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Pengaruh Rasio Tepung Komposit (Tepung Beras, Tapioka, Pati Jagung, Dan Tepung Almond) Terhadap Kualitas Sensoris Dan Fisik Scone

Effect Of Composite Flour Ratios (Rice Flour, Tapioca, Cornstarch, And Almond Powder) On The Sensory And Physical Quality Of Scones

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Abstract

This study analyzed the effects of composite flour ratios comprising white rice flour, tapioca, cornstarch, and almond powder on the sensory and physical quality of scones. Three wheat-free formulations were prepared at ratios of 2:1:1:1, 2:1:1:2, and 2:1:1:3, while a wheat-flour formulation was retained as the physical-quality control. The experimental study involved five expert validators and 45 semi-trained panelists. Sensory attributes included top color, side color, aroma, taste, outer texture, and inner texture. Physical quality was evaluated by measuring bake loss and expansion in three replications. Sensory data were analyzed using the Kruskal–Wallis test, while physical data were examined using one-way ANOVA followed by Duncan's Multiple Range Test when a significant effect was detected. The three composite-flour ratios did not significantly affect any sensory attribute because all calculated Kruskal–Wallis values were below the critical value of 5.991. Nevertheless, the 2:1:1:2 formulation produced the highest descriptive scores for top color (4.8) and taste (4.1), while maintaining favorable aroma and texture. Composite flour ratio significantly affected bake loss (F = 10.177 > Fcritical = 4.066), with means of 10.39%, 10.26%, and 9.97% for the three treatments, respectively. Expansion did not differ significantly (F = 0.452 < Fcritical = 4.066), with corresponding means of 9.84%, 9.73%, and 9.26%. Overall, the 2:1:1:2 ratio was recommended because it combined the strongest sensory acceptance with acceptable physical performance. The results demonstrate that a balanced composite-flour system can produce acceptable wheat-free scones while increasing the use of alternative flour Ingredients.
Keywords: *Almond Powder; Composite Flour; Physical Quality; Sensory Quality; Wheat-Free Scones*

Abstrak

Penelitian ini menganalisis pengaruh rasio tepung komposit yang terdiri dari tepung beras putih, tapioka, pati jagung, dan bubuk almond terhadap kualitas sensori dan fisik *scone*. Tiga formulasi bebas gandum disiapkan dengan rasio 2:1:1:1, 2:1:1:2, dan 2:1:1:3, sementara formulasi tepung gandum tetap digunakan sebagai kontrol kualitas fisik. Studi eksperimental ini melibatkan lima validator ahli dan 45 panelis semi-terlatih. Atribut sensori yang dinilai meliputi warna permukaan atas, warna sisi samping, aroma, rasa, tekstur bagian luar, dan tekstur bagian dalam. Kualitas fisik dievaluasi dengan mengukur susut panggang (*bake loss*) dan pengembangan dalam tiga kali ulangan. Data sensori dianalisis menggunakan uji Kruskal–Wallis, sedangkan data fisik diperiksa menggunakan ANOVA satu arah yang diikuti dengan uji *Duncan's Multiple Range Test* jika ditemukan pengaruh yang signifikan. Ketiga rasio tepung komposit tersebut tidak memberikan pengaruh yang signifikan terhadap atribut sensori mana pun karena semua nilai Kruskal–Wallis yang dihitung berada di bawah nilai kritis 5,991. Meskipun demikian, formulasi 2:1:1:2 menghasilkan skor deskriptif tertinggi untuk warna permukaan atas (4,8) dan rasa (4,1), sembari tetap mempertahankan aroma dan tekstur yang baik. Rasio tepung komposit berpengaruh signifikan terhadap susut panggang (F = 10,177 > F-kritis = 4,066), dengan nilai rata-rata masing-masing sebesar 10,39%, 10,26%, dan 9,97% untuk ketiga perlakuan tersebut. Pengembangan tidak menunjukkan perbedaan yang signifikan (F = 0,452 < F-kritis = 4,066), dengan nilai rata-rata masing-masing sebesar 9,84%, 9,73%, dan 9,26%. Secara keseluruhan, rasio 2:1:1:2 direkomendasikan karena menggabungkan tingkat penerimaan sensori terbaik dengan karakteristik fisik yang dapat diterima. Hasil penelitian menunjukkan bahwa sistem tepung komposit yang seimbang dapat menghasilkan *scone* bebas gandum yang dapat diterima sekaligus meningkatkan penggunaan bahan tepung alternatif.
Kata Kunci: Bubuk Almond; Tepung Komposit; Kualitas Fisik; Kualitas Sensori; *Scone* Bebas Gandum

