

THE INFLUENCE OF RED SORGHUM FLOUR COMPOSITION ON THE QUALITY OF KUE KIPAS

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ABSTRACT

Article history

Received

Revised

Accepted

Keywords

Red sorghum flour; tapioca flour; sorghum sticks; randomized block design; financial analysis.

Red sorghum (*Sorghum bicolor* L.) is a local cereal with significant potential as an alternative food source due to its high nutritional value, gluten-free properties, and adaptability to marginal lands and arid climates. Utilizing red sorghum in flour form can enhance added value and support local food diversification, such as in the production of *kue kipas*—a traditional snack with economic potential. This study aims to analyze the effect of red sorghum flour substitution on the chemical, physical, and organoleptic characteristics of *kue kipas*, determine the optimal formulation, and evaluate the financial feasibility of the product. The research was conducted from June to August 2025 at the Process Engineering Laboratory, Faculty of Agriculture, University of Tribhuwana Tunggal, Malang. Parameters observed included moisture, ash, and protein content, texture, and sensory properties (color, aroma, taste, and texture). Data were analyzed using ANOVA followed by the Least Significant Difference (LSD) test at a 5% significance level. The optimal treatment was determined using the effectiveness index method, while financial feasibility was evaluated through Cost of Production, BEP, and the R/C ratio. The results indicated that red sorghum flour substitution significantly affected the moisture, ash, and texture of the *kue kipas*. Increasing the proportion of sorghum flour tended to increase the ash content and textural hardness. The optimal formulation was achieved by treatment J3 (60% wheat: 30% sorghum: 10% cornstarch), which produced a balanced product quality and high panelist acceptance. Financial analysis confirms that red sorghum flour-based *kue kipas* is feasible for business.

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1. Introduction

Sorghum (*Sorghum bicolor* L.) is a cereal commodity with significant potential for development, particularly on marginal lands and in arid regions of Indonesia [1]. This plant exhibits excellent adaptability to diverse agroecological conditions and a high tolerance to drought stress.

Furthermore, sorghum is known for its relatively high productivity despite low cultivation input requirements [2]bi. Compared to other food crops, sorghum demonstrates superior resistance to pests and diseases. Its substantial nutritional content positions it as a potential alternative source for both food and feed. In Indonesia, farmers have long cultivated this crop, especially in Java, West Nusa Tenggara, and East Nusa Tenggara. In Java, sorghum is locally known as "*cantel*" and is commonly grown using intercropping systems with other food crops [3]

Despite its potential, sorghum production in Indonesia remains low and it is not widely available in the market [4]. In fact, approximately 853,000 hectares of marginal land are available, with the potential to produce 6–10 million tons of sorghum grain annually, along with 75–100 million tons of stalks and 40–60 million kiloliters of sap [5]. In reality, however, average national production only reaches approximately 400 to 6,000 tons per year. Productivity variations in production centers are influenced by diverse agroecological conditions and the application of cultivation technologies, particularly variety selection and fertilization [6]. One strategy to increase yields is the application of organic manure, which improves soil structure and optimizes plant growth and harvest outcomes [7].

One superior variety is red sorghum (*Sorghum bicolor* L.), which offers advantages in nutritional content, adaptability, and utilization as a functional food [8]. The anthocyanin pigments in the grain pericarp serve as natural antioxidants, capable of neutralizing free radicals and potentially reducing the risk of degenerative diseases [9]. Moreover, red sorghum is rich in dietary fiber, contains adequate protein, and is gluten-free, making it suitable as a healthy food alternative for individuals with gluten intolerance or celiac disease. From a cultivation perspective, red sorghum adapts well to arid marginal lands due to its deep root system and physiological tolerance to water deficiency [10]. This gives red sorghum immense potential to support food security, particularly in dryland areas [11]. Furthermore, *kue kipas* is a traditional Indonesian snack with a distinctive shape resembling a hand fan [12]. Characterized by its crunchy texture, *kue kipas* is made from a blend of wheat, sorghum, and cornstarch flours, which are baked using specialized techniques to create fan-like folds. Beyond being a snack, *kue kipas* carries socio-cultural significance as it is often served during traditional ceremonies such as *hajatan*, *syukuran*, and *kenduri*. According to Mushollaeni [13], traditional foods function not only as consumption items but also as reflections of local identity and social values. Thus, *kue kipas* represents a piece of intangible cultural heritage with historical and cultural value.

