

The Effect Of Wheat Flour Substitution With Mocaf And Mung Bean Flour On The Organoleptic Characteristics And Chemical Composition Of White Bread

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ABSTRACT

This study aimed to analyze the organoleptic characteristics and chemical properties of white bread substituted with mocaf (Modified Cassava Flour) and mung bean flour. Five formulations were evaluated: P0 (100% wheat flour), P1 (90% wheat flour + 5% mocaf + 5% mung bean flour), P2 (80% wheat flour + 10% mocaf + 10% mung bean flour), P3 (70% wheat flour + 15% mocaf + 15% mung bean flour), and P4 (60% wheat flour + 20% mocaf + 20% mung bean flour). Organoleptic evaluation was conducted using a five-point hedonic test involving 30 untrained panelists who assessed color, aroma, texture, and taste. Because the organoleptic data were ordinal and did not meet the normality assumption, the Kruskal–Wallis test was used at a 5% significance level, followed by the Mann–Whitney test for parameters showing significant differences. The best substitution treatment was determined based on the highest and most consistent acceptance across the organoleptic attributes and was subsequently subjected to laboratory analysis. P0 obtained the highest overall acceptance, while P1 was the most consistently accepted substitution treatment. P1 showed favorable acceptance for color (3.4), aroma (3.3), texture (3.2), and taste (3.3). Statistical analysis showed a significant effect of substitution on color ($P < 0.05$), while aroma ($P > 0.05$), texture ($P > 0.05$), and taste ($P > 0.05$) were not significantly affected. P1 was therefore selected as the best substitution formulation for chemical analysis. Laboratory results showed that P1 had a mean moisture content of 22.46% and protein content of 10.53%. The moisture content was below the maximum limit specified by the applicable Indonesian National Standard (SNI), while the protein content exceeded the reference value reported by the Directorate of Nutrition, Ministry of Health of the Republic of Indonesia. These findings indicate that P1 provides a favorable balance between sensory acceptance and protein content and has potential for further development as a white bread formulation using local flour resources.

Keywords: White Bread, Mocaf, Mung Bean Flour, Organoleptic Characteristics, Moisture Content, Protein

INTRODUCTION

Wheat flour is one of the most widely used food ingredients in Indonesia and serves as a major raw material for bread, noodles, cakes, and other processed foods. The high consumption of wheat-based products contributes to sustained demand for wheat flour, while Indonesia has limited domestic wheat production. Anugraheni et al. (2024) reported that Indonesia's wheat imports are strongly influenced by domestic demand for wheat-based products. Rizqi et al. (2024) similarly showed that trends in wheat imports are closely related to the increasing demand for wheat as a food-processing raw material. This dependence highlights the importance of developing alternative local flour resources that can partially replace wheat flour in food processing.

Cassava is one of the local agricultural commodities with potential for diversification into flour. Modified Cassava Flour (MOCAF) is produced through cassava processing and fermentation, resulting in functional characteristics that allow its application in various food products. Previous studies have demonstrated the potential of MOCAF in bakery products. Sirait et al. (2021) reported that MOCAF could be incorporated into white bread while maintaining acceptable sensory characteristics, whereas Azni et al. (2023) found that variations in wheat–MOCAF proportions affected the quality characteristics of bread. These findings indicate that MOCAF can serve as a local carbohydrate-based alternative to wheat flour, although its relatively low protein content remains a nutritional limitation.

Mung bean (*Vigna radiata* L.) flour provides a potential complementary ingredient because of its relatively high protein content and other nutritional components. Nor Azmah et al. (2023) reported that mung bean flour contains substantial protein, starch, and lipid components, supporting its application as a food ingredient. Its functional properties, however, may vary according to processing and milling conditions (Yu et al., 2023). Consequently, combining MOCAF with mung bean flour may provide a more balanced formulation by utilizing local carbohydrate resources while increasing the protein contribution of the product.

Previous research has investigated the use of MOCAF and mung bean flour in several food products. Yenrina et al. (2013) reported that the incorporation of mung bean flour into MOCAF-based bread influenced nutritional and sensory characteristics. More recently, Mubarak and Mulyadi (2024) demonstrated that variations in MOCAF and mung bean flour formulations affected the chemical and sensory properties of food products. Anosike et al. (2023) also found that increasing cassava and mung bean flour substitution in bread formulations could improve protein content while influencing sensory acceptance. These findings suggest that the nutritional benefits of composite flour substitution must be considered together with changes in product acceptability.

