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Pengaruh Substitusi Tepung Singkong terhadap Sifat Fisik dan Mutu Sensoris Apang Coe

The Effect Of Cassava Flour Substitution On The Physical Properties And Sensory Quality Of Apang Coe

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Abstract

Apang Coe is a traditional steamed cake from Manado, North Sulawesi, whose characteristic expansion and surface cracks depend on the behavior of its flour matrix. This study evaluated the effects of substituting cassava flour for 20%, 30%, and 40% of the total flour premix on physical properties and sensory quality. The experiment was conducted at the Pastry and Bakery Laboratory at Universitas Negeri Jakarta from August 2025 to July 2026. Expansion and relative cracking were measured in triplicate and analyzed by one-way analysis of variance; Duncan's test was used to follow up on significant results. Sensory quality was assessed by 45 semi-trained panelists (15 independent panelists per treatment) using eight five-point attribute scales, and the data were analyzed as individual scores with a tie-corrected Kruskal–Wallis test. Mean expansion increased from 89.93% at 20% substitution to 101.67% at 30% and 119.73% at 40%. The effect was significant (F(2,6)=6.07; p=0.036); the 40% treatment differed from the 20% treatment, with the 30% treatment intermediate. Relative cracking did not differ (p=0.770). None of the sensory attributes—surface cracking, color, brown-sugar aroma, cassava aroma, softness, pore structure, sweetness, or cassava taste—differed significantly (p=0.197–0.757). The 20% formulation is proposed as a practical, balanced formula because it retains the characteristic color, aroma, and pores, and a low cassava note. However, it was not statistically superior in overall sensory quality.

Keywords: *Apang Coe, cassava flour, food diversification, physical properties, sensory quality*

Abstrak

Apang Coe adalah kue kukus tradisional dari Manado, Sulawesi Utara, yang karakteristik pengembangan dan retakan permukaannya bergantung pada perilaku matriks tepungnya. Penelitian ini mengevaluasi pengaruh substitusi tepung singkong sebesar 20%, 30%, dan 40% dari total campuran tepung (premix) terhadap sifat fisik dan mutu sensoris. Eksperimen dilakukan di Laboratorium Pastri dan Bakery Universitas Negeri Jakarta dari bulan Agustus 2025 hingga Juli 2026. Pengembangan dan retakan relatif diukur dalam tiga ulangan dan dianalisis menggunakan analisis varians satu arah; uji Duncan digunakan untuk menindaklanjuti hasil yang signifikan. Mutu sensoris dinilai oleh 45 panelis semi-terlatih (15 panelis independen per perlakuan) menggunakan delapan skala atribut lima poin, dan data dianalisis sebagai skor individu dengan uji Kruskal–Wallis yang dikoreksi untuk nilai sama (tie-corrected). Rata-rata pengembangan meningkat dari 89,93% pada substitusi 20% menjadi 101,67% pada 30% dan 119,73% pada 40%. Pengaruh tersebut signifikan (F(2,6)=6,07; p=0,036); perlakuan 40% berbeda dari perlakuan 20%, dengan perlakuan 30% berada di antara keduanya. Retakan relatif tidak menunjukkan perbedaan (p=0,770). Tidak ada atribut sensoris—retakan permukaan, warna, aroma gula merah, aroma singkong, keempukan, struktur pori, rasa manis, maupun rasa singkong—yang berbeda secara signifikan (p=0,197–0,757). Formulasi 20% diusulkan sebagai formula praktis dan seimbang karena mempertahankan karakteristik warna, aroma, dan pori-pori, serta memiliki jejak rasa singkong yang rendah. Namun, formulasi ini tidak secara statistik lebih unggul dalam hal mutu sensoris secara keseluruhan.

Kata Kunci: Apang Coe, Tepung Singkong, Diversifikasi Pangan, Sifat Fisik, Mutu Sensoris

1. Introduction

Food diversification broadens food choices by drawing on local resources and food cultures. This direction is consistent with Law Number 18 of 2012 of the Republic of Indonesia, which positions dietary diversification as part of food security. National consumption data continue to show rice's dominance and the limited contribution of tubers, indicating that the development of cassava-based products remains relevant (Badan Pangan Nasional, 2024). Processing cassava into flour improves storage and ease of use in food formulations while expanding opportunities to add value to local foods (Widowati, 2023; Sayekti et al., 2023).