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1. Introduction

Scones are traditional quick breads associated with Scotland and British tea culture. Unlike yeast-leavened bread, they rely on chemical leavening to develop volume during baking and are valued for their lightly browned surfaces, crisp outer layers, and soft, slightly crumbly interiors (Baking Industry Research Trust, 2011; Clelland, 2017). Their relatively simple formulation and short processing time make scones suitable for product diversification. However, conventional scones rely on wheat flour, limiting their suitability for consumers who avoid gluten-containing ingredients.

The main technological challenge in developing wheat-free bakery products is the loss of gluten. Gliadin and glutenin create a viscoelastic network that supports the dough, retains gas, and contributes to product volume and texture (Biesiekierski, 2017). No single gluten-free flour or starch can completely reproduce these functions. A composite-flour system is therefore commonly used so that the functional advantages of different starches and flours compensate for one another (Sitanggang, 2016; Putri, 2023).

In this study, white rice flour, tapioca, and cornstarch formed the structural base. Rice flour provides a neutral flavor, a light color, and a starch that can gelatinize. Tapioca contributes water-binding, elasticity, and cohesiveness, whereas cornstarch supports a lighter, crisper structure when used in a controlled proportion (America's Test Kitchen, 2024; Laila, 2022; Little, 2025a). A balanced combination is necessary because excessive tapioca can lead to excessive chewiness, while excessive cornstarch can produce a dry or powdery mouthfeel.

Almond powder was incorporated as a functional component because it contains protein, fiber, natural lipids, and vitamin E. Its fat fraction can act as a tenderizing agent, improve moisture retention, and enrich the nutty aroma and flavor of baked products (Gotama et al., 2024; Hamel, 2017; Little, 2025b). At the same time, increasing the amount of almond powder changes the relative starch-to-fat ratio and may alter color development, aroma intensity, bake loss, expansion, and crumb structure. The amount added must therefore be evaluated rather than assumed to be beneficial at every level.

Previous studies have demonstrated that alternative flours can be used in scones, but their effects depend on raw material composition. Cassava-flour substitution affected acceptability and internal texture (Manurung, 2016), breadfruit flour produced acceptable scones at an appropriate substitution level (Kamila et al., 2024), and wheat–taro–lentil composite flour changed the physicochemical and sensory attributes of scones (Shongwe et al., 2024). Recent CEEJ research has likewise shown the importance of evaluating both sensory and physical responses when alternative ingredients are introduced into bakery products (Keishya et al., 2026). However, limited information is available on scones formulated from a fixed rice–tapioca–cornstarch base with graded almond-powder ratios.

Accordingly, this study aimed to analyze the effects of three composite flour ratios—2:1:1:1, 2:1:1:2, and 2:1:1:3—of rice flour, tapioca, cornstarch, and almond powder on the sensory and physical quality of scones. The study evaluated color, aroma, taste, outer and inner texture, bake loss, and expansion, and identified the formulation with the most favorable overall performance.

2. Methods

2.1. Research Design, Location, and Participants

A quantitative experimental design was used. Product development and physical testing were conducted from December 2025 at the Bread and Pastry Processing Laboratory of the Culinary Education Study Program, Faculty of Engineering, Universitas Negeri Jakarta. Three composite-flour treatments were evaluated. Five culinary lecturers served as expert validators, and 45 semi-trained panelists were selected from Culinary Education students who had completed or were taking Continental Cake and Bread Processing and sensory-evaluation courses. The panelists were randomly divided into three groups of 15, with each group evaluating one coded treatment to minimize expectation bias.

2.2. Treatments and Scone Preparation

The base composite flour contained 50 g white rice flour, 25 g tapioca, and 25 g cornstarch. Almond powder was added at 25, 50, or 75 g, producing ratios of 2:1:1:1, 2:1:1:2, and 2:1:1:3. A conventional wheat-flour scone was included in the physical-quality test as a control. Other ingredients were held constant relative to 100 g of base flour: 5 g milk powder, 6 g sugar, 0.6 g salt, 3 g baking powder, 45 g unsalted butter, 50 mL UHT milk, 15 mL whipping cream, and 2.5 mL lemon juice.