Despite these findings, a specific research gap remains concerning the use of MOCAF and mung bean flour simultaneously at different substitution levels in white bread, particularly in relation to the combined evaluation of sensory acceptance and selected chemical characteristics. Existing studies have generally focused on MOCAF substitution alone, mung bean flour incorporation in other bakery products, or broader composite-flour formulations. Limited attention has been given to identifying a substitution level that can maintain the sensory characteristics of conventional white bread while providing improved protein content. This study addresses that gap by systematically evaluating five formulations with different proportions of wheat flour, MOCAF, and mung bean flour and subsequently analyzing the moisture and protein contents of the most acceptable substitution formulation.

The novelty of this study lies in the integrated evaluation of organoleptic acceptance and chemical composition to identify an appropriate wheat flour substitution level using a combination of MOCAF and mung bean flour in white bread. Organoleptic evaluation covers color, aroma, texture, and taste, while chemical analysis focuses on moisture and protein contents of the selected formulation. This approach provides a practical basis for balancing sensory quality with nutritional characteristics rather than evaluating flour substitution solely from either a sensory or chemical perspective.

Therefore, this study aims to determine the effect of different levels of wheat flour substitution with MOCAF and mung bean flour on the organoleptic characteristics of white bread and to characterize the moisture and protein contents of the best-performing substitution formulation. The findings are expected to contribute to the development of acceptable white bread formulations while supporting the utilization of locally available cassava and mung bean resources as alternatives to imported wheat-based ingredients.

METHODS

The study was conducted at the Integrated Laboratory of the Faculty of Agricultural Technology, Universitas Sulawesi Tenggara, Kendari City, for bread preparation and organoleptic evaluation. Moisture and protein analyses were conducted at the Integrated Laboratory of Universitas Halu Oleo, Kendari City. The main ingredients were high-protein wheat flour, MOCAF (Modified Cassava Flour), and mung bean flour. Supporting ingredients included instant yeast, sugar, salt, powdered milk, butter, egg yolk, and water.

A single-factor experimental design was applied using five flour formulations. The total flour weight in each treatment was 250 g. P0 consisted of 100% wheat flour (250 g) and served as the control. P1 consisted of 90% wheat flour (225 g), 5% MOCAF (12.5 g), and 5% mung

bean flour (12.5 g). P2 consisted of 80% wheat flour (200 g), 10% MOCAF (25 g), and 10% mung bean flour (25 g). P3 consisted of 70% wheat flour (175 g), 15% MOCAF (37.5 g), and 15% mung bean flour (37.5 g). P4 consisted of 60% wheat flour (150 g), 20% MOCAF (50 g), and 20% mung bean flour (50 g). Each formulation contained 90 mL water, 5 g instant yeast, 3 g salt, 30 g powdered milk, 25 g sugar, 4 g egg yolk, and 25 g butter. The formulation levels were adapted and modified from previous studies on composite flour and bread formulations (Dwijatmoko et al., 2024; Rianta et al., 2019).

Bread preparation began by mixing the flour formulation with sugar, yeast, and powdered milk at low speed for 1 minute. Salt was then added, followed by gradual incorporation of cold water and egg yolk while mixing for 8 minutes. The dough was mixed at medium speed for 15 minutes until sufficiently elastic and smooth. Butter was then added and mixed at high speed for 10 minutes. The dough was fermented for 35 minutes at 20–25°C, punched down, and kneaded for 15 minutes. It was then rolled to approximately 2 cm thickness, shaped, and placed in greased baking pans. A second fermentation was conducted for 60 minutes, followed by baking at 180°C for 25 minutes. The baked bread was cooled at room temperature for 1 hour, sliced to approximately 1.4 cm thickness, and packaged for sensory evaluation.