Cassava flour is produced by drying and milling cassava roots; it differs from tapioca, which is primarily the starch fraction. Cassava flour retains non-starch components and the characteristic aroma of the root, while its starch contributes to water absorption, gelatinization, expansion, and product texture (Chisenga et al., 2019; Pasca et al., 2021). Because cassava flour contains no gluten, its behavior during mixing and heating differs from that of wheat flour. The substitution level must therefore be controlled so that the use of a local ingredient does not eliminate the defining characteristics of the original product (Subroto et al., 2022).

Apang Coe is a traditional steamed cake from Manado, North Sulawesi, prepared from a mixture of flour, brown sugar, coconut milk, yeast, and spices. Its expected characteristics include a brown color, a brown-sugar aroma, a soft, porous texture, and a cracked surface (Butter, 2023). During fermentation, yeast produces gas that is retained in the batter; heating then expands the gas and water vapor while the starch gelatinizes. The balance among gas formation, batter viscosity, and structural setting determines the volume and cracking pattern of the steamed product (Maicas, 2020; Compart et al., 2023). Changing the flour proportions through cassava substitution may therefore affect these two principal physical indicators.

Previous studies have shown that cassava flour can be used in a range of products, although the optimum level depends on the food matrix. Substitution in pie crusts, rice-based snacks, and bread products can alter expansion, color, crispness or softness, and sensory acceptance (Hardoko et al., 2020; Pasca et al., 2021; Zaki et al., 2024). Increasing the cassava fraction may also intensify the root's characteristic aroma or taste and alter water availability in the batter. Findings from one product, therefore, cannot be directly transferred to fermented, steam-cooked Apang Coe.

Specific evidence on cassava flour substitution in Apang Coe remains limited, particularly studies that combine physical measurements with sensory evaluation. This study analyzed the effects of substituting 20%, 30%, and 40% of cassava flour on expansion, surface cracking, and eight sensory attributes of Apang Coe. The findings are expected to support the formulation of local-food products and provide an initial basis for production training for home-scale food enterprises, while keeping the experimental findings distinct from empowerment outcomes that must be evaluated in subsequent activities.

2. Method

This study used a quantitative, single-factor experimental design with cassava flour substitution levels of 20% (P1), 30% (P2), and 40% (P3) of the total flour premix. The study was conducted from August 2025 to July 2026 at the Pastry and Bakery Laboratory of the Culinary Education Study Program, Faculty of Engineering, Universitas Negeri Jakarta. Preliminary trials covered substitution levels from 10% to 60%; the 20%–40% range was selected for the main experiment because it continued to produce the shape, aroma, and texture characteristic of Apang Coe.

Formula design and sample preparation

The base formula used a 5:2 mixture of rice flour and wheat flour with a total flour mass of 350 g. For each treatment, a portion of this mixture was replaced with cassava flour, while all other ingredients remained constant (Table 1). Thus, the treatment percentage represents the proportion of cassava flour in the total flour premix rather than its percentage of the entire batter mass.

Table 1. Apang Coe formulas at three cassava flour substitution levels

Ingredient	P1 (20%)	P2 (30%)	P3 (40%)
Flour premix (g)	280	245	210
Cassava flour (g)	70	105	140
Spekkoek spice (g)	2.5	2.5	2.5
Yeast (g)	5	5	5
Baking soda (g)	5	5	5
Brown sugar (g)	225	225	225
Water (g)	150	150	150
Salt (g)	2.5	2.5	2.5
Coconut milk (g)	250	250	250
Pandan leaf	1 leaf	1 leaf	1 leaf

Note: the flour premix was a 5:2 mixture of rice flour and wheat flour. The formula was adapted from the base formula in 150 Resep Kue Tradisional (2023).

The flour premix and cassava flour were combined and sieved. Brown sugar was dissolved in water with pandan leaves, then mixed with the dry ingredients, spekkoek spice, yeast, and coconut milk at low speed until homogeneous. The batter was fermented for 60 minutes, baking soda was added, and the batter was fermented for a further 10 minutes. A 50 g portion was placed in a 4.5 cm × 4.5 cm pandan-leaf cup. The steamer was preheated, the samples were steamed for 15 minutes, and the products were cooled for 20 minutes before measurement or evaluation. All treatments followed the same procedure and portion mass.

