Community Engagement & Emergence Journal
Volume 7 Nomor 2, Tahun 2026
Halaman : 1412-1418

Pengaruh Substitusi Tepung Singkong Modifikasi (MOCAF) Terhadap Mutu Fisik Dan Sensoris Roti Asin

Effect Of Modified Cassava Flour (MOCAF) Substitution On The Physical And Sensory Quality Of Salt Bread

Nayla Sabrina[a]*, Cucu Cahyana[b], Sachriani[c]
Culinary Education Study Program, Faculty of Engineering, Universitas Negeri Jakarta, Indonesia[a,b,c]
naylaa.shbrn@gmail.com[a]

Abstract

Salt bread is a Japanese-style bakery product characterized by a crisp outer crust, a soft crumb, and a savory butter flavor. Its quality depends strongly on the gluten network formed by wheat flour. This study evaluated the effect of modified cassava flour (MOCAF) substitution on the physical and sensory quality of salt bread. A completely randomized experimental design was used with three MOCAF substitution levels (10%, 20%, and 30%) and three replications. Bread volume was measured using the seed displacement method. Sensory quality was first validated by five expert panelists and then evaluated by 45 semi-trained panelists, with 15 evaluations per treatment. The assessed attributes included outer and inner color, MOCAF and butter aroma, MOCAF, butter, and salty taste, pore structure, outer-crust texture, and inner-crumb texture. Physical data were analyzed using one-way ANOVA followed by Duncan's Multiple Range Test. In contrast, ordinal sensory data were analyzed using the Kruskal–Wallis test and pairwise follow-up testing at $\alpha = 0.05$. MOCAF substitution significantly affected bread volume ($F = 21.35$), which decreased from 175.67 cm^3 at 10% substitution to 162.00 cm^3 at 20% and 127.33 cm^3 at 30%. Sensory analysis showed significant differences in MOCAF taste ($\chi^2 = 8.00$) and pore structure ($\chi^2 = 10.24$), but no significant differences in color, aroma, butter, and salty taste, or outer and inner texture. The 10% MOCAF formulation most closely retained the expected volume, pore structure, flavor balance, crisp crust, and soft crumb of conventional salt bread. Therefore, 10% MOCAF substitution is recommended as the most appropriate formulation within the tested range.

Keywords: *Bread Volume; Food Diversification; MOCAF; Salt Bread; Sensory Quality*

Abstrak

Salt bread adalah produk roti gaya Jepang yang memiliki karakteristik kulit luar yang renyah, bagian dalam yang lembut, dan cita rasa mentega yang gurih. Kualitasnya sangat bergantung pada jaringan gluten yang terbentuk dari tepung terigu. Penelitian ini mengevaluasi pengaruh substitusi tepung singkong termodifikasi (MOCAF) terhadap kualitas fisik dan sensori salt bread. Rancangan percobaan yang digunakan adalah Rancangan Acak Lengkap dengan tiga tingkat substitusi MOCAF (10%, 20%, dan 30%) dan tiga kali ulangan. Volume roti diukur menggunakan metode pemindahan biji-bijian. Kualitas sensori divalidasi terlebih dahulu oleh lima panelis ahli dan kemudian dievaluasi oleh 45 panelis semi-terlatih, dengan 15 evaluasi per perlakuan. Atribut yang dinilai meliputi warna luar dan dalam, aroma MOCAF dan mentega, rasa MOCAF, mentega, dan asin, struktur pori, tekstur kulit luar, serta tekstur bagian dalam roti. Data fisik dianalisis menggunakan ANOVA satu arah yang dilanjutkan dengan Uji Jarak Berganda Duncan. Sebaliknya, data sensori ordinal dianalisis menggunakan uji Kruskal-Wallis dan uji lanjut berpasangan pada taraf $\alpha = 0{,}05$. Substitusi MOCAF berpengaruh signifikan terhadap volume roti ($F = 21{,}35$), yang menurun dari 175,67 cm^3 pada substitusi 10% menjadi 162,00 cm^3 pada 20% dan 127,33 cm^3 pada 30%. Analisis sensori menunjukkan perbedaan signifikan pada rasa MOCAF ($\chi^2 = 8{,}00$) dan struktur pori ($\chi^2 = 10{,}24$), namun tidak terdapat perbedaan signifikan pada warna, aroma, rasa mentega dan asin, serta tekstur luar maupun dalam. Formulasi MOCAF 10% paling mampu mempertahankan volume, struktur pori, keseimbangan rasa, kerenyahan kulit, dan kelembutan bagian dalam roti yang diharapkan sebagaimana pada salt bread konvensional. Oleh karena itu, substitusi MOCAF sebesar 10% direkomendasikan sebagai formulasi yang paling tepat dalam rentang pengujian tersebut.