Organoleptic evaluation was conducted using a five-point hedonic test involving 30 untrained panelists. Samples were presented in random order and coded to minimize potential evaluation bias. Panelists evaluated color, aroma, texture, and taste using a five-point scale: 5 = like very much, 4 = like, 3 = neither like nor dislike, 2 = dislike, and 1 = dislike very much. Overall acceptance was determined from the proportion of panelists assigning scores of 4 or 5. The best substitution formulation was selected based on its overall acceptance and consistency of scores across color, aroma, texture, and taste, with consideration of its performance relative to the control. The selected formulation was subsequently subjected to chemical analysis.

Moisture content was determined using the gravimetric method according to SNI 01-2891-1992 by drying samples at 105°C until a constant weight was obtained. Protein content was determined using the semi-micro Kjeldahl method according to SNI 01-2891-1992, involving digestion, distillation, and titration.

Because the organoleptic scores were ordinal data, their distribution was first assessed using the Shapiro–Wilk test. The data were not normally distributed; therefore, the Kruskal–

Wallis test was applied to determine differences among the five treatments at a significance level of 5% ($\alpha = 0.05$). When a significant difference was detected, pairwise comparisons were performed using the Mann–Whitney test. Results were presented as mean scores and standard deviations. Statistical significance was interpreted at $P < 0.05$, whereas $P > 0.05$ indicated no statistically significant difference among treatments. The formulation selected through the predetermined organoleptic criteria was then analyzed for moisture and protein contents.

RESULTS AND DISCUSSION

RESULTS

3.1 Organoleptic Evaluation

Organoleptic evaluation was conducted to determine panelists' acceptance of the color, aroma, texture, and taste of white bread formulated by substituting wheat flour with mocaf and mung bean flour. The organoleptic data were ordinal in scale and were not normally distributed based on the Shapiro–Wilk test. Therefore, the data were analyzed using the Kruskal–Wallis test, followed by the Mann–Whitney test when significant differences were identified.

3.1.1 Color

The panelists' evaluations of bread color showed variations in acceptance across treatments. The highest mean score was observed for P0 (3.6), followed by P1 (3.4), P2 and P4 (3.2), while the lowest mean score was observed for P3 (2.6).

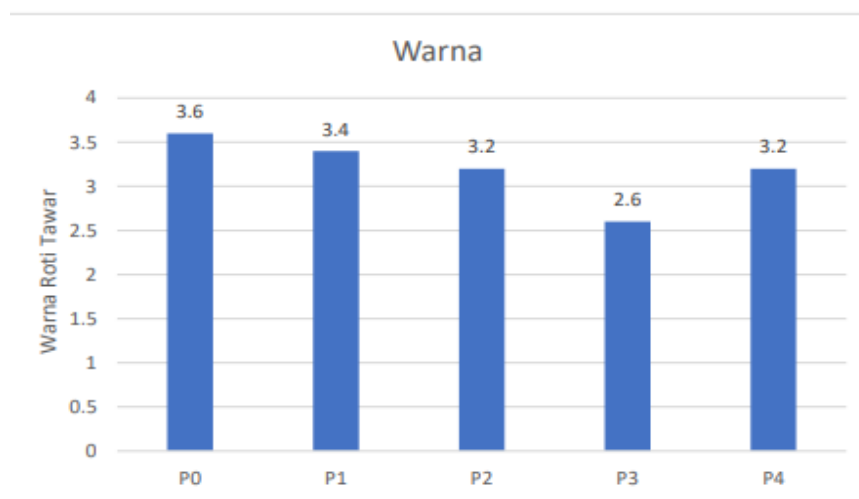


Figure 1. Mean panelist acceptance scores for white bread color

The differences in color were presumably influenced by the proportions of mocaf and mung bean flour used in each formulation. Increasing the proportion of mung bean flour may produce a darker

bread color, thereby reducing panelist acceptance (Bait & Ahmad, 2022). Treatment P3 received the lowest score because the bread tended to have a darker color and visible specks, which may have resulted from mung bean seed coats remaining in the flour. In contrast, P0 and P1 produced lighter-colored bread that more closely resembled the typical appearance of white bread.

The Kruskal Wallis test showed a significant difference in panelists' color acceptance among the treatment groups ($P < 0.05$). The Mann–Whitney test indicated significant differences between P0 and P3 and between P1 and P3 ($P < 0.05$). Thus, P0 had the highest color acceptance, whereas P3 had the lowest acceptance.