2. Method

2.1 Material

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 kipas*.

2.2 Research Design

This study employed a Randomized Block Design (RBD) based on the proportions of red sorghum flour, wheat flour, and tapioca flour, consisting of five formulations. Each treatment was replicated three times, resulting in a total of 15 experimental units. The research was conducted in two stages: the preparation stage and the production of sorghum sticks.

2.3 Red Sorghum Flour Preparation

The processing of red sorghum flour began with the selection of high-quality sorghum grains, characterized by intact kernels, absence of physical damage, and freedom from impurities. The selected grains were washed with clean water to remove surface contaminants. Subsequently, the grains were soaked in clean water for 6 hours to soften the kernel structure and facilitate further cleaning. After soaking, the grains were drained to reduce moisture and ensure no residual impurities remained. The drained red sorghum was then dried using a cabinet dryer at 40°C for 8 hours. This drying process aimed to reduce the moisture content to facilitate the milling process and enhance flour quality. The dried grains were milled using an FFC-23 type milling machine. Finally, the resulting flour was sifted through an 80-mesh sieve to achieve uniform particle size, producing red sorghum flour ready for use as a raw material.

2.4 Production of Kue Kipas

The initial stage involved blending all dry ingredients, including wheat flour, sorghum flour, cornstarch, and vanilla, until a homogenous mixture was achieved. Simultaneously, eggs and granulated sugar were whipped using a high-speed mixer for approximately 10 minutes until the batter expanded and turned pale yellow. This aeration process is essential to ensure a light and crunchy texture in the final product. Once the egg and sugar mixture reached the desired volume, the mixer speed was reduced, and the dry ingredient blend was added gradually. The batter was continuously stirred until it became uniform and homogenous. The final stage consisted of molding and baking. Approximately one tablespoon of batter was poured into a preheated *kue kipas* mold. During the baking process, the batter was flipped to ensure even doneness. Once the batter began to dry and set, the cake was removed from the mold using a tool, such as chopsticks, and set aside. This process was repeated until all the batter was processed.

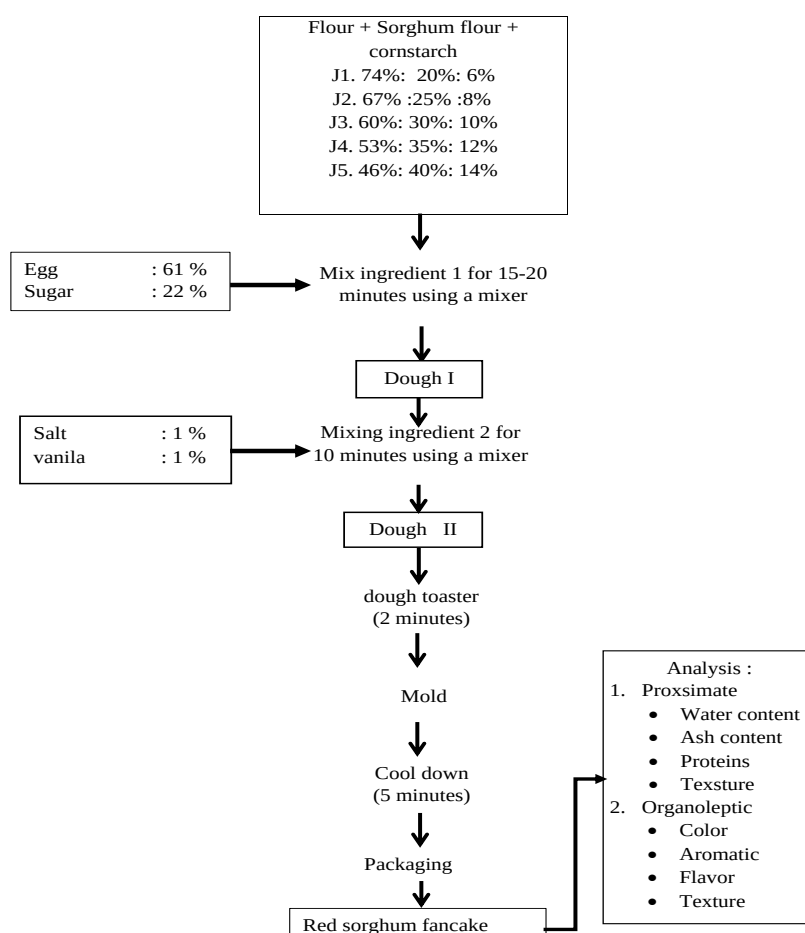
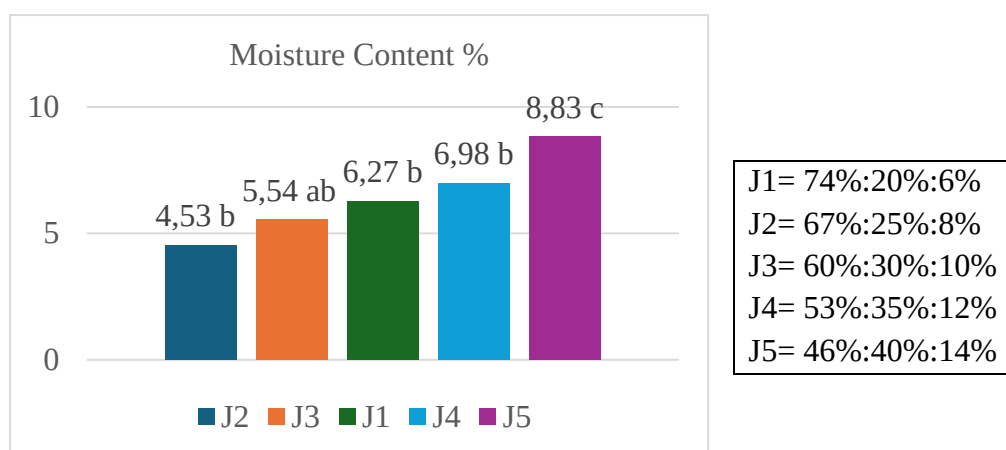


