

EVALUATION OF PHYSICOCHEMICAL AND ORGANOLEPTIC PROPERTIES OF GLUTEN-FREE WHITE BREAD WITH VARIATIONS IN THE PROPORTIONS OF MOCAF FLOUR AND MUNG BEAN FLOUR

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Abstract

Bread is a processed food product that is widely consumed as a substitute for rice or as a snack because of its popular taste in Indonesia. MOCAF (Modified Cassava Flour) is fermented cassava flour that has a smooth texture, white color, neutral aroma, and is gluten-free, while mung bean flour is a source of high vegetable protein ($\pm 22.9\%$) and is rich in vitamins and minerals so it has the potential to increase the nutritional value of processed food products. This study aims to determine the effect of the proportion of MOCAF flour and mung bean flour and to determine the best treatment on the physicochemical and organoleptic properties of gluten-free white bread. The study was conducted using a laboratory experimental method with a one-factor Completely Randomized Design (CRD) consisting of four treatments, namely P1 (100%:0%), P2 (85%:15%), P3 (80%:20%), and P4 (75%:25%), each with three replications. The parameters analyzed included swelling power as a physical property, water content, crude fiber, and protein as chemical properties, and color, taste, aroma, and texture as organoleptic properties. The results showed that treatment P2 produced the best characteristics with a protein content of 13.306%, fiber 2.436%, water content 37.546%, swelling power 1.726%, and an average organoleptic value of 3.2 (neutral). These results indicate that MOCAF flour and mung bean flour have the potential as alternative raw materials for gluten-free white bread based on local food.

Keywords: *white bread, gluten free, MOCAF flour, mung bean flour*

INTRODUCTION

Bread is a popular processed food product in Indonesia because it can be consumed as a substitute for rice or as a snack, with its soft texture and sweet taste that are favored by various groups. High public interest in this product is reflected in 2020 food consumption data, which shows that bread consumption reached 1,129 ounces per capita per week. However, national bread production still relies heavily on wheat flour as its primary raw material, while Indonesia does not produce wheat. In 2022, national wheat flour consumption was recorded at 6.7 million tons, with wheat imports remaining relatively stable at around 10 million tons per year. This condition has resulted in high wheat flour prices and contributed to the weakening of the country's foreign exchange reserves (Shinta, 2023). Apart from dependence on imports, wheat flour contains gluten which has the potential to cause health problems if consumed by individuals with gluten sensitivity or celiac disease (Tethool, 2017). Therefore, developing gluten-free bread products based on local food ingredients is crucial as a means of food diversification and reducing dependence on imported wheat. One potential alternative ingredient is Modified Cassava Flour (mocaf), a cassava flour modified through a lactic acid bacteria fermentation process. Mocaf flour is characterized by its white color, fine texture, neutral aroma, and gluten-free nature. However, this flour has limitations in the form of low protein content and the absence of gluten, which plays a role in forming the bread's structure (Ernawati, 2018; Dewi, 2023; Ihromi, 2018). Other local protein-rich ingredients, such as mung bean flour. Mung beans contain approximately 22.9% protein and various essential vitamins and minerals that have the potential to improve the nutritional quality of processed food products (Nezly, 2011). Mung bean flour is the result of processing mung bean seeds that have been peeled and ground into a powder (Pertiwi, 2018). Previous research shows that the use of a mixture of wheat flour, mocaf, and mung bean flour still produces the best chemical and organoleptic characteristics of white bread (Nezly, 2011; Wening, 2024). However, this formulation still relies on wheat flour, so it does not yet produce a completely gluten-free bread product.

Based on these conditions, further research is needed that focuses on the development of white bread based on 100% mocaf flour with the addition of mung bean flour as a source of vegetable protein. This study aims to analyze the effect of the proportion of mocaf flour and mung bean flour on the physicochemical and organoleptic properties of gluten-free white bread, as well as to determine the best formulation that has the potential to be developed as an alternative local food product.