3.1.2 White Bread Aroma

Aroma is one of the sensory attributes that influences panelists' acceptance of food products. The organoleptic evaluation showed that P0 had the highest mean score (3.5), followed by P1 (3.3), P2 and P4 (3.2 each), while P3 had the lowest mean score (3.1).

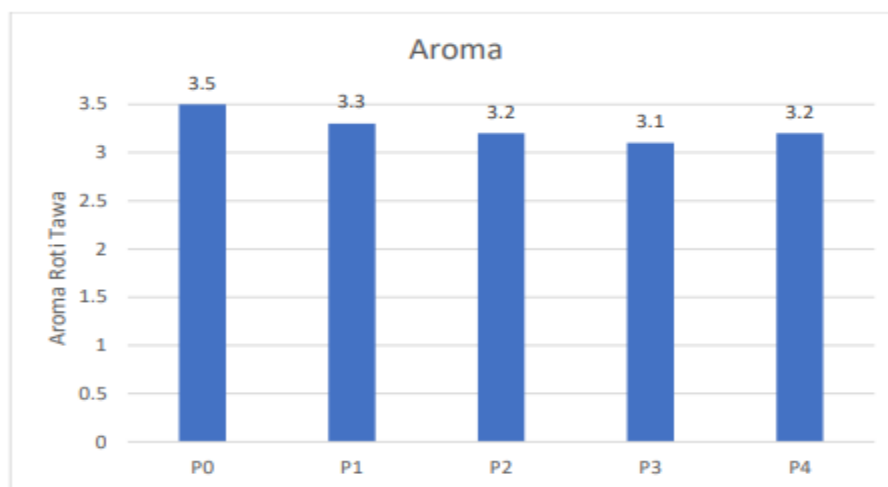


Figure 2. Mean panelist acceptance scores for white bread aroma

The differences in aroma scores were presumably associated with the increasing proportion of mung bean flour, which may produce a characteristic aroma that tends to be beany or slightly grassy. As its proportion increases, the characteristic mung bean aroma may become more pronounced and potentially mask the typical bread aroma produced during fermentation and baking (Mubarak & Mulyadi, 2024). However, the Kruskal–Wallis test showed that substitution of wheat flour with mocaf and mung bean flour did not result in a significant difference in aroma acceptance ($P > 0.05$).

3.1.3 White Bread Texture

Texture is an important physical and sensory attribute that contributes to the quality and acceptance of white bread. The highest mean score was obtained by P0 (3.3), followed by P1 and P2 (3.2 each). P4 received a mean score of 2.9, while the lowest score was observed for P3 (2.7).

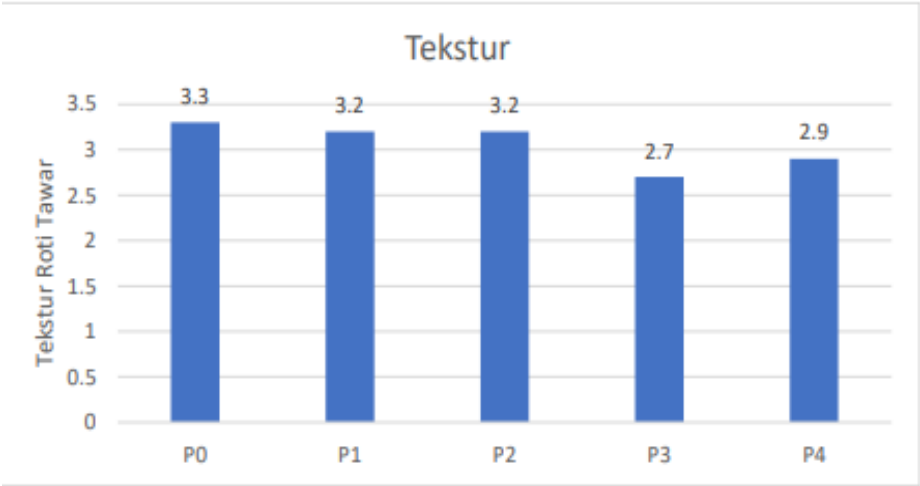


Figure 3. Mean panelist acceptance scores for white bread texture

The lower texture acceptance observed at higher substitution levels was presumably caused by the reduction in gluten, which plays an important role in retaining gas during fermentation. The use of non-gluten flours, such as mocaf and mung bean flour, at higher proportions may reduce dough expansion and result in a denser, firmer, or more crumbly texture (Dwijatmoko et al., 2024). The Kruskal–Wallis test showed that there was no significant difference in texture acceptance among the treatment groups ($P > 0.05$).

