

INNOVATION OF CUMIN COOKIES (KUKIS JINTAN) UTILIZING RED SORGHUM FLOUR

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ABSTRACT

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This study aims to develop an innovative cumin cookie product based on red sorghum flour as an effort to diversify local food sources and reduce dependence on imported wheat. The addition of black cumin (*Habbatussauda*), known for its thymoquinone compound, further enhances the functional value of the product. The objective of this research was to determine the optimal formulation of cumin cookies by evaluating their proximate analysis (protein, moisture, and ash content) and consumer preference levels. A Completely Randomized Design (CRD) was employed with five different formulations of sorghum flour, wheat flour, and tapioca flour. The results indicated that formulation F3 (20% sorghum flour, 23% wheat flour, and 11% tapioca flour) was the best treatment, yielding a protein content of 8.06%, moisture content of 5.79%, and ash content of 3.82%. Organoleptic testing showed high levels of preference across all parameters, including taste, texture, aroma, and color. Financial analysis concluded that this enterprise is feasible, with an R/C ratio of 1.62.

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1. Introduction

Cookies are a popular and convenient snack with a steadily increasing consumption trend in Indonesia [1]. However, the heavy reliance on imported wheat flour poses a significant challenge to national food sovereignty [2]. In Indonesia, the utilization of sorghum as a primary food ingredient remains limited, as it is predominantly used for livestock feed rather than human consumption [3]. Sorghum (*Sorghum bicolor* L.) emerges as a viable local alternative that is gluten-free and rich in antioxidants, fiber, and minerals [4-5]. Through this innovation, cookie products can enhance both the nutritional value and health benefits provided to consumers [6-7].

The incorporation of black cumin (*Habbatussauda*), which contains active compounds such as thymoquinone, further strengthens the product's functional value [8]. Black cumin (*Nigella sativa*) is a type of seed widely recognized as a herbal remedy [9]. It plays a crucial role in terms of nutritional, sensory, and functional food aspects. *Habbatussauda* can enhance nutritional content by providing essential proteins and amino acids, unsaturated fatty acids, and minerals such as calcium, iron, and magnesium [10]. Specifically, its bioactive compounds (thymoquinone) transform these cookies into a functional food [3].

This research innovates the traditional cumin cookies (*Kukis Jintan*) from East Nusa Tenggara by substituting wheat flour with red sorghum flour and tapioca flour, while adding black cumin as a functional component [11-12]. The processing method employed is deep-frying, which is more

practical for regions or production scales with limited equipment. This approach opens opportunities for the diversification of cumin cookie products through simpler and more economical processing methods.

2. Method

2.1 Materials

This research was conducted from August to November 2025 at the Agricultural Industrial Engineering Laboratory, University of Tribhuwana Tunggal, Malang. The primary raw material used was red sorghum cultivated in Maumere, East Nusa Tenggara, representing a distinctive local commodity. This sorghum was subsequently blended with other ingredients, specifically wheat flour and cornstarch, for the production of kue kippas.

2.2 Research Design

This study employed a single-factor Randomized Block Design (RBD) with five formulations of sorghum, wheat, and tapioca flour ratios: F1 (26%:17%:11%), F2 (23%:20%:11%), F3 (20%:23%:11%), F4 (17%:26%:11%), and F5 (14%:29%:11%). Each treatment was replicated three times, resulting in 15 experimental units. The observed parameters included proximate analysis (protein, moisture, and ash content) and hedonic testing (taste, texture, aroma, and color). Data were analyzed using Analysis of Variance (ANOVA) to determine the best treatment, and the study further incorporated a financial feasibility analysis.

2.3 Cumin Cookies Production

The research was conducted in several stages, including material preparation and the production of cumin cookies. The initial stage involved preparing the raw materials and equipment, followed by weighing all ingredients according to the designated formulations. The first mixing stage (*Mixing I*) involved blending eggs, sugar, vanilla, and salt using a mixer. Subsequently, melted margarine, black cumin (*Habbatussauda*), vegetable oil, and baking powder were added and stirred until a homogeneous mixture was achieved.

In the second mixing stage (*Mixing II*), sorghum flour, wheat flour, and tapioca flour were incorporated into the dough and stirred thoroughly. The resulting dough was then shaped by rolling it diagonally and cutting it into elongated pieces with a diameter of approximately 3 cm. The shaped dough was deep-fried in hot oil over medium heat for 3–5 minutes until it turned golden brown, followed by a draining process to reduce oil content. The cookies were then cooled at room temperature before being packaged. Finally, the produced cumin cookies were analyzed for protein, moisture, and ash content, as well as consumer preference.

