian people. The reasons are practical: filling, relatively cheap, no need for a long processing time, and many choices of flavor. Based on data from the World Instant Noodles Association (WINA) in 2023, Indonesia emerged as one of the largest instant noodle consumers in the world. Indonesia is second in rank with the amount of instant noodle consumption of 14.54 billion portions per year [1].

A prominent ingredient in noodle processing is wheat flour, which is imported. Due to its lack of domestic wheat production, Indonesia is entirely dependent on imports to meet its needs for foods made from wheat flour as well as for use as a feed ingredient for livestock,

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poultry, and aquaculture. The demand for imported wheat flour increased by 44.7% between July 2023 and June 2024. With a 91.1 percent market share, Turkey is the primary supplier of Indonesia's imported wheat flour, followed by Vietnam with a 6.2 percent market share [2]. Developing local food ingredients to manufacture noodles requires new creativity. Mocaf (Modified Cassava Flour) is a product from fermented cassava that enhances the quality compared to regular cassava flour. Mocaf exhibits properties such as viscosity, gelatinization, dehydration power, and solubility similar to wheat flour. Mocaf has high levels of amylose, is relatively low in protein, and does not contain gluten. Mocaf is gluten-free, making it suitable for individuals with gluten intolerance [3]. Mocaf as a substitute for wheat flour has been formulated in various foods such as noodles, analog rice, and bread [3, 4]. A lot of research has been done regarding making gluten-free noodles. The main ingredient of wheat flour can be replaced with carbohydrate source flour, such as corn [5], rice [6, 7, 8, 9, 10], local tubers including sweet potato, tiger nut (*Cyperus esculentus*) [11, 12], Coleus rotundifolius tuber [13], taro tuber [14], and arrowroot tuber [15].

In noodle making, the content of amylose and amylopectin is crucial. Starch with high amylose content is ideal due to its superior gelling ability during gelatinization. High amylopectin content contributes to the chewiness of the noodles. It is necessary to substitute other flours to achieve the desired texture of noodles [16]. In this study, rice, sago, and tapioca flours were added. Rice flour was used to develop a harder texture [17] and a chewy texture [18] in the noodle. Many studies were conducted to develop gluten-free noodles from local tubers, but the research about the development of gluten-free instant noodles based on mocaf flour was not reported yet. This research aimed to develop a gluten-free instant noodle based on mocaf flour.

2 Materials and methods

The ingredients used in this research include mocaf flour, tapioca flour, sago flour, rice flour, eggs, CMC, salt, and water. Mocaf flour was produced by Putri 21 Small Medium Enterprises (SME) located at Gunungkidul, Yogyakarta. Tapioca flour, sago flour, eggs, CMC, and salt were purchased from the local market. The noodle processing equipment included an analytical balance, sieve, basin, sheeter noodle machine, steaming pot, deep fryer, and oil drainer.

This research consists of 2 stages: optimizing the formulation of noodle processing and analyzing the noodles. In the 1st stages, the noodle-making process consists of five noodle formulations, as described in Table 1.

Table I. The noodle formulation

Formulation	Mocaf flour (%)	Rice flour (%)	Sago flour (%)	Tapioca flour (%)
Mo1	37	7	14	7
Mo2	37	6	15	7
Mo3	37	8	13	7
Mo4	37	4	17	7
Mo5	37	10	11	7

As shown in Table 1, there were 5 formulations of noodles between the composition of rice flour and sago flour, while the other ingredients (mocaf flour, tapioca flour) remained at the same amount. The noodle processing was started by pre-gelatinization of sago flour, tapioca flour, and water. The pre-gelatinized dough was then mixed with the other ingredients, including mocaf flour, rice flour, CMC, eggs, and salt. The mixture dough was then made into sheets using a sheeter noodle machine until a compact and elastic noodle strand was formed. Then, steamed for 20 minutes, followed by air drying for 2 hours at room

temperature. Furthermore, the noodles were fried using a deep fryer. The instant noodles are then finally packaged in cups.

The second stage was an analysis of the instant noodles that included textural properties and hedonic sensory tests. Textural properties of the noodles were analyzed, including compression tests and tensile strength [19], using the testing machine "Zwick Z0.5." The sensory test was conducted using 28 untrained panelists. The sensory test used a hedonic test with a scale of 1-5, where 1 = very dislike; 2 = dislike; 3 = neutral; 4 = like; 5 = very like.

The selected noodles based on analysis of textural properties and sensory analysis were tested for proximate composition [20], sugar content, saturated fat, and dietary fiber [21]. The experimental design used a completely randomized design with five variations in the formulation of rice flour and sago flour. Each treatment was set in duplicates, while analyses were performed in three replicates. All statistical analyses were performed with SPSS 23, using Duncan's multiple-range test after one-way analysis of variance (ANOVA) to identify significant differences (p-values <0.05) between groups.

3 Results and discussion

The five instant noodle formulations were then analyzed for their textural properties and sensory tests. Textural properties were analyzed, including compression tests and tensile strength. A compression test is a method for measuring the texture of a noodle by applying a force to it and recording the extent of deformation. The compression test measured the hardness of noodles. Tensile strength is the amount of force that a material can bear before breaking or deforming irreversibly. A tensile fixture test can be used to measure the distance to the breaking point in noodles in order to estimate their tensile strength. The graph's tensile strength increases with the force value. Noodles elasticity and crushing strength are represented by their tensile strength, which is the highest force needed to break their strand [22].