3.1.4 White Bread Taste

Taste is one of the primary parameters determining the acceptance of a food product. The organoleptic evaluation showed that P0 had the highest mean score (3.5), followed by P1 (3.3), P2 (3.0), P4 (2.9), and P3 (2.6).

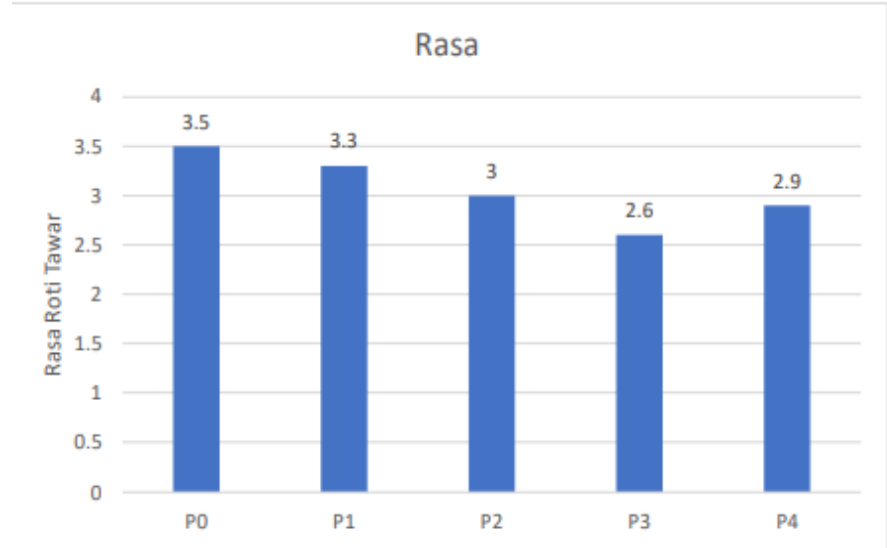


Figure 4. Mean panelist acceptance scores for white bread taste

Based on the panelist acceptance threshold of a score of 3, treatments P0, P1, and P2 remained acceptable, whereas P3 and P4 fell below the acceptance threshold. The decline in acceptance was presumably associated with the characteristic flavor of mung bean flour, which may produce a beany or grassy taste and an unpleasant aftertaste when used at higher proportions (Bait & Ahmad, 2022). The Kruskal–Wallis test showed that there was no significant difference in taste acceptance among the treatments ($P > 0.05$); therefore, the analysis was not followed by the Mann–Whitney test.

3.1.5 Overall Acceptance

The best treatment was determined based on panelists' acceptance of color, aroma, texture, and taste.

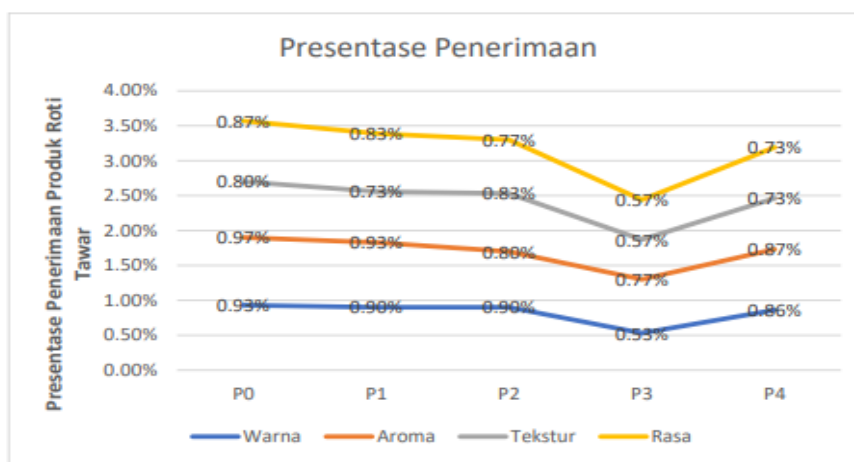


Figure 5. Percentage of panelist acceptance of white bread

Overall, P0, the control treatment, had the highest level of panelist acceptance. However, among the substituted formulations, P1 showed the most favorable overall acceptance, particularly in terms of aroma and taste. These findings indicate that the P1 substitution level was still able to produce organoleptic characteristics that were acceptable to the panelists. Therefore, P1 was selected as the preferred formulation and subsequently used for laboratory analysis.