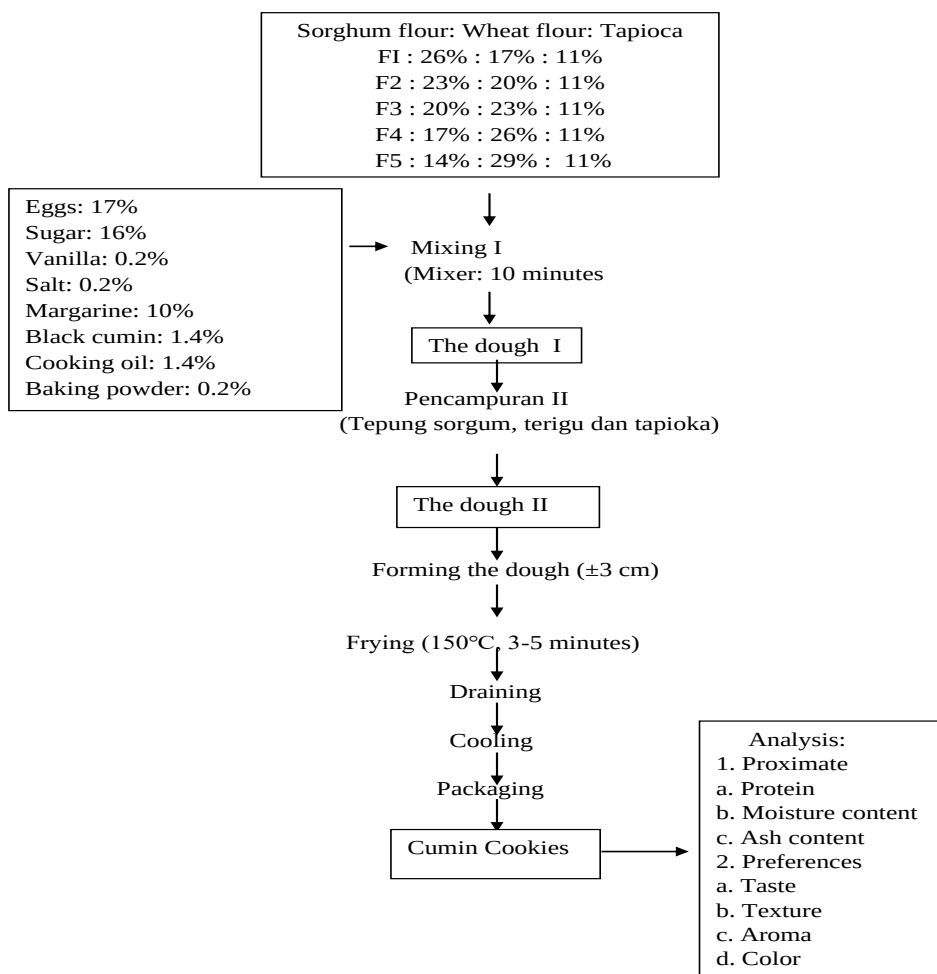


Figure 1. Cumin cookies production

3. Results and Discussion

3.1 Protein Content

Protein serves as a vital structural component in food and significantly influences the texture and final quality of the product. Based on the Analysis of Variance (ANOVA), the calculated F-value was 115.45, which is greater than the F-table value of 8.65 at the 1% significance level ($115.45 > 8.65$). Since the calculated F-value exceeds the critical F-table value, the treatments exerted a highly significant effect on the protein content of the cookies, indicating that the variations in formulations led to significant differences in protein levels. To determine which treatments provided the most substantial impact, a post-hoc Least Significant Difference (LSD) test was conducted at the 5% significance level. The calculation yielded an LSD value of 0.16. The results of the LSD test indicated that each treatment had a highly significant difference in mean protein content. The average protein values for each treatment are presented in the bar chart in the figure below.