Physical measurements

Expansion was measured at five points—four around the edge and one at the center—before and after steaming. The expansion percentage was calculated as $[(T_\beta - T_a)/T_a] \times 100\%$, where T_a is the batter height before steaming and T_β is the product height after steaming. Surface cracking was assessed by counting cracks on the upper surface and expressing the value relative to the mean number of cracks in the control product: (treatment mean/control mean)×100% (Fatimah et al., 2026). Each treatment was measured in triplicate.

Sensory quality assessment

Sensory quality was evaluated by 45 semi-trained panelists enrolled in the Culinary Education Study Program. The panelists were assigned to three independent groups of 15, each evaluating one three-digit-coded sample: 714 (20%), 286 (30%), or 593 (40%). A five-point category scale was used for surface cracking, color, brown-sugar aroma, cassava flour aroma, softness, pore structure, sweetness, and cassava flour taste. Higher scores indicated closer agreement with the product descriptor;

specifically, for cassava aroma and taste, higher scores indicated a lower perceived cassava intensity.

Data analysis

Physical data were analyzed by one-way analysis of variance at α=0.05. When the ANOVA indicated a significant difference, mean separation was performed using Duncan's test. Sensory scores were analyzed using the Kruskal–Wallis test because they were ordinal and obtained from three independent groups (Sugiyono, 2023). For this article, the sensory statistics were recalculated from the individual scores in the data appendix using a tie correction; decisions were based on two-sided p-values at α=0.05.

3. Results and Discussion

Visual characteristics of the product

All three formulas produced brown, porous Apang Coe with surface cracks. Visually, increasing the substitution level did not eliminate the product's basic form, although the cracking pattern varied among replicates. This variation is plausible because crack formation results from the interaction of gas pressure, steam distribution, batter viscosity, and structural setting during steaming. The products at the three substitution levels are shown in Figure 1.

Figure 1. Apang Coe with 20%, 30%, and 40% cassava flour substitution (from left to right)

Expansion and surface cracking.

Mean expansion increased with the proportion of cassava flour. The highest value was observed for P3 (119.73%), followed by P2 (101.67%) and P1 (89.93%). ANOVA indicated a significant effect of substitution level on expansion ($F(2,6)=6.07$; $p=0.036$). Duncan's test placed P3 and P1 in different groups, whereas P2 did not differ between treatments (Table 2). The increasing trend should therefore not be interpreted as a stepwise difference between every pair of treatments.

Table 2. Physical properties of Apang Coe

Variable	P1 (20%)	P2 (30%)	P3 (40%)	ANOVA
Expansion (%)	89.93^{b}	101.67^{ab}	119.73^{a}	F=6.07; p=0.036
Relative cracking (%)	119.07	114.30	109.53	F=0.27; p=0.770

Note: n=3 replicates per treatment. Different superscript letters in the expansion row indicate differences according to Duncan's test (α=0.05).

The greater expansion at the 40% level may be due to cassava starch's capacity to absorb water and swell during heating. Gelatinized starch granules increase the viscosity of the continuous phase and help retain some gas and steam before the structure sets (Chisenga et al., 2019; Silviwanda et al., 2023). In a system without added gluten, this response also depends on the available water, amylose-to-amylopectin ratio, particle size, and interactions with rice and wheat flours (Wang et al., 2024). The result, therefore, describes the behavior of this specific formula rather than a universal property of all cassava flours.

Relative cracking tended to decrease from 119.07% in P1 to 109.53% in P3, but variation among replicates was substantial, and the difference was not significant ($F(2,6)=0.27$; $p=0.770$). Cracks form when internal pressure exceeds the surface layer's strength. In fermented batters, this process is sensitive to yeast distribution, fermentation time, steam temperature, sample position in the steamer, and surface thickness. The limited number of replicates—three per treatment—also reduced the power to detect small differences. This finding is consistent with the visual observation that all substitution levels still produced the characteristic cracks, although the pattern varied among products.