3.2 Organoleptic Properties and Their Relationship to Chemical Composition

Based on the organoleptic evaluation, treatment P1 showed relatively the highest level of acceptance compared with P2, P3, and P4, particularly in terms of color, aroma, and taste. This finding was presumably because the proportions of mocaf and mung bean flour used in P1 were still able to maintain the characteristic properties of white bread. In contrast, P3 received the lowest acceptance for several parameters because of its darker color and the development of beany or grassy aroma and taste associated with the higher proportion of mung bean flour. For the texture parameter, P2 received the highest acceptance score. The amylopectin content of mung bean flour may increase water-binding capacity and consequently influence the textural characteristics of the product (Sumartini et al., 2024).

Table 1. Laboratory analysis results for moisture and protein content of P1 white bread

Sample Code	Replicate	Moisture Content (%)	Protein Content (%)
P1	U1	22.03	10.65
P1	U2	22.28	10.32
P1	U3	23.08	10.63
Mean		22.46	10.53

Source: Integrated Laboratory of Universitas Halu Oleo.

The laboratory analysis showed that the moisture and protein contents of P1 were relatively consistent across the three replicates. Moisture content ranged from 22.03% to 23.08%, whereas protein content ranged from 10.32% to 10.65%. The relatively small differences among replicates indicate that the mixing and baking processes produced a reasonably homogeneous product.

3.2.1 Moisture Content

The mean moisture content of P1 white bread was 22.46%, which was below the maximum limit of 40% specified by SNI 01-3840-1995 and lower than the reference value of 37.7% reported by the Directorate of Nutrition, Ministry of Health of the Republic of Indonesia. This finding indicates that substituting 10% of the wheat flour with mocaf and 10% with mung bean flour still produced white bread with a moisture content within the applicable reference limits. Maintaining an appropriate moisture level is also important because excessive moisture can accelerate deterioration and shorten the shelf life of bread (Sachriani & Yulianti, 2021).

Table 2. Comparison of the chemical composition of P1 white bread with reference standards

Component	P1 Result (%)	SNI White Bread (%)	Directorate of Nutrition, Ministry of Health (%)
Moisture content	22.46	Max. 40	37.7
Protein content	10.53	–	9.7
Fat content	–	–	4.2
Dietary fiber	–	–	2.95

Source: Research data and Fauzia & Azizah (2023).

3.1.2 Protein Content

The mean protein content of P1 white bread was 10.53%, which was higher than the reference value of 9.7% reported by the Directorate of Nutrition, Ministry of Health of the Republic of Indonesia. This increase was presumably attributable to the incorporation of mung bean flour, which has a higher protein content than mocaf. The mocaf used in the formulation contained 1.88% protein, whereas the

mung bean flour contained 23.41% protein. The addition of mung bean flour has been reported to increase the protein content of food products (Rianta et al., 2019).

Therefore, the substitution of wheat flour with mocaf and mung bean flour in treatment P1 not only produced organoleptic characteristics that remained acceptable to the panelists but also improved the nutritional value of the product, particularly its protein content. The moisture content of 22.46% and protein content of 10.53% indicate that P1 had favorable chemical characteristics and remained within the reference limits used in this study.

DISCUSSION

Organoleptic acceptance indicates that a balanced ingredient composition is important for maintaining the characteristic properties of white bread. Lower substitution levels tend to be more readily accepted because changes in product characteristics are not yet highly pronounced. Anosike et al. (2023) reported that increasing the proportion of cassava and mung bean flour in bread formulations tended to reduce sensory scores, although protein content increased. This pattern supports the findings of the present study, indicating that the substitution level should be controlled to achieve optimal panelist acceptance.