Table 1. Composition of the experimental scone formulations

Ingredient	Control	2:1:1:1	2:1:1:2	2:1:1:3
Wheat flour (g)	100	–	–	–
White rice flour (g)	–	50	50	50
Tapioca (g)	–	25	25	25
Cornstarch (g)	–	25	25	25
Almond powder (g)	–	25	50	75
Constant ingredients	Milk powder 5 g; sugar 6 g; salt 0.6 g; baking powder 3 g; butter 45 g; milk 50 mL; whipping cream 15 mL; lemon juice 2.5 mL	Same	Same	Same

Almond kernels were blanched for approximately 1 minute, peeled, oven-dried at 170°C for 7–10 minutes, ground for approximately 1 minute, and sieved. For the scones, the dry ingredients were mixed, and cold butter was incorporated using the rubbing-in method until coarse crumbs formed. Milk, whipping cream, and lemon juice were added with minimal mixing. The dough was folded, rolled to approximately 2–3 cm, cut vertically with a ring cutter, frozen for about 2 hours, brushed with egg wash, and baked at 190–210°C for 15–20 minutes. The baked products were transferred to a cooling rack before assessment.

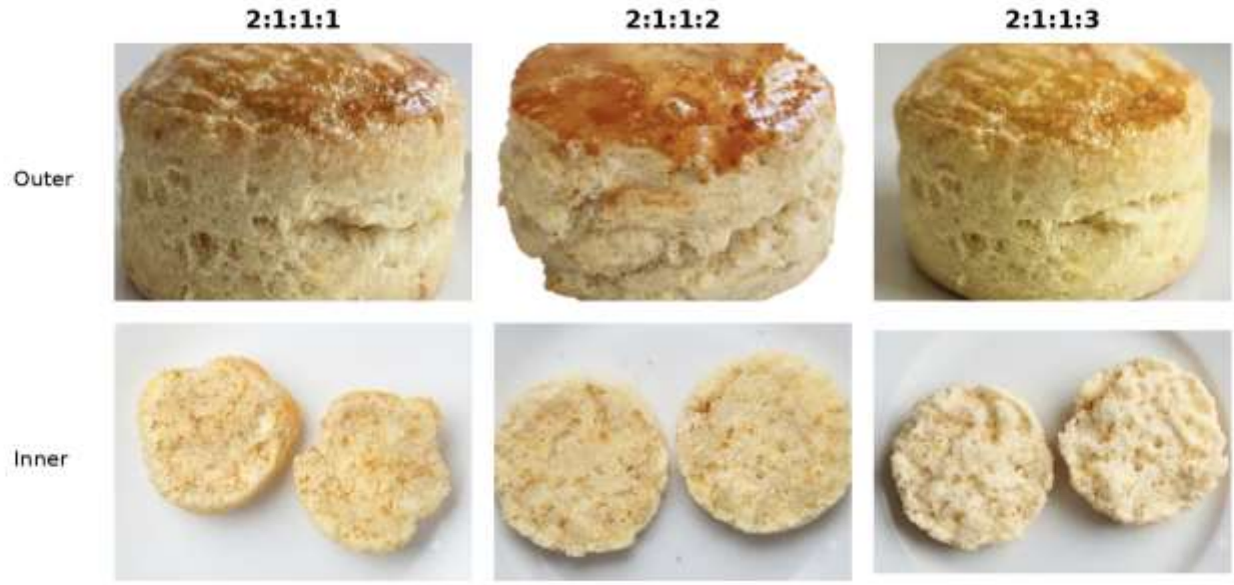

Figure 1. Outer and inner appearance of scones at composite flour ratios of 2:1:1:1, 2:1:1:2, and 2:1:1:3

2.3. Sensory and Physical Assessment

Sensory quality was evaluated on a five-point quality scale. The attributes were top color, side color, almond aroma, almond taste, outer texture, and inner texture. The target profiles were golden-yellow top color, pale-yellow side color, perceptible almond aroma and taste, crisp outer texture, and soft interior. Expert validation used the same criteria before the semi-trained panel test.

Physical quality was measured in three replications for the wheat control and each composite-flour treatment. Expansion was calculated from the initial and final heights: expansion (%) = [(final height − initial height)/initial height] × 100. Bake loss was calculated from the raw and baked weights: bake loss (%) = [(raw weight − baked weight)/raw weight] × 100.

