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Chemical and Organoleptic Quality of Free-Gluten Dry Noodles from Sorghum *(Sorghum bicolor)* and Modified Cassava Flour with Different Drying Temperature

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Abstract. Dry noodles are widely commercialized thanks to their durability and practicality for consumption as side dishes or staples to replace rice. The development of dry noodles is robustly conducted, mainly by substituting its main ingredient of wheat flour to local staple flour with similar or better nutritional value and characteristics compared to wheat flour and gluten-free as well. Some alternatives are sorghum *(Sorgum bicolor)* flour and mocaf *(Modified cassava flour).* Applying the correct drying temperature to produce dry noodles with good chemical and organoleptic quality. This research utilized a factorially formulated Completely Randomized Design with three levels for each actor. The first factor is the sorghum flour and MOCAF proportions with levels of 40:60, 60:40, and 80:20, and the second factor is the noodle drying temperature with levels of 50^0C, 60^0C, and 70^0C. Each treatment is repeated three times. Chemical quality aspects that would be analyzed are water, ash, fiber, and protein contents. Meanwhile, the organoleptic quality analysis is conducted by the organoleptic test based on the likeness level/organoleptic hedonic test that encompasses color, aroma, texture, and flavor. The P1S1 treatment, in which the flour ratio is 40 g: 60 g with a drying temperature of 50^0C is the best treatment, obtaining the highest Result Value of 0.699, with the research variable criteria as follows: chewiness 5.6, (like), water content 6.6733%, flavor: 5.3 (rather like), protein content: 9.7033%, coarse fiber: 5.2233%, ash content: 0.2767%, color: 5.4 (rather like), and aroma: 5.4 (rather like).

Keywords: Dry Noodles, Drying Temperature, Mocaf, Sorghum Flour

1 Introduction

The wheat flour-based food industry keeps increasing, which leads to its import statistics surpassing 31,000 tons in 2021 [1]. Therefore, an effort to decrease the wheat flour demand is the utilize Cerealia and tuber-based local food that is common in Indonesia, such as sorghum, cassava, et cetera that could be made into flour. Sorghum (*Sorghum bicolor*) contains 70% starch with an amylose and amylopectin content ratio of around 20-30% [2]. Its protein content is similar to wheat, around 11%. The advantages of sorghum, compared to other Cerealia, are higher fat, coarse fiber, B complex vitamin, and iron content, so it is beneficial for curing nutritional anemia. Until recently, sorghum has been utilized in semi-finished processed products such as sorghum rice (dhal) and finished processed products such as sorghum flour. The sorghum flour could be utilized as the ingredient of any gluten-free [3], one of them is the raw material for dry noodles. The nutritional content of wheat flour per 100 grams is 14% water; protein content 8-12%; ash content 0.25-1.60%; and 24-36% wet gluten [5].

Cassava (*Manihot esculenta*) is an abundant local tuber that grows all year and has been processed into a variety of flours, such as tapioca flour and mocaf. Mocaf (Modified Cassava Flour) is made through fermentation to modify the cells in the cassava with the assistance of lactic acid bacteria, so it has the advantages of better organoleptic, physical, and chemical characteristics [4]. From a nutrition perspective, mocaf contains higher carbohydrates, fiber, and calcium than wheat flour [5] The nutritional content per 100 grams of mocaf includes: calories 363 Cal, protein 1.2 grams, fat 0.3 grams, carbohydrates 34.7 grams, calcium 33 mg, phosphorus 40 mg, and iron 0.7 mg, so it can be utilized as a substitute for wheat flour [6] for processed food such as dry noodles.

Dry noodles are one of the popular products in society and are generally made from wheat flour that contains gluten, so people with celiac disease/gluten intolerant cannot consume it [7][8]. To diversify local food, push

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back wheat import, and safe food provision, mainly for people with celiac disease or gluten intolerant and generally for the public, the processing of sorghum flour and mocaf into dry noodles could be a solution for free-gluten local food development.