LITERATURE REVIEW

Gluten-Free White Bread

White bread is a fermented bakery product that is conventionally made using wheat flour as a source of gluten. Gluten plays an important role in forming dough structure, elasticity, and the ability to retain gas during fermentation, thus producing good bread volume and texture. However, a number of studies report that gluten consumption can cause health problems in certain individuals, such as gluten sensitivity and celiac disease, thus encouraging the development of gluten-free bread products (Tethool, 2017). However, gluten-free bread still faces various challenges, particularly regarding physical and sensory quality, such as a dense texture, low volume, and lower consumer acceptance compared to conventional bread. This highlights the need to explore appropriate raw materials and formulations to produce gluten-free bread of acceptable quality.

MOCAF Flour as a Basic Ingredient for Gluten-Free Bread

Modified Cassava Flour (MOCAF) is cassava flour modified through a fermentation process using lactic acid bacteria. This fermentation process produces better physical characteristics than regular cassava flour, such as a whiter color, smoother texture, and a more neutral aroma (Ernawati, 2018). Furthermore, MOCAF is gluten-free and rich in carbohydrates, making it a potential base ingredient for gluten-free bread. However, several studies have reported that the use of MOCAF as a wheat flour substitute has limitations, particularly its low protein content and the absence of gluten, which results in suboptimal bread structure, characterized by low rise volume and a fragile crumb texture (Dewi, 2023; Ihromi, 2018). These limitations indicate that MOCAF requires combination with other ingredients to improve the physical and nutritional quality of gluten-free bread products.

Green Bean Flour as a Source of Vegetable Protein

Mung bean flour (*Vigna radiata*) is a processed mung bean seed product that has a fairly high vegetable protein content, ranging from 22–23%, and contains various important vitamins and minerals such as calcium, phosphorus, and iron (Nezly, 2011). The addition of mung bean flour in gluten-free bread formulations has been reported to increase protein and fiber levels, thus contributing to improved nutritional value of the product. However, several studies also noted that the use of mung bean flour in high proportions can affect sensory characteristics, such as changes in color to a darker color, the appearance of a distinctive peanut aroma, and a denser texture (Pertiwi, 2018). This shows that there is a trade-off between increasing nutritional value and sensory acceptance, so that adjusting the proportion of mung bean flour is an important factor in product formulation.

Physicochemical and Organoleptic Characteristics of Bread Based on MOCAF and Mung Bean Flour

Physicochemical and organoleptic characteristics are key parameters in assessing the quality of gluten-free white bread. Physicochemically, the proportion of MOCAF flour influences the moisture content and rise of the bread. The high starch content in MOCAF increases its water absorption capacity, potentially resulting in a softer crumb texture, but with a relatively low rise volume due to the absence of gluten (Ernawati, 2018; Ihromi, 2018). Conversely, the addition of mung bean flour increases protein, fiber, and ash content, while tending to decrease total carbohydrate content. These changes in chemical composition reflect the important role of ingredient formulation in determining the nutritional value of gluten-free bread (Nezly, 2011; Pertiwi, 2018). From an organoleptic aspect, a higher proportion of MOCAF generally results in a brighter crumb color and a relatively neutral aroma. On the other hand, increasing the proportion of mung bean flour can result in a darker bread color and a stronger distinctive bean aroma, which has the potential to influence the level of panelists' preference (Nezly, 2011). The texture of gluten-free bread is also greatly influenced by the absence of gluten, where MOCAF tends to produce a crumbly texture, while the addition of mung bean flour can increase crumb density. Therefore, the right combination of proportions between the two ingredients is needed to produce bread with a texture that is not too dense and remains sensorially acceptable (Tethool, 2017).