2.4. Data Analysis

Sensory scores were analyzed with the Kruskal–Wallis test at $\alpha = .05$. With three treatments, the critical chi-square value was 5.991; a calculated H value below this threshold indicated no significant treatment effect. Physical data were analyzed using one-way ANOVA at $\alpha = .05$. The critical F value was 4.066. When the ANOVA indicated a significant effect, Duncan's Multiple Range Test (DMRT) at 5% was used to compare treatment means.

2.5. Research Hypothesis

Based on the conceptual framework, the research hypothesis stated that differences in the composite flour ratio (rice flour, tapioca, cornstarch, and almond powder) would significantly affect the sensory and physical quality of scones.

3. Results and Discussion

3.1. Product Validation

The five expert validators considered all three formulations suitable for further sensory testing. Descriptively, the 2:1:1:3 treatment received the highest expert scores for top and side color, whereas the 2:1:1:1 treatment received the highest aroma and taste scores. Outer texture improved as the almond proportion increased, while inner-texture scores remained within the soft to sufficiently soft range. This pattern indicated that the three formulations had distinct descriptive strengths, but all met the basic product criteria.

3.2. Sensory Quality

Table 2. Sensory means and Kruskal–Wallis results for composite-flour scones

Attribute	2:1:1:1	2:1:1:2	2:1:1:3	H	Decision
Top colour	4.3	4.8	4.7	2.18	Not significant
Side colour	4.3	4.6	4.4	1.17	Not significant
Almond aroma	4.3	4.3	3.7	2.06	Not significant
Almond taste	3.4	4.1	3.9	2.43	Not significant
Outer texture	4.3	4.3	4.1	0.36	Not significant
Inner texture	4.7	4.5	4.8	1.00	Not significant

None of the sensory attributes differed significantly, as all calculated H values were below 5.991. The narrow range of color scores suggests that the common baking conditions and constant quantities of sugar, milk solids, and egg wash exerted a stronger influence than the almond ratio. Browning on the upper surface was promoted by direct heat exposure and non-enzymatic browning reactions, while the protected sides remained lighter (Purlis, 2010). The 2:1:1:2 treatment nevertheless achieved the highest top-color mean (4.8) and the highest taste mean (4.1).

Aroma scores were high for the first two ratios but decreased at 2:1:1:3. Almond aroma is strongly associated with volatile compounds, particularly benzaldehyde, that are released during processing and consumption (Franklin & Mitchell, 2019). Increasing the amount of almond powder can intensify these compounds, but a stronger aroma is not automatically perceived as more appropriate. Differences in individual olfactory sensitivity and the masking effects of butter and baked-flour aromas may explain why the highest almond level did not receive the highest aroma score.

Taste followed a similar non-linear pattern. The 2:1:1:2 treatment was rated highest, whereas the lower ratio produced a weaker almond impression, and the highest ratio did not further increase acceptance. Flavor compounds may be retained within fat- and sugar-rich food matrices, and interactions among taste stimuli may suppress the perception of individual components (Guichard, 2002; Keast & Breslin, 2003). Therefore, a moderate almond level may have provided the clearest balance between the nutty component and the constant sweet–buttery base.

The outer texture remained between 4.1 and 4.3, indicating crisp to sufficiently crisp products. Tapioca supported cohesion, while cornstarch reduced structural density and promoted a more friable crust (Laila, 2022; Little, 2025a). Inner-texture means were consistently high (4.5–4.8). Butter acted as a shortening agent, sugar retained moisture, gelatinized rice starch supported the crumb, and almond lipids contributed tenderness. The absence of a significant difference indicates that these common structural factors compensated for the increased almond content across the tested range (Figoni, 2010; Hamel, 2017; Juanda & Sutedja, 2024).

3.3. Physical Quality

Table 3. Physical quality and one-way ANOVA results

Parameter	Control	2:1:1:1	2:1:1:2	2:1:1:3	F	Decision
Bake loss (%)	12.27 ± 0.16^{a}	10.39 ± 0.92^{b}	10.26 ± 0.61^{b}	9.97 ± 0.21^{c}	10.177	Significant
Expansion (%)	11.29 ± 2.58	9.84 ± 2.31	9.73 ± 2.42	9.26 ± 1.61	0.452	Not significant

Values are mean ± standard deviation (n = 3). Different superscript letters within the bake-loss row indicate different DMRT groups at the 5% level.