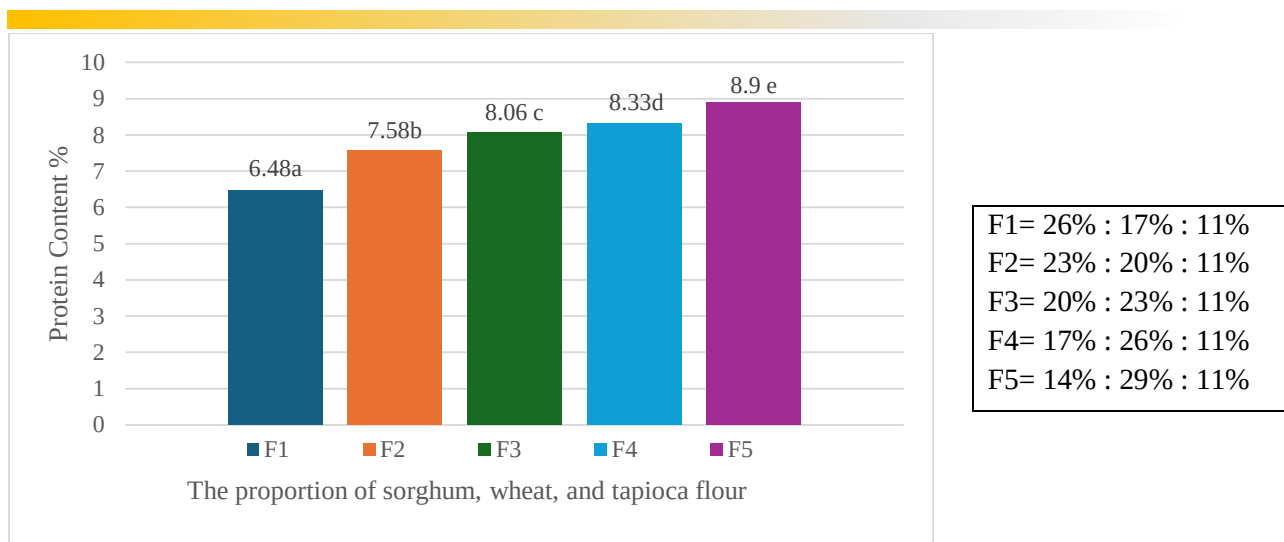


Figure 2. Protein Content

The high protein content in this treatment is influenced by the balanced composition of sorghum and wheat flour. Sorghum flour possesses a relatively high protein content, while wheat flour serves as a source of gluten protein that supports the dough structure. The F3 formulation successfully maximized the protein contribution from both flour types without compromising the sensory quality of the product [13]. This indicates that the partial substitution of wheat flour with sorghum flour at the appropriate proportion can enhance the nutritional value of cumin cookies. According to the protein content graph (Figure 5), a downward trend in protein levels is observed from F1 to F2, followed by an increase from F3 to F5. This suggests that while increasing wheat flour to a certain point can raise protein levels, the reduction in sorghum proportions beyond the optimum point (F3) causes the protein content to decrease [14]. Consequently, F3 represents the optimum point in the protein content trend.

3.2 Moisture Content

Water is a critical component in food materials as it significantly influences the appearance, texture, and flavor profile of the product. Moisture content refers to the total amount of water present within a food material or product. This component plays a vital role in determining both the quality and the shelf life of food. Excessive moisture content makes the product more susceptible to spoilage, whereas a moisture level that is too low can alter its texture and sensory properties. Based on the Analysis of Variance (ANOVA), the calculated F-value was \$8.41\$, which is greater than the F-table value of \$7.01\$ at the \$1\%\$ significance level (\$8.41 > 7.01\$). Since the calculated F-value exceeds the F-table value, the treatments exerted a highly significant effect on the moisture content. Consequently, a post-hoc Least Significant Difference (LSD) test was performed. The results of the calculation yielded an LSD value of \$0.56\$. The LSD test results further indicate that the mean moisture content of each treatment is significantly different.