Research Gaps

Based on literature review, previous research generally still uses wheat flour as part of the MOCAF-based bread formulation and mung bean flour, so it has not yet completely produced gluten-free bread products. Furthermore, comprehensive studies on the effect of varying the proportions of MOCAF flour and mung bean flour on the physicochemical and organoleptic properties of gluten-free white bread are still limited. Therefore, this study was conducted to fill this gap by evaluating the formulation of 100% MOCAF-based white bread with the addition of mung bean flour, in order to obtain the best formulation with optimal physicochemical quality and sensory acceptability.

RESEARCH METHODS

This research was conducted in Food Processing, Food Technology Study Program, Faculty of Food Technology and Fisheries Dr. Soetomo University from November 2025 to January 2026 using an experimental quantitative method. The study aims to examine the effect of variations in the proportion of MOCAF flour and mung bean flour on the characteristics of gluten-free white bread. The main ingredients used include MOCAF flour and mung bean flour with xanthan gum as a binding agent, as well as supporting ingredients in the form of eggs, sugar, yeast, oil, milk powder, and water. The chemicals used in the analysis include H_2SO_4 , NaOH, ethanol, and $(NH_4)_2HPO_4$, while the equipment used includes bread processing equipment and standard laboratory chemical analysis equipment. The experimental design used was a one-factor Completely Randomized Design (CRD) with four treatment levels, namely the ratio of MOCAF flour and mung bean flour of 100:0, 85:15, 80:20, and 75:25, each with three replications. The bread-making process refers to the Irsalina (2023) method with several modifications including weighing ingredients, yeast activation, mixing ingredients using a stand mixer, fermentation for 30 minutes at a temperature of $\pm 30^\circ C$, baking at a temperature of $180^\circ C$ for 45 minutes, and cooling before testing. The parameters observed included physicochemical properties in the form of water content, protein, and crude fiber which were analyzed based on SNI 01-2891-1992 as well as the bread's rising power, while organoleptic tests were carried out on color, aroma, taste, and texture using a hedonic test with 30 untrained panelists. Physicochemical data were analyzed using analysis of variance (ANOVA) with the help of SPSS version 24 and continued with the BNT, BNJ, or Duncan test if there were significant differences, while organoleptic data were analyzed non-parametrically using the Kruskal–Wallis test.

RESULTS AND DISCUSSION

1. Chemical Test

Protein Content

This section presents the results of testing the protein content of gluten-free white bread with varying proportions of MOCAF flour and mung bean flour to determine the effect of differences in ingredient composition on protein content and the potential for increasing the nutritional value of the product.

Table 1. Average protein content of gluten-free white bread

Mocaf Flour : Flour Mung beans	Average (%)
P1(100%)	6,866 ± 0, 621 ^a
P2 (85% : 15%)	13,306 ± 0.668 ^b
P3 (80 % : 2 0%)	14,210 ± 0, 124 ^b
P4 (75 % : 2 5%)	15,460 ± 0, 141 ^c

The results of the analysis of variance showed a significant difference ($p < 0.05$) in the protein content of gluten-free white bread. Increasing the proportion of mung bean flour increased the protein content, while the use of higher MOCAF flour decreased it. The highest protein content was found in treatment P4 at 15.46%, while the lowest was in P1 at 6.87%. This finding is in line with previous research which stated that the addition of mung bean flour increases protein content because its protein content is higher than MOCAF. Based on SNI 8371:2018, only treatments P2, P3, and P4 met the protein content standards for white bread, while P1 did not meet the requirements.

Fiber Content

This section presents an overview of the results of testing the fiber content of gluten-free white bread formulated with varying proportions of MOCAF flour and mung bean flour. This testing was conducted to determine the effect of differences in raw material composition on the fiber content of the bread and to evaluate the

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potential for increasing nutritional value through the addition of mung bean flour as a source of dietary fiber in gluten-free white bread products.