According to Winarti (2019), gluten-free dry noodles can be made from mocaf flour and gadung flour with the best proportions of 40%: 60% which are dried using a cabinet dryer at 60 ºC. Meanwhile, according to Maryani (2011), the best gluten-free dry noodles are made from mocaf flour and cassava flour in the proportion of 60%: 40% with an oven temperature of 70 ºC. Based on this, a preliminary study was carried out to determine the treatment for making dry noodles made from sorghum and mocaf flour. The purpose of this study was to determine the proportion of sorghum and mocaf flour with the proper/optimal temperature for drying noodles so as to produce chemical and organoleptic quality of dry noodles that could be well received by consumers. The results of this study can increase the number and types of non-gluten food diversification products, the availability of food, especially for gluten intolerant sufferers and the public in general and can reduce consumption of flour which is still imported.

2 Research Method

2.1 Ingredients

The main ingredients in making dry noodles are sorghum flour and mocaf, which were bought at UD Brawijaya Blora. The supporting ingredients are water, eggs, salt, and CMC. Besides water, all supporting ingredients are bought at Sembilan cake ingredients shop, Jemursari Street 234, Surabaya.

Ingredients for chemical tests in this research are 3.25% NaOH solution, 30% ethanol, 96% H_2SO_4 solution, 1.25% concentrated H_2SO_4 solution, K_2SO_4 solution, 4% H_3BO_3 solution, and 0.01 N HCl solution.

2.2 Research Design

This research uses the Completely Randomized Design formulated by factorial using two factors, and each factor contains three levels as follows:

Factor 1: The proportion of sorghum flour and mocaf, consisted of three levels, namely:
- P1 = 40 grams of Sorghum flour : 60 grams of Mocaf
- P2 = 60 grams of Sorghum flour : 40 grams of Mocaf
- P3 = 80 grams of Sorghum flour : 20 grams of Mocaf

Factor 2: Noodle drying temperature, consisting of three levels, namely:
- S1 = Drying temperature of 50^0C
- S2 = Drying temperature of 60^0C
- S3 = Drying temperature of 70^0C

Based on the (t-1) ≥ 15 equation, with *t* as the amount of treatment and *r* as the repetition [9], then the repetition would be 3 (three) times and there would be 9 (nine) treatment combinations.

Table 1. Treatment combination of the research

The proportion of sorghum flour and mocaf	Drying temperature		
	S1	S2	S3
P1	$(P1SI)_{123}$	$(P1S2)_{123}$	$(P1S3)_{123}$
P2	$(P2S1)_{123}$	$(P2S2)_{123}$	$(P2S3)_{123}$
P3	$(P3S1)_{123}$	$(P3S2)_{123}$	$(P3S3)_{123}$

Note: $_{123}$ Repetition

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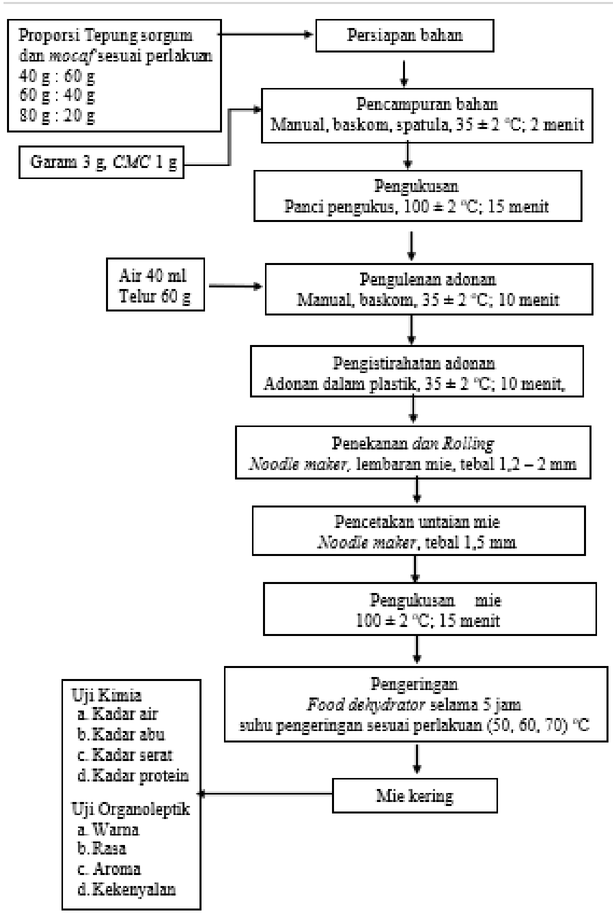