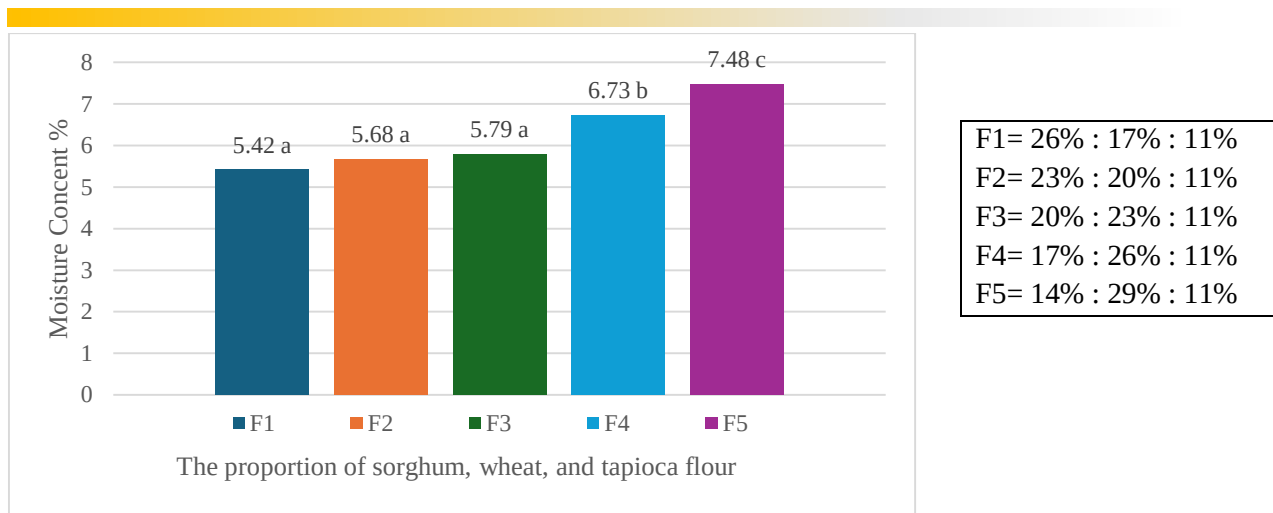


Figure 3. Moisture Content

The diagram illustrates the differences in moisture content of cumin cookies formulated with various mixtures of sorghum, wheat, and tapioca flour. Each treatment (F1–F5) resulted in distinct moisture levels, influenced by the variations in ingredient composition. As shown in the diagram, the moisture content of the cumin cookies fluctuated across each flour formulation. Treatment F5 exhibited the highest moisture content (7.48%), which is attributed to the higher proportions of wheat and tapioca flour that enhance water-binding capacity. Conversely, treatment F1 showed the lowest moisture content (5.42%) due to the high proportion of sorghum flour, which has lower water absorption properties. Treatment F3 produced a moisture content of 5.79%, which is considered low and supports a crispy texture in the cookies. Low moisture content is crucial for dry pastry products as it directly impacts shelf life and product stability [15]. The flour combination in F3 created a dough structure capable of releasing water optimally during the frying process, preventing excessive retention in the final product. The moisture content graph (Figure 6) displays a downward trend from F1 to F3, followed by a slight increase in F4 and F5. The decrease in moisture content up to F3 is caused by the balance between the water-binding abilities of sorghum and wheat flour [16]. The subsequent increase in F4 and F5 is presumably due to the higher wheat flour content, which possesses greater water-holding capacity. Therefore, F3 demonstrates the most ideal moisture content. In food materials, moisture content is a key determinant of both freshness and shelf stability.

3.3 Ash Content

Ash content is an essential indicator for evaluating the quality of food products, including cumin cookies. The ash content of a material represents the residue resulting from the combustion of all organic components within that material (Pamungkas, 2008). This component indicates the total minerals remaining after organic matter is incinerated at high temperatures. A high ash value signifies that the product possesses a greater mineral content. However, excessively high ash levels may indicate the presence of contaminants, such as dust, impurities, or other unintended residues (Winarno, 2004). Based on the Analysis of Variance (ANOVA), the calculated F-value was 7.48, which is greater than the F-table value of 7.01 at the 1% significance level ($7.48 > 7.01$). Since the calculated F-value (7.48) exceeds the F-table value (7.01), the treatments exerted a highly significant effect on the ash content. Consequently, a post-hoc Least Significant Difference (LSD) test was performed. Based on the calculations, an LSD value of 0.48 was obtained. The results of the LSD test indicate that the mean ash content for each treatment is significantly different.