Figure 1. Production of Kue Kipas

3. Results and Discussion

3.1 Moisture Content

Kue kipas generally contains a specific amount of water, including those formulated with red sorghum flour. Moisture content plays a critical role in determining the quality of the final product. The Analysis of Variance (ANOVA) results indicated a calculated F-value of 6.71, which is greater than the F-table value at the 5% significance level (3.84) but remains lower than the F-table value at the 1% level (7.01). Thus, the treatments had a significant effect on the moisture content, necessitating further analysis using the Least Significant Difference (LSD) test. The calculation yielded an LSD value of 1.18. The post-hoc LSD test results demonstrated that the average moisture content for each treatment was significantly different. These differences are illustrated in Figure 2.

**Figure 2. Moisture Content**

The analysis of the moisture content in red sorghum flour-based *kue kipas* is presented in the figure above. The diagram illustrates variations in the moisture content of the products formulated with different compositions of red sorghum, wheat, and cornstarch. Each treatment (J1–J5) resulted in distinct moisture levels, which were influenced by the varying proportions of the dough's constituent ingredients. Based on the diagram, it is evident that the moisture content of the red sorghum *kue kipas* fluctuated across the different flour formulations. Treatment J5 exhibited the highest moisture content at 8.83%, presumably due to the high proportion of cornstarch and sorghum flour, which enhanced the water-binding capacity of the materials. Conversely, treatment J2 recorded the lowest moisture content at 4.53%, which is likely attributed to the dominance of sorghum flour that possesses lower water absorption capacity compared to the other constituent ingredients [14].

3.2 Protein Content

Protein content is a vital parameter in evaluating the quality of food products, particularly flour-based products such as red sorghum *kue kipas* and similar snacks. Proteins serve as essential structural nutrients and influence the physical characteristics of

the product, especially its texture and final quality [15]. Based on the Analysis of Variance (ANOVA), the calculated F-value was 39.53, which is significantly higher than the F-table value at the 1% level (7.01) and the 5% level (8.65). These results indicate that the treatments had a highly significant effect on the protein content of the *kue kipas*, meaning that variations in the formulations led to significant differences in protein levels. To determine the most influential treatment, the analysis was followed by the Least Significant Difference (LSD) post-hoc test at a 5% significance level. The calculation yielded an LSD value of 0.21. The results of the LSD test demonstrated that the average protein content for each treatment was highly significant. The mean protein values across treatments are presented in the bar chart in Figure 3.