Changes in bread color are associated with ingredient composition and reactions occurring during baking. Legume flours contain protein components that can interact with reducing sugars during heating and produce brown coloration through the Maillard reaction. Artina et al. (2023) showed that the use of legume-based flour in combination with mocaf resulted in changes in the color and sensory characteristics of the product. Similar findings were reported by Yulviatun et al. (2022), who found that a combination of mocaf and mung bean sprout flour produced specific color characteristics that influenced formulation acceptance.

The aroma and taste of the product are influenced by the characteristic properties of mung bean, which become more readily detectable as its proportion increases. Mulyantari (2025) showed that the use of mung bean flour in nastar products remained acceptable to consumers, although the characteristics of the substitute ingredient contributed to the sensory response. Dulinayan et al. (2025) likewise demonstrated that the addition of mung bean flour to pandesal can be evaluated based on aroma, taste, texture, and overall acceptability. These findings reinforce the importance of controlling the characteristic properties of mung bean flour in bakery formulations.

The absence of significant differences in several organoleptic attributes indicates that changes in formulation do not necessarily produce sensory changes that can be statistically distinguished. Ponelo et al. (2022) found that the addition of modified mung bean flour to French baguettes did not significantly affect aroma or taste, although it altered certain chemical characteristics. Herviana et al. (2023) also

reported that the sensory characteristics of mung bean flour can be influenced by processing methods; however, aroma responses do not necessarily differ significantly among treatments.

Texture is strongly associated with dough structure and the ability of the dough to retain fermentation gases. Reducing the proportion of wheat flour decreases the amount of gluten-forming proteins, which may alter bread expansion and softness. Sabrina et al. (2026) explained that mocaf substitution in bread products is closely related to physical and sensory quality because bread quality is strongly influenced by gluten network formation. Faridah and Yuhelma (2023) also found that mocaf substitution can affect the internal texture of bread products, whereas some other sensory attributes may not show significant changes.

From a chemical composition perspective, the incorporation of mung bean flour has the potential to increase protein content because mung bean is a source of plant-based protein. Anosike et al. (2023) showed that increasing the substitution level of cassava–mung bean flour could increase the protein content of bread products. Jordge et al. (2022) also demonstrated that composite flours based on cereals, root crops, and legumes can influence the physicochemical characteristics and nutritional value of food products. Artina et al. (2023) further showed that formulations combining mocaf with legume flour can produce differences in protein content and other chemical characteristics.

Moisture content is related to texture and product stability during storage, whereas ingredient composition influences the product's ability to retain water. Rofida et al. (2026) showed that variations in the proportions of mocaf and mung bean flour can produce differences in the physicochemical and organoleptic characteristics of bread. Yuliani et al. (2026) likewise demonstrated that the use of mocaf in bread requires an appropriate formulation to maintain favorable physical characteristics and consumer acceptance. Therefore, the findings of the present study indicate that formulation P1 provides a favorable balance between sensory acceptance and the chemical characteristics of the product.

CONCLUSION AND IMPLICATIONS

Substitution of wheat flour with mocaf and mung bean flour altered the organoleptic characteristics of white bread, particularly its color, whereas aroma, texture, and taste did not show significant differences among treatments. P1 was the most consistently accepted substitution treatment and produced sensory characteristics that were relatively similar to those of the control white bread. Chemical analysis of P1 showed a moisture content of 22.46% and a protein content of 10.53%. The moisture content remained below the maximum limit specified by the applicable Indonesian National Standard (SNI), while the protein content indicated an improvement in nutritional value compared with

the reference standard. Therefore, P1 can be considered the preferred formulation for further development of white bread based on local flour resources.

The findings of this study imply that the use of mocaf and mung bean flour can serve as an alternative approach to diversifying raw materials for white bread production while increasing the utilization of local food resources. The substitution level should be carefully controlled to prevent changes in color, aroma, taste, and texture from reducing consumer acceptance. P1 demonstrated the greatest potential for further development because it maintained favorable sensory acceptance while producing a relatively high protein content and a moisture content that remained within the applicable quality standard. Future development should focus on optimizing the formulation, improving textural characteristics, controlling the beany aroma associated with mung bean flour, and evaluating shelf life and other nutritional components.

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