Sensory quality

Mean sensory scores ranged from 3.00 to 5.00 (Table 3). Color scores were very high for all treatments (4.87–5.00), indicating that the characteristic brown color from brown sugar remained dominant. Brown-sugar aroma was also relatively strong (4.13–4.33), whereas cassava flour aroma scores ranged from 3.33 to 3.87. The 20% formula had the highest cassava-aroma score, meaning that the panelists perceived the lowest cassava intensity at this level.

Table 3. Mean sensory scores and Kruskal–Wallis test results

Attribute	P1	P2	P3	H	p
Surface cracking	4.13	4.07	3.93	0.56	0.757
Color	5.00	4.87	4.93	2.10	0.351
Brown-sugar aroma	4.33	4.13	4.20	0.95	0.621
Cassava flour aroma	3.87	3.33	3.60	2.30	0.316
Softness	3.80	4.07	4.20	1.53	0.465
Pore structure	4.40	4.00	4.13	2.96	0.228
Sweetness	3.87	4.13	4.20	2.12	0.346
Cassava flour taste	3.53	3.53	3.00	3.25	0.197

Note: n=15 independent panelists per treatment; df=2; all $p>0.05$. Higher scores indicate closer agreement with the attribute descriptor; for cassava aroma and taste, higher scores indicate lower cassava intensity.

The Kruskal–Wallis test showed no significant differences in surface cracking, color, brown-sugar aroma, cassava flour aroma, softness, pore structure, sweetness, or cassava flour taste (all $p>0.05$). Thus, within the 20%–40% range, the compositional changes were not large enough to produce different sensory-score distributions among the tested panelist groups. Differences in mean scores may still be used to describe tendencies, but they should not be treated as evidence of statistical superiority.

Softness and sweetness tended to increase in P3, with both reaching 4.20. The tendency toward greater softness is consistent with the higher expansion and the possible water retention of cassava starch. In contrast, the cassava flour taste score decreased to 3.00 in P3, indicating that the cassava character became easier to recognize as its proportion increased. The aroma and taste of substituted products are influenced by volatile compounds in the ingredients, reactions during heating, and the ability of brown sugar and spices to mask the root character (Prastiani et al., 2024; Susanto & Hartati, 2024).

P1 had the highest combination of mean scores for sensory cracking (4.13), color (5.00), brown-sugar aroma (4.33), pore structure (4.40), and low cassava-aroma intensity (3.87). Based on this balance of traditional characteristics, the 20% level is suitable as an initial formula for product development. However, this is a practical, multi-attribute recommendation; the data do not show that P1 was preferred overall, as the instrument assessed attribute quality rather than global liking, and none of the between-treatment tests were significant.

Implications and limitations

Substitution levels of 20%–40% enabled the use of cassava flour without significantly reducing the sensory attributes, while the 40% treatment produced the greatest expansion. These findings support two application paths: a 20% formula to retain a balanced traditional profile and a 40% formula when greater cassava utilization and product expansion are the priorities. For food businesses, the selected level should also account for ingredient prices, flour consistency, process capacity, and target-consumer preferences. Application in training or business mentoring still requires a separate evaluation of participant skills, production costs, shelf-life quality, and market acceptance.

The generalizability of the results is limited by the three physical replicates, the recruitment of panelists from a single study program, and the between-group sensory design with 15 panelists per formula. The study also did not measure moisture content, instrumental texture, nutritional composition, water activity, shelf life, or consumer acceptance. Further research should include a more diverse consumer panel, a balanced presentation design in which each panelist evaluates all formulas, more physical replicates, and tighter control of temperature and steam distribution within the steamer.

4. Conclusion

Cassava flour substitutions at 20%, 30%, and 40% significantly affected Apang Coe expansion but did not affect relative cracking. The 40% level produced the greatest expansion (119.73%) and differed from the 20% level (89.93%), whereas the 30% treatment (101.67%) was intermediate. None of the tested sensory attributes—surface cracking, color, brown-sugar aroma, cassava flour aroma, softness, pore structure, sweetness, or cassava flour taste—differed significantly. The 20% formula may be used as a balanced starting formulation that retains the character of Apang Coe. In comparison, the 40% formula is appropriate when higher cassava utilization and greater expansion are priorities. Any claim regarding the best formula should be confirmed through consumer acceptance testing, cost analysis, and shelf-life evaluation.

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