The composite flour ratio significantly affected bake loss. All composite-flour formulations lost less mass during baking than the wheat control, and bake loss declined as almond powder increased. The values remained close to the typical range reported for bakery products. The lower bake loss may reflect stronger moisture retention by the composite system. Sugar is hygroscopic; tapioca forms a water-binding gel during heating, and almond powder contributes fat and fiber, which can reduce water mobility (Figoni, 2010; Gotama et al., 2024). DMRT separated the wheat control from the composite treatments, placed the 2:1:1:1 and 2:1:1:2 treatments in the same group, and distinguished the 2:1:1:3 treatment as the lowest-bake-loss formulation.

Expansion did not differ significantly. The values decreased descriptively from 11.29% in the control to 9.26% in the highest-almond treatment, but the within-treatment variability was sufficiently large that the differences were not statistically significant. Baking powder and lemon juice were constant across the formulations, providing a comparable source of carbon dioxide. In the wheat-free treatments, gelatinized rice starch and the tapioca–cornstarch matrix helped stabilize the expanding structure even without a gluten network. Similar work has shown that composite ingredients can alter scone structure, but the extent depends on the balance of starch, protein, fiber, and water-binding components (Lee et al., 2023; Shongwe et al., 2024).

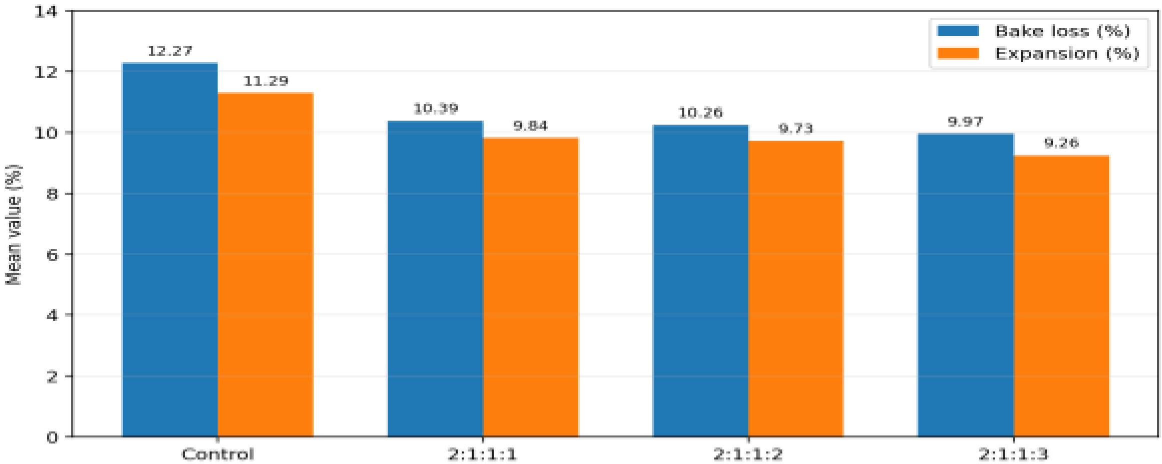

Figure 2. Mean bake loss and expansion of the control and composite-flour scones

3.4. Recommended Formulation and Study Limitations

The 2:1:1:2 treatment was recommended as the best overall formulation. It achieved the highest descriptive scores for top color and taste, maintained favorable aroma and texture, and produced acceptable bake loss and expansion. The result suggests that 50 g almond powder per 100 g of the rice–tapioca–cornstarch base provided a more balanced sensory profile than either the lower or higher level.

Two limitations should be considered. First, the sensory samples cooled during transportation to the testing location, whereas scones are ideally evaluated warm for optimal crispness and volatile-aroma release. Second, only three almond ratios were examined. Further research should use objective texture and color instruments, evaluate shelf life and nutrient composition, and investigate locally available nut powders, such as canarium nut or cashew, as more economical alternatives.

4. Conclusion

The ratios of rice flour, tapioca, cornstarch, and almond powder did not significantly affect top color, side color, aroma, taste, outer texture, or inner texture of the scones. All three formulations were sensorially acceptable. The composite-flour ratio significantly affected bake loss but did not significantly affect expansion. The 2:1:1:2 formulation was recommended because it achieved the strongest overall sensory profile while retaining acceptable physical quality. These findings confirm that a rice–tapioca–cornstarch base can be combined with almond powder to produce acceptable wheat-free scones, provided that the almond proportion is balanced with the starch matrix.

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