Kata Kunci: Volume Roti; Diversifikasi Pangan; MOCAF; Salt Bread; Kualitas Sensori

https://journal.yrpipku.com/index.php/ceej
e-ISSN:2715-9752, p-ISSN:2715-9868

1. Introduction

Salt bread, also known as shio pan, is a savory bread product distinguished by a crisp golden crust, a soft interior, and a butter-filled central cavity. The combination of wheat flour, fermentation, shaped dough, and butter produces the characteristic contrast between the crust and crumb. In Indonesia, the product has become increasingly visible in modern bakeries, creating opportunities for formulating with locally available ingredients. Nevertheless, its structure remains highly dependent on wheat flour because gluten provides the viscoelastic network required to retain carbon dioxide during proofing and the early stages of baking.

The protein composition and rheological properties of wheat flour are directly related to bread volume and crumb quality. Strong gluten formation enables dough to absorb water, expand, and retain fermentation gases, whereas dilution of the gluten-forming proteins commonly lowers gas-retention capacity and bread volume (Kusnandar et al., 2022). Emulsifiers and fats can improve dough handling and crumb softness, but they do not completely replace the structural function of gluten (Tebben et al., 2022). This issue becomes particularly important in composite-flour bread, where increasing the proportion of non-wheat flour can produce a denser crumb and reduced loaf expansion.

Modified cassava flour (MOCAF) is produced by fermenting cassava, then drying and milling it. Compared with conventional cassava flour, MOCAF has a relatively neutral color and aroma and can be used as a partial wheat-flour substitute in bakery products. Its use supports local-food diversification and may reduce the proportion of imported wheat in formulated foods (Sulistiadi, 2020). However, MOCAF does not contain gluten; therefore, the technological benefit of substituting local ingredients must be weighed against changes in dough development, bread volume, pore formation, and sensory properties.

Previous studies have consistently reported that the proportion of MOCAF determines the final quality of bread. MOCAF-based sweet bread remained acceptable at low substitution levels, whereas higher levels reduced volume and softness due to gluten dilution (Yasa et al., 2016). A study on soft rolls similarly showed that increasing MOCAF changed consumer acceptance and physical characteristics (Nurfiantoro, 2023). Wheat research–MOCAF bread also reported that the substitution level influenced the product's physical and sensory properties, with lower substitution levels generally producing characteristics closer to wheat bread (Tambunan, 2025). These findings suggest that an optimal level must be established for each bread type, as formulation, shaping, fat content, and fermentation conditions differ among products.

Salt bread presents a specific research problem because its quality is determined not only by overall expansion but also by the interaction between a crisp crust, a soft crumb, a distinctive butter flavor, and an internal pore or cavity structure. Evidence concerning MOCAF substitution in this product remains limited. Accordingly, this study aimed to determine the effect of 10%, 20%, and 30% MOCAF substitution on salt bread volume and sensory quality and to identify the formulation that most closely maintains the expected characteristics of conventional salt bread.

2. Methods

The experiment was conducted from November 2025 at the Bread and Patisserie Processing Laboratory of the Culinary Education Study Program, Faculty of

Engineering, Universitas Negeri Jakarta. The experimental factor was the proportion of MOCAF used to replace high-protein wheat flour. Three treatments were evaluated: 10%, 20%, and 30% MOCAF substitution. Each physical measurement was replicated three times under the same processing conditions.

The principal dough formula used 225 g of combined wheat flour and MOCAF. The quantities of sugar, instant yeast, milk powder, water, emulsifier, salt, and margarine were held constant across the three treatments. The flour composition is shown in Table 1. A preliminary 40% formulation was also tested during product development. However, it was not included in the main experiment because the resulting bread differed markedly from the standard formula in volume, crumb structure, and sensory characteristics.

Table 1. Flour formulation of salt bread treatments

Ingredient	10% MOCAF	20% MOCAF	30% MOCAF
High-protein wheat flour (g)	202.5	180.0	157.5
MOCAF (g)	22.5	45.0	67.5
Total flour (g)	225.0	225.0	225.0
MOCAF proportion (%)	10	20	30

All dry ingredients were mixed before water and emulsifier were added. After a dough matrix had formed, margarine was incorporated, and mixing continued until the dough became smooth and elastic. The dough was rounded, rested for approximately 10 minutes, divided into equal portions, and shaped into teardrops. Each piece was rolled lengthwise, filled with chilled butter, rolled into the characteristic salt-bread shape, and placed on a greased tray. Final proofing was conducted for approximately 60 minutes at 30–36°C. The bread was baked at 200°C for approximately 14–15 minutes after preheating the oven to 210°C, then transferred to a cooling rack.