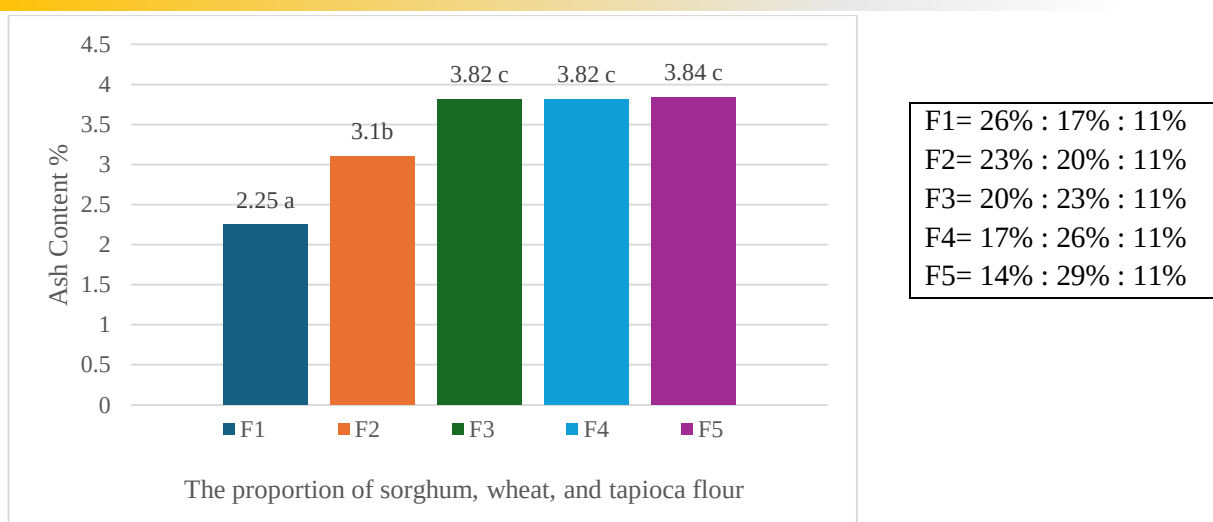


Figure 4. Ash Content

Based on the diagram above, the ash content of the cumin cookies varies across treatments. Treatment F5 (14%:29%:11%) recorded the highest ash content at 3.84%, indicating a higher mineral concentration due to the greater proportion of sorghum flour. Conversely, the lowest ash content was found in F1 (26%:17%:11%) with a value of 2.25%, signifying lower mineral levels. Analysis results show that treatment F3 possesses an ash content of 3.82%, reflecting a relatively high mineral concentration. In cumin cookie products, ash content is influenced by the type and composition of the ingredients used, particularly the ratios of sorghum, wheat, and tapioca flour. Sorghum flour has a higher mineral content compared to the other two flours; thus, a larger proportion of sorghum in the formulation tends to increase the product's ash content [17]. Consequently, formulations utilizing more sorghum flour generally yield higher ash content than those dominated by wheat or tapioca flour. Processing factors such as the mixing stage, frying technique, and heating duration also play a role in determining ash levels. Excessive heating can increase ash content as organic components are further reduced, making the remaining mineral concentration appear higher [18]. The ash content graph (Figure 7) illustrates an upward trend in ash levels as the proportion of sorghum flour increases. However, the ash content in F3 is considered optimal; while treatments with higher sorghum content (F1 and F2) yielded higher ash values, they were less preferred in sensory evaluations. Thus, F3 represents the equilibrium point between mineral content and consumer acceptance.

3.4 Sensory Evaluation: Taste

Taste is a primary factor influencing an individual's acceptance of a food product. It is a physiological response of the tongue to the stimuli provided by food and serves as one of the most critical elements in determining the preference level of panelists or consumers toward a specific food product.

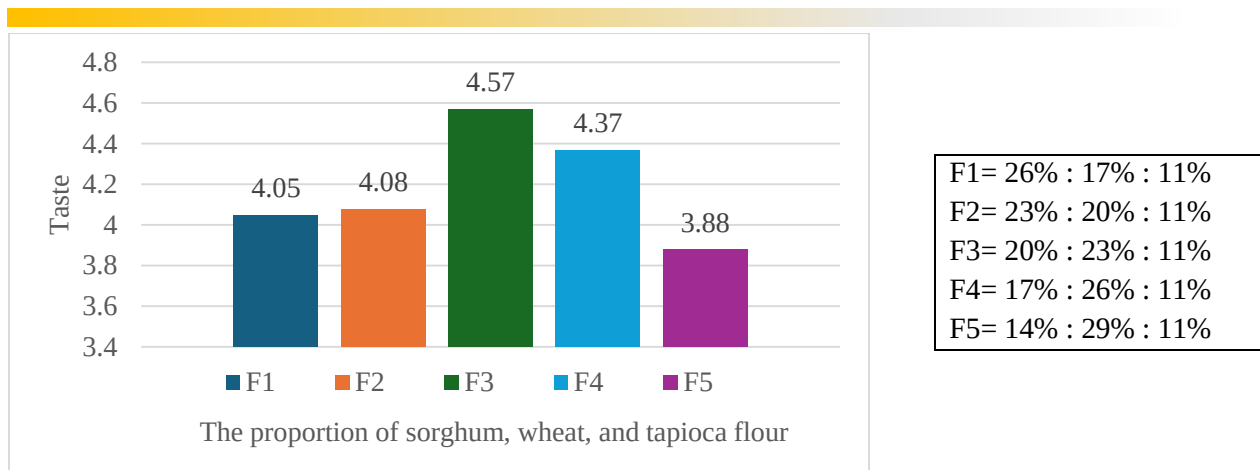


Figure 5. Sensory Evaluation: Taste

The sensory evaluation results for taste indicate that variations in the composition of sorghum, wheat, and tapioca flour influence the level of panelist acceptance of the sorghum stick products. Treatment F3 achieved the highest score (4.57), suggesting that the blend of 20% sorghum flour, 23% wheat flour, and 11% tapioca flour produced the most preferred flavor profile. This combination is considered capable of providing a balance between the distinct flavor of sorghum and the other flours [19]. Treatment F4 also obtained a relatively high score (4.37), likely due to the higher proportion of wheat and tapioca flour, which results in a more neutral taste and a texture that complements the overall flavor [20]. Meanwhile, treatment F5 showed the lowest score (3.88), presumably because the dominant and stronger sorghum flavor was less preferred by the panelists. Statistically, the treatments were not significantly different, as the calculated chi-square value was lower than the table value ($8.80 < 9.48$), X^2 -table ($\alpha = 0.05$, $df = 4$) = 9.48.