Table 2. Average fiber content of gluten-free white bread

Mocaf Flour : Flour Mung beans	Average (%)
P1(100%)	1,133 ± 0,076 ^a
P2 (85% : 15%)	2,436 ± 0.293 ^b
P3 (80 % : 2 0%)	3,550 ± 0.438 ^c
P4 (75 % : 2 5%)	4,066 ± 0.100 ^c

The analysis of variance results showed a significant effect ($p < 0.05$) on the fiber content of gluten-free white bread. Increasing the proportion of mung bean flour increased the fiber content, while the use of higher MOCAF flour decreased it. The highest fiber content was found in treatment P4 at 4.07%, while the lowest was in P1 at 1.13%. This finding is in line with previous research which stated that mung bean flour has a higher fiber content than MOCAF, thus being able to increase the fiber content in mung bean flour-based products.

Water content

Presenting the results of the moisture content test of gluten-free white bread made from MOCAF (modified cassava flour) and mung bean flour (*Vigna radiata*), where the difference in proportion in each treatment has an effect on the moisture content of the resulting white bread.

Table 3. Average results of water content of gluten-free white bread

Mocaf Flour : Flour Mung beans	Average (%)
P1(100%)	33,586 ± 0.374 ^a
P2 (85% : 15%)	37,546 ± 0.695 ^b
P3 (80 % : 2 0%)	38,780 ± 0.504 ^b
P4 (75 % : 2 5%)	42,290 ± 0.782 ^c

The analysis of variance results showed a significant effect ($p < 0.05$) on the moisture content of gluten-free white bread. Increasing the proportion of mung bean flour tended to increase the moisture content, while the use of higher MOCAF flour decreased it. The highest moisture content was found in treatment P4 at 42.29%, while the lowest was in P1 at 33.59%. These results are in line with previous research which stated that substitution of flour types affects the water absorption capacity of the product. Water plays an important role in increasing the softness and decreasing the hardness of bread, and in general the moisture content of gluten-free white bread in all treatments was still within acceptable limits according to quality standards.

Development Power Test

This section presents the results of the test on the rising power of gluten-free white bread with variations in the proportion of MOCAF flour and mung bean flour to determine the effect of the formulation on the bread's rising ability.

Table 4. Average results of the gluten-free white bread rise test

Mocaf Flour : Flour Mung beans	Average (%)
P1(100%)	1,990 ± 0.155 ^c
P2 (85% : 15%)	1,726 ± 0.096 ^{bc}
P3 (80 % : 2 0%)	1,526 ± 0.102 ^{ab}
P4 (75 % : 2 5%)	1,443 ± 0.051 ^a

The results of the analysis of variance showed a significant effect ($p < 0.05$) on the rising power of gluten-free white bread. Increasing the proportion of MOCAF flour increased the rising power, while the addition of mung bean flour decreased it. The highest expansion power was obtained in treatment P1, while the lowest was in P4. This condition shows that the use of 100% MOCAF makes a real difference to the bread's rising power. The low rise power in formulations with mung bean flour is related to the absence of gluten network formation and the high starch and fiber content, which can inhibit yeast fermentation and the dough's ability to trap gas.

2. Organoleptic Test

Presenting the results of organoleptic tests on gluten-free white bread made from mocaf flour and mung bean flour, with each different treatment having an effect on the level of preference for white bread.

Table 5. The average results of the hedonic test of gluten-free white bread

Treatment	Parameter				Average	Category
	Color	Flavor	Aroma	Texture		
P1	3.78 ± 0.150 ^a	2,77 ± 0.104 ^a	2.93 ± 0.03 ^a	2,77 ± 0.075 ^a	3.10	Neutral
P2	2,96 ± 0.085 ^b	3.77 ± 0.169 ^a	3.23 ± 0,100 ^a	3.33 ± 0.117 ^b	3,32	Neutral
P3	2,84 ± 0.131 ^b	2,62 ± 0.243 ^a	2,66 ± 0.232 ^a	2,65 ± 0.302 ^{ab}	2.69	Do not like
P4	2,66 ± 0.123 ^b	2,35 ± 0.182 ^a	2,70 ± 0.050 ^a	2.76 ± 0.057 ^a	2.61	Do not like

Color

The results of organoleptic tests showed that variations in the proportion of MOCAF flour and mung bean flour had a significant effect on the color of gluten-free white bread. Bread with a higher proportion of MOCAF tends to have a brighter color and is preferred by panelists, while increasing the use of mung bean flour results in a darker color. This color change is related to the natural characteristics of the raw material, so the higher the substitution of mung bean flour, the level of panelist acceptance of the color tends to decrease.