Figure 1. Flowchart of research on making dry noodles (Modification of Rahayu et al., 2019)

2.3 Research Variable

Analysis of chemical and organoleptic quality aspects in this study is a research parameter, which consists of chemical and organoleptic quality parameters. Chemical quality parameters of free-gluten dry noodles consisted of water and ash content using the gravimetric method, coarse fiber content using the extraction method, and protein content using micro-Kjeldahl method [10]. The organoleptic test of color, taste, and aroma is conducted on the pre-boiled free-gluten dry noodle. The chewiness organoleptic test was then conducted on the boiled noodles. There were 25 panelists for this test, and this test uses seven scales (1 = very dislike, 2 = dislike, 3 = rather dislike, 4 = neutral, 5 = rather like, 6 = like, and 7 = very like).

2.4 Data Analysis

The parametric data obtained from water, ash, coarse fiber, and protein content, are analyzed through Analysis of Variance (ANOVA), using the SPSS application. If the analysis shows a significant or very significant difference, the test then continued further test using the Least Significance Different (LSD) test, should the Coefficient of Variation (CV) is under 5%. If the CV value is between 5-10%, it is subjected to the Tukey test. If the CV value exceeded 10%, the Duncan test must be conducted [9].

The non-parametric data obtained from the organoleptic test which are color, aroma, taste, and chewiness, are analyzed through the Hedonic test. And to observe the difference between treatments, the research then continued to the Kruskal-Wallis test [11]. Both parameters were then subjected to an Effectivity test to obtain the best treatment [12].

3 Result and Discussion

3.1 Water Content

According to [13], dry noodles should have low water content, around 13%, because it could influence water activity (A_w), which determined its shelf life. The result of the water content for the free-gluten dry noodles is

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shown below in Table 2.

Table 2. Average of water, ash, coarse fiber, and protein content of dry noodles (%)

Treatment code	Water content average (%)	Ash content average (%)	Coarse fiber average (%)	Protein content average (%)
P1S1	6.6733^{e}	0.2767^{a}	5.2233^{a}	9.7033^{a}
P1S2	6.6233^{e}	0.4933^{b}	5.3733^{a}	9.3166^{a}
P1S3	6.1200^{d}	0.7800^{c}	6.4600^{b}	9.0500^{a}
P2S1	5.8233^{d}	1.2700^{d}	6.5667^{b}	11.7366^{bc}
P2S2	5.3967^{c}	1.7733^{e}	6.7800^{bc}	11.5066^{bc}
P2S3	5.3633^{c}	1.8500^{ef}	6.8500^{bcd}	11.1366^{b}
P3S1	4.4700^{b}	1.9700^{fg}	7.1600^{bcd}	12.3633^{c}
P3S2	4.2100^{ab}	2.0400^{g}	7.3067^{cd}	11.9500^{bc}
P3S3	4.1233^{a}	2.4267^{h}	7.5767^{e}	11.6900^{bc}

Table 2 illustrates that lower sorghum flour and higher mocaf ratio would increase the noodle's water content, due to the high starch content in the mocaf. According to [14], mocaf contains 79-81% starch, which contains a hydroxyl group that influences the ability to optimally absorb water, and this ability would increase with the addition of the mocaf ratio. Therefore, on treatment with more mocaf than sorghum flour ratio, the dry noodles would have higher water content.

The decreasing water content of the dry noodle is also influenced by higher drying temperatures. The treatment with the lowest drying temperature produces high water content noodles, and vice versa. The decreasing water content on high-temperature treatment could happen due to optimal evaporating water in the food ingredient by heat introduction. The finding is in line with the statement of [15], which explained that heat and mass transfer during the drying process are happened simultaneously and influenced by the high drying temperature, which triggers the free water transfer in the food ingredient towards the surface and later it optimally evaporated so that the dried food's mass and volume are decreasing.

3.2 Water Content

The ash content can be used as the indicator of minerals contained in the food ingredients. Besides being influenced by the temperature and water content increase, the ash content amount from the dry noodle is also influenced by its ingredients.

Table 2 shows that the drying temperature affects the ash content because a higher drying temperature means higher ash content due to burnt organic matter during the heating, but the inorganic mattes are not burned. During the ingredient's drying process, water molecule binds would break, which leads to increasing mineral content. In conclusion, the increasing drying temperature influences the ash content [16].