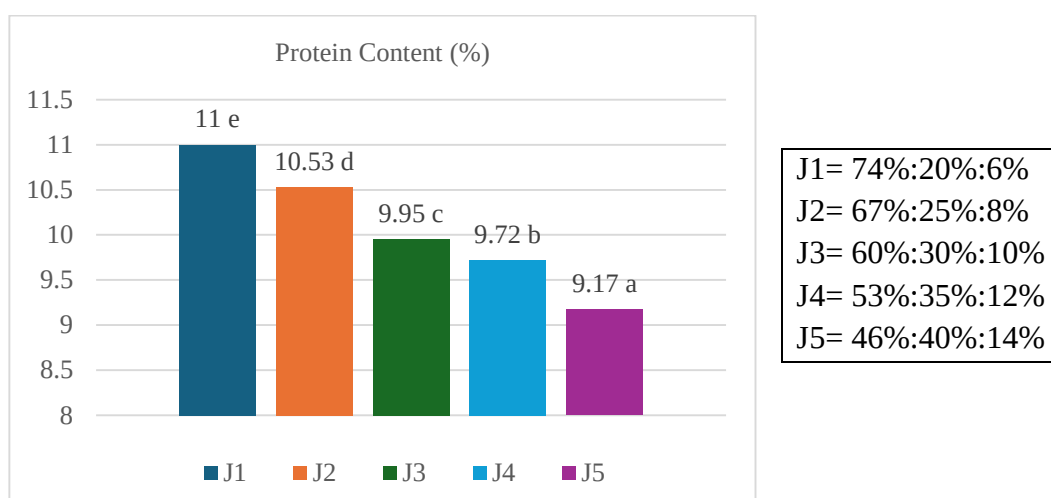


Figure 3. Protein Content

The analysis results for the protein content of red sorghum *kue kipas* are presented in the figure above. The testing was conducted on five treatments with varying formulations of red sorghum, wheat, and cornstarch. The results indicate that the protein content of the products ranged from 9.17% to 11.00%, demonstrating that differences in the composition of the dough's constituent ingredients influenced the nutritional value of the resulting *kue kipas* [12]. Based on the statistical analysis, the highest protein content was obtained from the treatment consisting of 74% wheat flour, 20% sorghum flour, and 6% cornstarch. Conversely, the lowest protein content was found in the formulation containing 53% wheat flour, 35% sorghum flour, and 12% cornstarch. In general, these findings suggest that a higher proportion of wheat flour tends to increase the protein content of the product, whereas an increased proportion of cornstarch in the formulation leads to a decrease in protein content [16].

3.3 Ash Content

Ash content is a quality parameter used to evaluate the standards of food products, including red sorghum-based *kue kipas*. This parameter represents the total mineral content remaining after the organic components of the material are combusted at high temperatures [17]. A higher ash value indicates a greater mineral content within the product. However,

excessively high ash content may indicate the presence of contaminants, such as dust, dirt, or other unintended residues [18]. Based on the Analysis of Variance (ANOVA), the calculated F-value was 3.84, which was compared against the F-table value of 7.01 at the 1% significance level. The analysis showed that the treatment had a significant effect on the ash content; therefore, the analysis was followed by a Least Significant Difference (LSD) post-hoc test. The calculation yielded an LSD value of 0.19. The LSD test results indicated that the mean ash content for each treatment was significantly different.