Bread volume was determined using the seed-displacement method. A container was first filled with millet seeds and leveled. The bread sample was placed inside, the container was refilled to the same level, and the displaced seeds were collected and measured in a graduated cylinder. The displaced volume was reported as bread volume in cm^3. The three treatment means were compared using one-way ANOVA at $\alpha = 0.05$, followed by Duncan's Multiple Range Test when a significant treatment effect was detected.

Sensory evaluation was conducted in two stages. Five lecturers with expertise in culinary product evaluation first validated the products. The main assessment involved 45 semi-trained panelists from the Culinary Education Study Program who had completed sensory-evaluation coursework; 15 evaluations were allocated to each formulation. Samples were presented using three-digit codes. A five-point quality scale was used for outer color, inner color, MOCAF aroma, butter aroma, MOCAF taste, butter taste, salty taste, pore structure, crust texture, and crumb texture. Kruskal–Wallis analysis at $\alpha = 0.05$ was used for each sensory attribute, followed by pairwise testing when the overall result was significant.

3. Results and Discussion

Preliminary formulation trials demonstrated a progressive change in product structure as the MOCAF proportion increased. The 10%, 20%, and 30% formulations could still be shaped and baked, whereas the 40% formulation produced a visibly less developed, less characteristic product. Figure 1 presents the external and internal appearance of the three formulations included in the main study.

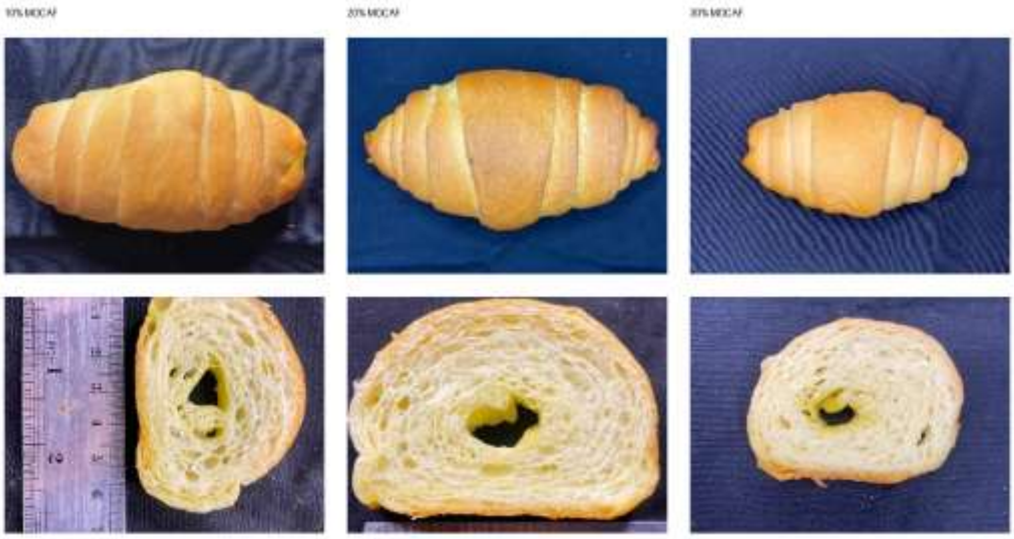

Figure 1. External and cross-sectional appearance of salt bread containing 10%, 20%, and 30% MOCAF (research documentation)

3.1. Physical Quality

Table 2. Bread-volume results and ANOVA summary

MOCAF level	Rep. 1	Rep. 2	Rep. 3	Mean ± SD (cm^3)	ANOVA
10%	172	170	185	175.67 ± 8.14	
20%	164	167	155	162.00 ± 6.24	F = 21.35
30%	140	127	115	127.33 ± 12.50	$p < 0.05$

MOCAF substitution significantly affected bread volume because the calculated F value (21.35) exceeded the critical F value (5.14). The highest mean volume was obtained at 10% substitution (175.67 cm^3), followed by 20% (162.00 cm^3), while the 30% formulation had the lowest volume (127.33 cm^3). Thus, increasing MOCAF from 10% to 30% reduced mean volume by approximately 27.5%. The post hoc analysis reported separation among the treatment groups, confirming that the decline was associated with the substitution level rather than random replication variation.