3.5 Sensory Evaluation: Texture

Texture is defined as the sensation of pressure that can be perceived through the mouth (during biting, chewing, and swallowing) or through tactile sensation with the fingers. Based on the analysis of variance (Appendix 10), the results indicate that the proportions of sorghum, wheat, and tapioca flour had no significant effect on the texture scores of the cumin cookies. This is evidenced by the calculated chi-square value being lower than the table value $X^2_{\text{calc}} < X^2_{\text{table}}$, specifically $8.27 < 9.48$ with X^2_{table} at $\alpha = 0.05$, $df = 4$). The average panelist preference scores for the texture of the cumin cookies are presented in the following figure.

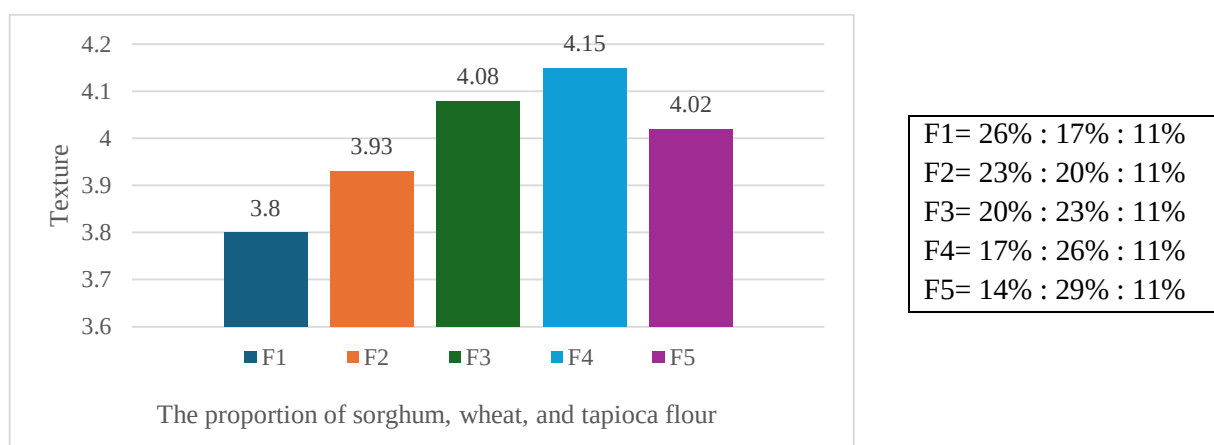


Figure 6. Sensory Evaluation: Texture

The results indicate that the highest average panelist preference for texture was observed in formulation F4 (17% sorghum flour, 26% wheat flour, and 11% tapioca flour) with a score of 4.15, which falls into the "Liked" category, followed by formulation F3 (20% sorghum flour, 23% wheat flour, and 11% tapioca flour). Conversely, the lowest preference for the texture of the cumin cookies was found in formulation F1 (26% sorghum flour, 17% wheat flour, and 11% tapioca flour) with a score of 3.80, categorized as "Slightly Liked." This variation is influenced by the differing proportions of sorghum, wheat, and tapioca flour, as the combination of these ingredients determines the level of crispness and the final structure of the product [21]. This finding is consistent with Winarno (2004), who states that the composition of raw materials plays a vital role in shaping the textural characteristics of food products.

3.6 Sensory Evaluation: Aroma

Aroma is a crucial factor that must be considered in product acceptance. In many respects, aroma determines the palatability of food; the food industry, in fact, places significant importance on aroma testing as it provides immediate results regarding whether a product is preferred or not. Based on the Analysis of Variance (ANOVA), the treatments had no significant effect on the aroma scores of the cumin cookies formulated from sorghum, wheat, and tapioca flour. This is indicated by the calculated chi-square value being lower than the table value $X^2_{\text{calc}} < X^2_{\text{table}}$, specifically $8.27 < 9.48$ with X^2_{table} at $\alpha = 0.05$, $df = 4$). The average panelist preference scores for the aroma of the cumin cookies are presented in Figure 7.