The treatment of higher sorghum flour produces dry noodles with higher ash content compared to treatment with higher mocaf content because sorghum flour has 1.88% higher ash and mineral content [17].

3.3 Coarse Fiber Content

Table 2 shows the coarse fiber content of the research treatments of the dry noodles is around 5.2233 - 7.5767%, with the lowest coarse fiber content detected on the P1S1 treatment (5.2233%), and the highest content on the P3S3 treatment (7.5767%). The high coarse fiber content of the food ingredient is also affected by its constituent materials. On the treatments with higher sorghum flour than mocaf, the noodle has high coarse fiber. This happened because mocaf has a small amount of coarse fiber compared to sorghum flour, which is around 7.9% [17][6].

The free-gluten dry noodle from sorghum flour and mocaf contain high coarse fiber, influenced by the basic ingredient of high-fiber sorghum flour. The existence of coarse fiber in this noodle is beneficial as a functional food because half of its coarse fiber content is the dietary fiber that is beneficial in lowering cholesterol, by preventing bile acid liquid, which makes cholesterol and fat reabsorbed into the body. Besides, the dietary fiber on cereals-based coarse fiber is beneficial in preventing diverticulitis because coarse fiber will influence the softer fecal consistency, so it will not wound and infect the digestive system [16].

3.4 Protein Content

Table 2 also shows that higher sorghum flour than mocaf could increase the protein content. The different result happened due to the sorghum flour, which comes from the sorghum seeds, being cereal with higher protein content (11.4%) compared to other types of cereals such as rice, corn, and barley [17]. [4] stated that mocaf does not contain protein, so the treatment with a higher ratio of sorghum flour would increase the protein content of the dry noodles.

From Table 2, it is concluded that temperature takes a role in the dry noodle's protein content. The protein content is related to the water content because both are directly proportional and have a similar pattern of decreasing content along the rising temperature, which causes the alteration of the water molecule's polypeptide chain and leads to protein denaturation. This occurrence is in line with the statement of [16], in which the structural change in the protein molecule (denaturation) could happen because of temperature, pH, chemical ingredients, and mechanical influences.

3.5 Color

The treatment of higher mocaf compared to the sorghum flour led to more favorable dry noodles color by panelists because, according to [14], mocaf has clear white color, compared to the darker white color of sorghum flour, thanks to the tannin inside [2]. Therefore, despite the making of free-gluten dry noodles using eggs, which is the natural yellow coloring, the treatment with higher sorghum flour produces darker dry noodle color.

Table 3. The average score results of the organoleptic test (color, taste, aroma, and chewiness) of dry noodles

Treatment code	Color average score	Taste average score	Aroma average score	Chewiness average score
P1S1	5.4	5.3	5.3	5.6
P1S2	5.6	5.2	5.4	5.3
P1S3	5.3	5.1	5.2	5.4
P2S1	5.0	5.4	5.1	5.2
P2S2	5.2	5.5	4.9	5.0
P2S3	5.3	5.0	4.8	5.5
P3S1	4.9	4.7	4.6	4.9
P3S2	5.0	5.0	4.9	4.8
P3S3	4.8	4.9	4.8	4.7

The color of dry noodles could be influenced by drying temperature because of the non-enzymatic browning reaction process during the noodles' color forming. The high-temperature heating process on food ingredients could trigger the Mallard browning reaction, caused by carbohydrates, especially reducing sugar, is in reaction with the primary amine group, so the reaction resulted in food colored brown, which often expected or, in some conditions, not expected because it signs as an indicator of a quality downgrade of the ingredients [18].

3.6 Taste

Treatment that has higher sorghum flour ratio than mocaf resulted in dry noodles with flavor being less liked by panelists because the fermented mocaf does not have a strong cassava flavor [14]. Meanwhile, according to [19], sorghum flour has a distinctive savory flavor so despite the noodle-making process involving eggs as a savory flavor enhancer, the high ratio of sorghum flour reduces the savory taste of dry noodles and receiving a reduced score on likeness by panelists.

3.7 Aroma

Dry noodles aroma could be influenced by its ingredients because flour that a distinctive aroma from its

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floured foodstuffs. Dry noodles must have a normal aroma quality [20].