The decrease in volume is consistent with the structural role of wheat gluten. During mixing and proofing, hydrated gluten proteins form a viscoelastic network that traps carbon dioxide released by yeast. Replacing wheat flour with MOCAF dilutes this network, allowing a greater proportion of fermentation gas to escape and limiting oven spring. Similar reductions in bread volume at higher levels of MOCAF or other non-gluten composite flours have been reported in sweet bread, soft rolls, and composite bread systems (Yasa et al., 2016; Nurfiantoro, 2023; Tambunan, 2025). The relatively high volume at 10% indicates that the remaining wheat-flour proportion was sufficient to maintain a continuous gas-retaining structure.

The standard deviations also indicate that the 30% treatment had the greatest variation among replications. This variation is compatible with the study limitation identified during production: butter temperature and manual shaping were not fully standardized. When the gluten network is already weakened by a higher MOCAF level, small differences in shaping and proofing can produce larger changes in the final volume and internal cavity.

3.2. Sensory Quality

Table 3. Mean sensory scores and Kruskal–Wallis results

Attribute	10%	20%	30%	χ^2	Decision
Outer color	4.33	4.33	4.60	1.57	Not significant
Inner color	4.47	4.40	4.20	1.70	Not significant
MOCAF aroma	4.33	4.27	4.13	0.39	Not significant
Butter aroma	4.60	4.40	4.53	0.91	Not significant
MOCAF taste	4.33	4.07	3.27	8.00	Significant
Butter taste	4.53	4.40	4.47	0.39	Not significant
Salty taste	3.07	3.20	3.20	0.27	Not significant
Pore structure	3.93	3.60	4.53	10.24	Significant
Outer crust texture	4.47	4.40	4.27	0.91	Not significant
Inner crumb texture	4.40	4.30	4.00	2.74	Not significant

The three formulations did not differ significantly in outer or inner color. All treatments were generally described as golden brown on the outside and white to yellowish white on the inside. The uniform baking temperature and duration helped standardize surface browning, while the relatively light color of MOCAF allowed substitution up to 30% without producing a statistically detectable change in crumb color. Maillard and caramelization reactions primarily generate surface color in bread; therefore, consistent thermal conditions can reduce visible differences in treatment even when flour composition changes.

Neither MOCAF aroma nor butter aroma differed significantly among treatments. Mean MOCAF-aroma scores declined slightly as the substitution level increased, indicating that the characteristic cassava-derived aroma became somewhat easier to detect. However, the change was not large enough to be statistically significant. The butter aroma remained strong across all formulations because the butter amount and baking process were held constant. Similarly, butter and salty tastes did not differ significantly, indicating that the fixed butter-to-salt proportions continued to dominate these sensory dimensions.

In contrast, MOCAF taste differed significantly among treatments (χ^2 = 8.00). The mean score decreased from 4.33 at 10% substitution to 3.27 at 30%, indicating that the characteristic MOCAF taste became increasingly apparent. Pairwise analysis in the thesis showed differences among all three treatment pairs. This pattern supports the conclusion that low-level substitutions can remain relatively neutral, whereas a larger proportion can change the bread's flavor profile. Similar product-specific limitations have been noted in MOCAF bread research, where acceptance and resemblance to wheat bread decrease as the substitution proportion rises (Yasa et al., 2016; Tambunan, 2025).

Pore structure also differed significantly (χ^2 = 10.24). The sensory scale described pore size rather than preference; therefore, the higher score at 30% reflected very small pores and should not be interpreted as superior quality. When considered alongside the physical-volume data and cross-sectional photographs, the 30% treatment produced a smaller, denser crumb. At 10% substitution, the dough retained a more developed and characteristic structure because a larger proportion of wheat flour remained available to form gluten. Research on composite and gluten-reduced bread similarly shows that weaker gas retention results in a more compact pore network and lower expansion (Indahsari et al., 2024; Nurfiantoro, 2023).

The outer crust and inner crumb textures did not differ significantly. All treatments remained within the crisp-to-moderately-crisp category for the crust and the soft-to-very-soft category for the crumb. The relatively limited substitution range, constant emulsifier and fat levels, and standardized proofing and baking conditions likely helped retain these attributes. Emulsifiers can improve dough stability and crumb softness by supporting gas-cell structure and lipid distribution, although they cannot fully compensate for gluten loss at higher substitution levels (Tebben et al., 2022). The numerical decline in inner-texture scores from 4.40 to 4.00, together with the volume reduction, nevertheless indicates a gradual tendency toward a denser product.