Textural properties of the five instant noodles were shown in Table 2. The starch properties of raw materials significantly affect the characteristics of non-wheat noodles, thus influencing consumer acceptance. As shown in Table 2, the highest compression test was the Mo4 noodle, and the lowest compression test was the Mo3 noodle. The compression test of the Mo4 noodle was the highest and significantly different from the other sample. This indicated that the Mo4 noodles, made with the lowest rice flour (4%) and highest sago flour (17%), were less prone to breaking and disintegration; therefore, it facilitated product distribution to consumers. The addition of sago starch can enhance the noodles' texture [23]. Sago starch has a 70–80% higher amylopectin level and a 15–30% amylose content [24]. The starch makes the noodles' texture elastic and resistant to breaking. The highest tensile strength was the Mo5 noodle, and the lowest was the Mo3 noodle.

Table 2. Textural properties of the noodle

Sample	Parameter	
	Compression test (Newton)	**Tensile strength (Newton)**
Mo1	4.5299^{b}	0.0264^{bc}
Mo2	4.5313^{b}	0.0128^{a}
Mo3	3.0258^{a}	0.0102^{a}
Mo4	6.5134^{c}	0.0207^{b}
Mo5	4.6320^{b}	0.0322^{c}

The same alphabet superscript in the same column indicates no significant difference at a 95% confidence interval.

Sensory evaluation is considered the most reliable method for measuring the quality attributes of noodles. Sensory analysis is used to evaluate the quality of noodles and to help determine whether to accept or reject them. In this study, sensory analyses were conducted using a hedonic test with 28 untrained panelists, and the sensory parameters, including taste, aroma, color, elasticity, stickiness, and overall acceptance, were evaluated. The result of the sensory analysis was described in Table 3.

Table 3. The sensory attributes of the noodle

Sample	Attributes					
	Taste	Aroma	Color	Elasticity	Sticky	Overall
Mo1	3.07^{a}	3.79^{a}	3.21^{a}	2.79^{a}	2.75^{a}	2.89^{a}
Mo2	3.61^{ab}	3.75^{a}	3.39^{a}	2.79^{a}	2.71^{a}	3.14^{ab}
Mo3	3.39^{a}	3.57^{a}	3.36^{a}	3.14^{ab}	3.04^{a}	3.32^{ab}
Mo4	4.07^{b}	3.96^{a}	4.00^{b}	3.68^{b}	3.93^{b}	4.04^{c}
Mo5	3.68^{ab}	3.61^{a}	3.64^{ab}	3.43^{b}	3.21^{a}	3.46^{b}

The same alphabet superscript in the same column indicates no significant difference at a 95% confidence interval.
Hedonic scale 1-5, where 1 = very dislike; 3 = neutral; 5 = very like.

As described in Table 3, taste attributes for the Mo4 noodle showed the most preferred noodles compared with the others. This indicated that the Mo4 noodles, made with the lowest rice flour (4%) and the highest sago flour, have the best taste. From the statistical analysis, it showed that the aroma attributes of 5 noodles were not significantly different. The highest preferred color was Mo4 noodle. The same results were shown with the other sensory attributes. Elasticity and sticky attributes were highest in the Mo4 noodle. Sago starch addition can enhance the noodles' texture, i.e., elasticity and stickiness. Noodle elasticity is a property of dough that allows it to regain its shape after being stretched. It is a critical measure of the eating quality of noodles. The Mo4 also has the highest overall acceptance, and it is significantly different from such variation.

The most preferred noodles were Mo4, which were more favorable than the others. The important characteristics of cooked noodles were texture and sensory attributes. Good noodles were sturdy, chewy, and non-sticky after cooking, have a relatively short cooking time, and exhibit low loss of solids [23].

The selected Mo4 noodle products were then tested for nutritional content, including water content, ash content, total fat content, protein content, carbohydrate content, total energy, dietary fiber, total sugar, and trans fat. The results were as follows: water content 6.15%, ash content 2.65%, total fat content 14.7%, protein content 1.92%, carbohydrate content 74.60%, total energy 526 kcal, dietary fiber content 4.12%, total sugar content 0.95%, and trans fat 0.06%. These results indicated that the gluten-free ready-to-eat noodles based on mocaf flour were a source of dietary fiber, which contained 4.12%. According to BPOM RI Regulation No. 1/2022 concerning supervision of claims on labels and advertising of processed food, a product is referred to as a source of fiber if it contains at least 3% dietary fiber.

4 Conclusion

The preferred noodle was Mo4, which contains water 6.15%, ash 2.65%, total fat 14.7%, protein 1.92%, carbohydrate 74.60%, total energy 526 kcal, dietary fiber 4.12%, total sugar 0.95%, and trans fat 0.06%. This noodle is a good source of dietary fiber (according to BPOM RI Regulation) and can become an alternative healthy food for individuals with gluten intolerance.

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