Higher sorghum flour ratio would reduce the aroma likeness score of the noodle. The addition of high-ratio mocaf does not have any influence on the formation of dry noodles' aroma because, during the processing, mocaf passed the fermentation process so it does not have a strong aroma [14]. According to [21], sorghum flour has a strong aroma similar to a nutty and grassy smell, so it could influence the end product's aroma.

3.8 Chewiness

Chewiness is the main component used to determine the noodle texture. The chewy noodle texture is generally liked by noodle consumers because it could ease people of all ages to consume it [22].

Despite all noodles in the treatment rosters being subjected to the same cooking process, which was cooked in 500 ml of boiling water for 3 minutes, it resulted in different chewiness levels so it influenced the likeness scale from the panelists. A higher mocaf ratio will increase the chewiness and be liked by panelists because, during the processing stage, the chewy noodle texture is heavily influenced by the higher amylose content in the ingredient because it binds water well, which influences the gelatination process and determines the noodle chewiness due to the high amylose content, around 29-30% [14]. Meanwhile, according to [23], amylose in sorghum flour is only 20%, so a higher mocaf ratio than sorghum flour would result in chewy noodles. [21] also explained that ingredients containing high amylose would produce chewier and not easy-to-break noodles.

Sorghum flour has high protein but it does not have any influence in forming a chewy noodle texture because it contains essential amino acids, not gluten [2]. The high fiber in sorghum flour also influences the noodle's chewy texture formation. Higher sorghum flour ratio than mocaf means cooked noodles with more fiber but decreasing chewiness because fiber is a texture-enhancing polysaccharide in the foodstuff, so higher coarse fiber in noodle ingredients would result in denser and firmer, so the product's texture would be harder [24].

3.9 Best Treatment

The effectivity test of all treatments could be seen below in Table 4.

Table 4. Results Values of the research parameter's effectivity test

	Results Value (RV) of treatment								
Parameter	P1S1	P1S2	P1S3	P2S1	P2S2	P2S3	P3S1	P3S2	P3S3
Chewiness	0.138	0.092	0.107	0.076	0.046	0.122	0.030	0.015	0
Water	0.138	0.135	0.108	0.092	0.068	0.067	0.018	0.004	0
Taste	0.103	0.086	0.069	0.120	0.138	0.051	0	0.051	0.034
Protein	0.024	0.009	0	0.099	0.091	0.077	0.123	0.107	0.098
Coarse Fiber	0	0.007	0.064	0.070	0.081	0.085	0.101	0.108	0.123
Ash	0.123	0.110	0.094	0.066	0.037	0.032	0.026	0.022	0
Color	0.080	0.107	0.066	0.026	0.053	0.066	0.013	0.026	0
Aroma	0.093	0.107	0.080	0.066	0.040	0.026	0	0.040	0.026
Total	**0.699**	0.653	0.588	0.615	0.554	0.526	0.311	0.373	0.281

From the average score of the effectivity test on all treatments as illustrated in Table 4, the dry noodle with P1S1 treatment in which the sorghum flour and mocaf ratio is 40 g : 60 g with a drying temperature of 50^0C is the best treatment, obtaining the highest Result Value of 0.699, with the research variable criteria as follows: chewiness 5.6, (like), water content 6.6733%, flavor: 5.3 (rather like), protein content: 9.7033%, coarse fiber: 5.2233%, ash content: 0.2767%, color: 5.4 (rather like), and aroma: 5.4 (rather like).

4 Conclusion

Based on the results of the observation of chemical and organoleptic quality of the free-gluten dry noodle, this research concludes the interaction between the sorghum flour and mocaf proportion with different drying temperature significantly influences water, ash, and coarse fiber content and does not have a significant influence on protein content.

The P1S1 treatment, in which the sorghum flour and mocaf ratio of 40 g: 60 g with a drying temperature of 50^0C is the best treatment, obtaining the highest Result Value of 0.699, with the research variable criteria as follows: chewiness 5.6, (like), water content 6.6733%, flavor: 5.3 (rather like), protein content: 9.7033%, coarse fiber: 5.2233%, ash content: 0.2767%, color: 5.4 (rather like), and aroma: 5.4 (rather like).

Gluten-free dry noodles made from sorghum and mocaf flour can be processed, served, consumed and marketed like dry noodles in general so that they can increase the type and quantity of gluten-free food, as well as play a role in efforts to reduce wheat imports.

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