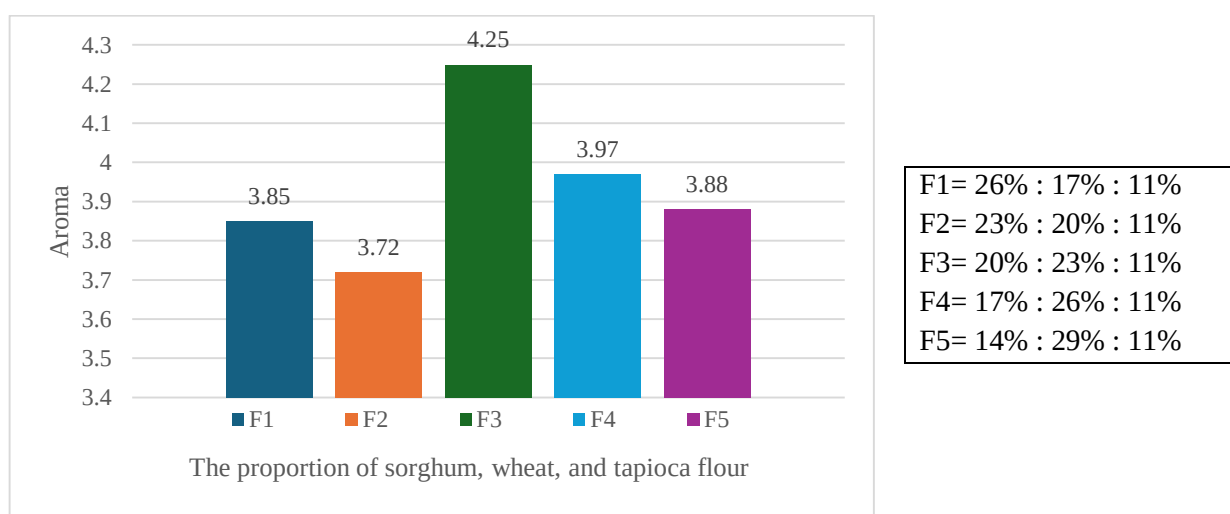


Figure 7. Sensory Evaluation: Aroma

The sensory analysis results for the aroma of cumin cookies are presented in Figure 10. The aroma test was conducted to assess the acceptability of the product's scent, derived from the blend of sorghum, wheat, and tapioca flour [22]. Aroma is a critical parameter in sensory evaluation as it influences the initial impression and the panelists' overall preference for a food product. A higher aroma score indicates a greater level of panelist preference for the resulting scent. The aroma testing results demonstrate that variations in the composition of sorghum, wheat, and tapioca flour influenced the panelists' preference levels [23]. Formulation F2 obtained the lowest aroma score (3.72), which is attributed to the high sorghum content that resulted in a more pronounced "musty" or "earthy" (*langu*) aroma characteristic of sorghum, making it less acceptable to the panelists. In contrast, formulation F3 achieved the highest score (4.25), indicating that the combination of 20%

sorghum flour, 23% wheat flour, and 11% tapioca flour produced the most preferred aroma. Meanwhile, the aroma score for formulation F4 decreased slightly to 3.97, although it rem

3.7 Sensory Evaluation: Color

Product color is an attribute that provides the first impression perceived by panelists before they recognize other sensory stimuli. Color is a vital quality attribute, as its visual appeal can significantly influence consumer acceptance of a product (Sianipar et al., 2008). Among the various properties of food products, color is the factor that creates the most immediate and easiest impression; however, it is difficult to describe and measure objectively, making subjective assessment a primary determining factor. Based on the Analysis of Variance (ANOVA), the results indicate that the treatments were significantly different, as the calculated chi-square value was greater than the table value $X^2_{\text{calc}} < X^2_{\text{table}}$, specifically $10.13 > 9.48$ with X^2_{table} at $\alpha = 0.05$, $df = 4$). The average panelist preference scores for the color of the cumin cookies are presented in the following figure.