Overall, the 10% formulation achieved the most balanced result. It produced the highest bread volume, relatively characteristic pores, a neutral MOCAF flavor, a strong butter profile, a crisp crust, and a soft crumb. Although certain individual attributes produced numerically higher scores at other treatment levels, the integrated physical and sensory evidence indicates that 10% MOCAF most closely resembled the intended salt-bread standard. The study was limited by manual shaping and incomplete standardization of chilled-butter temperature, both of which may have influenced the internal cavity and between-replication variation. Future work should standardize these variables and include instrumental texture and chemical-composition analyses.

4. Conclusion

MOCAF substitution significantly affected the physical volume of salt bread and the sensory attributes of MOCAF taste and pore structure. Mean volume decreased from 175.67 cm^3 at 10% substitution to 127.33 cm^3 at 30%, demonstrating that greater gluten dilution reduced dough expansion and gas retention. The substitution level did not significantly affect outer or inner color, MOCAF and butter aroma, butter and salty taste, or outer and inner texture. Based on the cSombined physical measurements, sensory scores, product appearance, and flavor balance, 10% MOCAF substitution was the most appropriate formulation within the tested range. This level supports local cassava-flour utilization while maintaining salt-bread characteristics closest to those of a conventional wheat-flour product.

References

Indahsari, I. N., Sutrisno, A., & Ulandari, D. (2024). Evaluasi karakteristik roti komposit bebas gluten dengan konsentrasi hidrokoloid dan waktu proofing yang berbeda [Evaluation of gluten-free composite bread characteristics at different hydrocolloid concentrations and proofing times]. Jurnal Teknologi dan Mutu Pangan, 3(1), 31–41. https://doi.org/10.30812/jtmp.v3i1.4207

Koswara, S. (2009). Teknologi pengolahan roti [Bread-processing technology].

Kusnandar, F., Danniswara, H., & Sutriyono, A. (2022). Pengaruh komposisi kimia dan sifat reologi tepung terigu terhadap mutu roti manis [Effects of chemical composition and rheological properties of wheat flour on sweet-bread quality]. Jurnal Mutu Pangan: Indonesian Journal of Food Quality, 9(2), 67–75. https://doi.org/10.29244/jmpi.2022.9.2.67

Nurfiantoro, T. (2023). Pengaruh substitusi tepung MOCAF pada pembuatan roti soft roll dengan metode Taiwanese bread terhadap daya terima konsumen [Effect of MOCAF substitution in Taiwanese-method soft rolls on consumer acceptance] [Undergraduate thesis, Universitas Negeri Jakarta].

Purwandari, U., Khoiri, A., & Muchlis, M. (2022). Karakteristik fisik dan sensoris roti tawar dengan penambahan tepung ubi jalar ungu [Physical and sensory characteristics of white bread containing purple sweet-potato flour]. Jurnal Teknologi Pangan dan Gizi, 21(1), 45–56.

Rahayu, W. P., Nurosiyah, S., & Widyanto, R. (2020). Evaluasi sensori [Sensory evaluation]. Universitas Terbuka.

Sulistiadi, S. (2020). Analisis teknologi pengembangan produk pangan pengganti terigu menggunakan modified cassava flour (MOCAF) di Kabupaten Banyumas, Jawa Tengah [Technology analysis of wheat-replacement food development using MOCAF in Banyumas]. Jurnal Agroekoteknologi dan Agribisnis, 4(1), Article 408. https://doi.org/10.51852/jaa.v4i1.408

Tambunan, E. C. (2025). Penggunaan MOCAF (modified cassava flour) sebagai substitusi terigu pada pembuatan roti tawar [Use of MOCAF as a wheat-flour substitute in white bread]. Jurnal Review Pendidikan dan Pengajaran, 8(1), Article 43771. https://doi.org/10.31004/jrpp.v8i1.43771

Tarwendah, I. P. (2017). Comparative study of sensory attributes and brand awareness in food products: A review. Jurnal Pangan dan Agroindustri, 5(2).

Tebben, L., Chen, G., Tilley, M., & Li, Y. (2022). Improvement of whole wheat dough and bread properties by emulsifiers. Grain & Oil Science and Technology, 5(2), 59–69. https://doi.org/10.1016/j.gaost.2022.05.001

Yasa, I. W. S., Zaini, M. A., & Hadi, T. (2016). Mutu roti berbahan dasar MOCAF: Formulasi dan metode pembuatan adonan [Quality of bread made from modified cassava flour: Dough formulation and method]. Pro Food, 2(2).