Flavor

The difference in the formulation of MOCAF flour and mung bean flour has a significant effect on the taste of gluten-free white bread. The addition of mung bean flour in moderate amounts resulted in a more balanced taste and was acceptable to panelists. However, at higher proportions, the distinctive taste of mung beans becomes more dominant and decreases the level of liking. This shows that the proportion of ingredients plays an important role in determining the taste character and consumer acceptance.

Aroma

The aroma of gluten-free white bread is significantly influenced by variations in the proportion of flour used. Formulations with a balanced combination of MOCAF and mung bean flour produced an aroma preferred by panelists, while increasing the proportion of mung bean flour tended to produce a less acceptable, distinctive aroma. The resulting aroma reflects the interaction of the raw materials during the roasting process.

Texture

The test results showed that variations in the proportions of MOCAF flour and mung bean flour did not have a significant effect on the texture of gluten-free white bread. However, there is a tendency that adding mung bean flour in limited amounts produces a softer and more acceptable texture. In general, the texture of gluten-free bread is influenced by the absence of gluten, so differences in flour formulations result in relatively small variations in texture between treatments.

3. Determination of Best Treatment (effectiveness test)

Effectiveness testing was used to determine the best and most preferred treatment. Based on the results of the effectiveness test on all research parameters, including chemical and organoleptic tests, as seen in Appendix 10, it was shown that the best treatment achieved the highest yield (NH) value. The average NH for all effectiveness test research parameters can be seen in Table 4.6 below.

Table 6. Effectiveness Test Results

Parameter	Mark Results (NH) Treatment			
	P1	P2	P3	P4
Protein Content	0,000	0.103	0.118	0.138
Fiber Content	0,000	0.061	0.144	1,138
Water content	0.123	0.067	0.050	0,000
Development Power Test	0.123	0.063	0.018	0,000
Color	0.108	0.029	0.017	0,000
Flavor	0.047	0.138	0,000	0.008
Aroma	0.051	0.108	0,000	0.008
Texture	0.022	0.123	0,000	0.020
Total	0.474	0.692 *	0.317	0.312

Based on the results of the effectiveness test on all research parameters listed in Appendix 10, white bread with treatment code P2 was determined as the best treatment with a yield value (NH) of 0.692. This treatment has characteristics of 13.30% protein content, 2.43% fiber content, 37.54% water content, 1.72% rise power, and organoleptic values including color 2.96, taste 3.77, aroma 3.23, and texture 3.33. Overall, treatment P2 showed the most optimal balance of chemical, physical, and sensory qualities compared to other treatments, so it is worthy of being determined as the best gluten-free white bread formulation.

CONCLUSION

Based on the research results, it can be concluded that the use of MOCAF flour and mung bean flour significantly affects the protein content, crude fiber content, water content, rising power, and organoleptic properties of gluten-free white bread including color, taste, aroma, and texture. Increasing the proportion of mung bean flour increases the protein, fiber, and water content, but decreases the rising power due to the absence of gluten and the high fiber content that inhibits the formation of dough structure. Conversely, increasing the proportion of MOCAF flour tends to increase rising power, but decreases the protein, fiber, and water content. Based on the effectiveness test, the best treatment was obtained in the P2 formulation (85% MOCAF flour and 15% mung bean flour) with the most balanced chemical, physical, and organoleptic quality characteristics. These results indicate that the combination of MOCAF flour and mung bean flour has the potential to be developed as an alternative raw material for gluten-free white bread based on local food to reduce dependence on imported wheat flour.

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