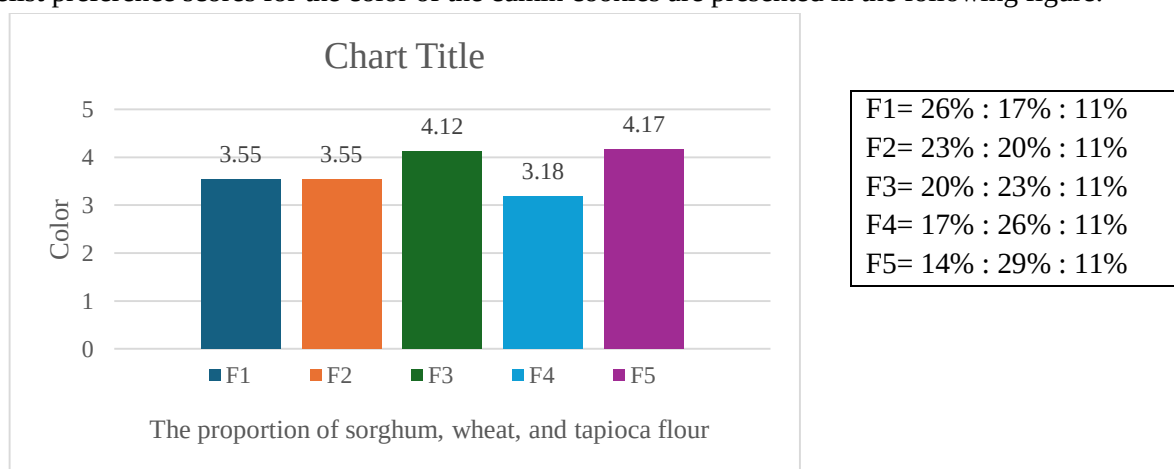


Figure 8. Sensory Evaluation: Color

The sensory analysis results for the color of the cumin cookies are presented in the figure above. The color test demonstrates that variations in the composition of sorghum, wheat, and tapioca flour influenced the panelists' preference levels regarding the product's visual appearance. Formulations F1 and F2 received the lowest scores (3.55) because the high sorghum content caused the products to appear darker, making them less visually appealing to the panelists [23]. As the proportions of wheat and tapioca flour increased in formulations F3 and F4, the product color became lighter and more preferred. This upward trend reached its peak in formulation F5 (4.17), which was rated as the most attractive in terms of color. Meanwhile, in formulation F3, the color score decreased slightly to 4.12, yet it remained within the category of good acceptance.

3.8 Determination of the Best Treatment

Based on the comprehensive evaluation of all parameters, the optimal formulation was achieved in treatment F3 (20% sorghum flour, 23% wheat flour, and 11% tapioca flour). The proximate characteristics of this formulation included a protein content of 8.06%, a moisture content of 5.79%, and ash content of 3.82%. Furthermore, the sensory preference evaluation (hedonic scores) for F3 yielded high results across all attributes, with scores of 4.57 for taste, 4.08 for texture, 4.25 for aroma, and 4.12 for color, all of which fall within the "liked" category.

Treatment	NH							Total NH
	Protein	Moist	Ash	Taste	Texture	Aroma	Color	
F1	0,00	0,18	0,16	0,03	0,00	0,00	0,03	0,41

F2	0,09	0,16	0,08	0,00	0,00	0,05	0,04	0,42
F3	0,13	0,15	0,00	0,10	0,08	0,10	0,14	0,70
F4	0,16	0,07	0,00	0,05	0,04	0,12	0,10	0,53
F5	0,20	0,00	0,00	0,03	0,08	0,08	0,00	0,39

3.9 Financial feasibility

Financial feasibility analysis was evaluated based on several criteria, including the Cost of Goods Manufactured (COGS/COGM), Break-Even Point (BEP), and the Revenue-Cost (R/C) Ratio. This analysis focused on a household-scale production of cumin cookies, encompassing capital, fixed costs, and variable costs [24].

The production capacity is set at 27,300 packages per year, with a net weight of 100 grams per unit. The total annual operational expenditure is IDR 268,901,556. The calculation of the Cost of Goods Manufactured includes all production costs incurred to process raw materials into finished products within a specific period. According to Susanto [25], the production cost serves as a tool to measure the efficiency of the production process for decision-making purposes; therefore, inaccuracies in this calculation can lead to significant financial losses. The HPP (COGM) for cumin cookies is IDR 9,850, with a selling price of IDR 16,000 based on a 62% markup of the total annual costs, which is considered feasible. The BEP represents the sales volume at which there is neither profit nor loss. The production BEP for these cookies is 6,038 units, indicating that the break-even point for cumin cookies made from sorghum, wheat, and tapioca flour is reached at 6,038 units per production cycle. The price BEP is recorded at IDR 96,609,610 per year. Furthermore, the Revenue-Cost (R/C) Ratio is 1.62. Since the R/C ratio is greater than 1 ($1.62 > 1$), the business is concluded to be financially viable and feasible for development.

4. Conclusion

The optimal formulation was achieved with a composition of 20% sorghum flour, 23% wheat flour, and 11% tapioca flour (F3). The chemical properties of this formulation included a protein content of 8.06%, moisture content of 5.79%, and ash content of 3.82%. In terms of sensory evaluation, panelists expressed a preference for the product, with hedonic scores of 4.57 for taste, 4.08 for texture, 4.25 for aroma, and 4.12 for color. The production of these cumin cookies is financially feasible for business development. The total annual production cost is IDR 268,901,556, with a 62% markup, resulting in a selling price of IDR 16,000 per pack. The Break-Even Point (BEP) in units is 6,038 packs, and the BEP in value is IDR 96,609,610 per year. Furthermore, the Revenue-Cost (R/C) Ratio is 1.62, which exceeds the threshold of 1 ($\$1.62 > \$1$), confirming that the business is profitable and economically viable. Continuous refinement and development of the raw material formulations are necessary to further enhance the quality of cumin cookies made from sorghum, wheat, and tapioca flour. It is expected that students and future researchers will conduct follow-up studies related to this topic to explore broader aspects of product optimization and alternative ingredients.

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Data and Software Availability Statements

The data supporting this study are derived from published literature included in Google Scholar and Elsevier. No new datasets or software were generated. Citation management was performed using **Mendeley**. Extracted data are available from the corresponding author upon reasonable request.

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