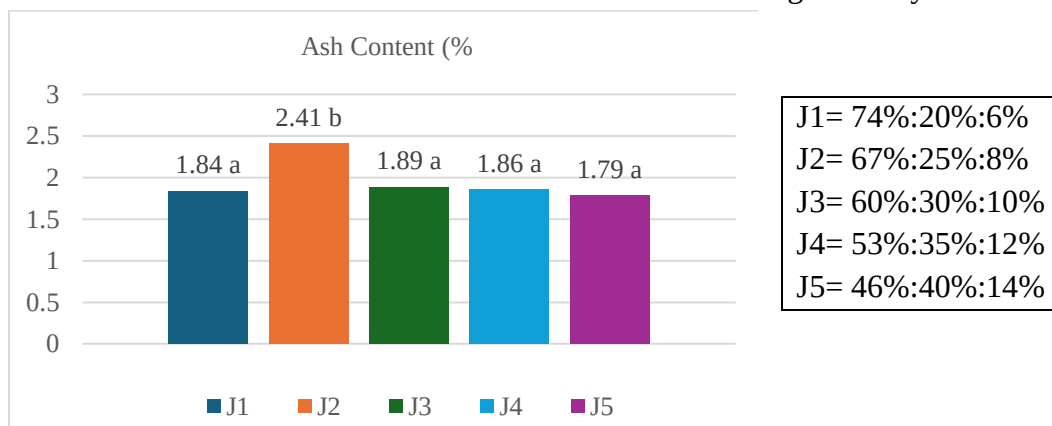


Figure 4. Ash Content

The analysis results for the ash content of red sorghum *kue kipas* are presented in the figure above. Based on the diagram, it is evident that the ash content varied across the different formulation treatments. Treatment J2, consisting of 67% wheat flour, 25% sorghum flour, and 8% cornstarch, yielded the highest ash content at 2.41%, indicating that this formulation contains a higher mineral concentration [19]. Conversely, treatment J5, with a composition of 46% wheat flour, 40% sorghum flour, and 14% cornstarch, exhibited the lowest ash content at 1.79%, signifying a relatively lower mineral content.

3.4 Sensory Evaluation: Texture

Based on the Analysis of Variance (ANOVA), the calculated F-value was \$3.84\$, which was compared against the F-table value of 7.01 at the 1% significance level. The results indicated that the treatment had a significant effect on the texture of the product; therefore, the analysis was followed by a Least Significant Difference (LSD) post-hoc test [20]. The calculation yielded an LSD value of \$0.30\$. The LSD test results indicated that the mean texture values for each treatment were significantly different.

J1= 74%:20%:6%
J2= 67%:25%:8%
J3= 60%:30%:10%
J4= 53%:35%:12%
J5= 46%:40%:14%

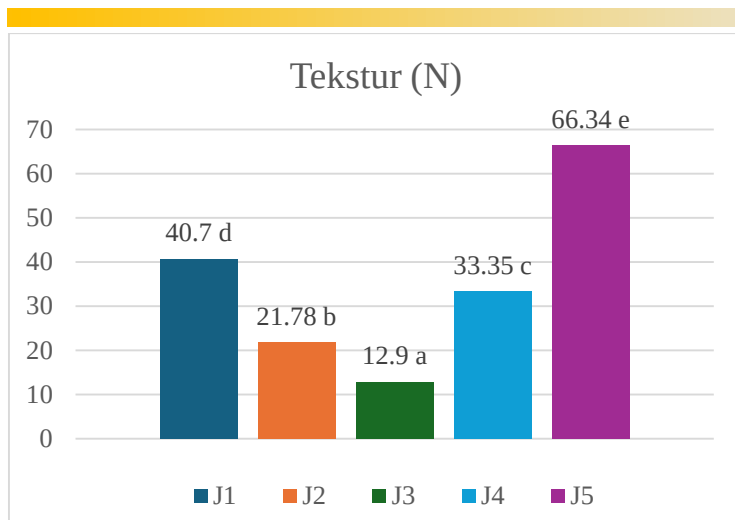


Figure 5. Sensory Evaluation: Texture

The texture analysis results for the *kue kipas* formulated with red sorghum flour are presented in the figure above. The data illustrate variations in texture across the different flour formulation treatments. Treatment J5, consisting of 46% wheat flour, 40% sorghum flour, and 14% cornstarch, yielded the highest texture value at 66.34%, indicating a higher degree of hardness compared to the other treatments. Meanwhile, treatment J3, with a formulation of 60% wheat flour, 30% sorghum flour, and 10% cornstarch, obtained the lowest texture value at 12.9%, signifying that the product in this treatment possessed a lower degree of hardness [21].

3.5 Sensory Evaluation: Taste

Taste is one of the primary aspects considered in the development of food products. It is a sensory response elicited by food stimuli perceived by the taste buds. The variations in flavor characteristics of food products are influenced by the type and proportion of ingredients used in the formulation. A product is deemed acceptable to consumers if it possesses a flavor profile that aligns with expected preferences [22]. Therefore, taste testing is a critical parameter in sensory evaluation to assess the level of consumer acceptance. In red sorghum flour-based *kue kipas*, the taste evaluation is influenced by the raw material composition, specifically the ratios of sorghum flour, wheat flour, and cornstarch used in each treatment, as shown in the following figure.

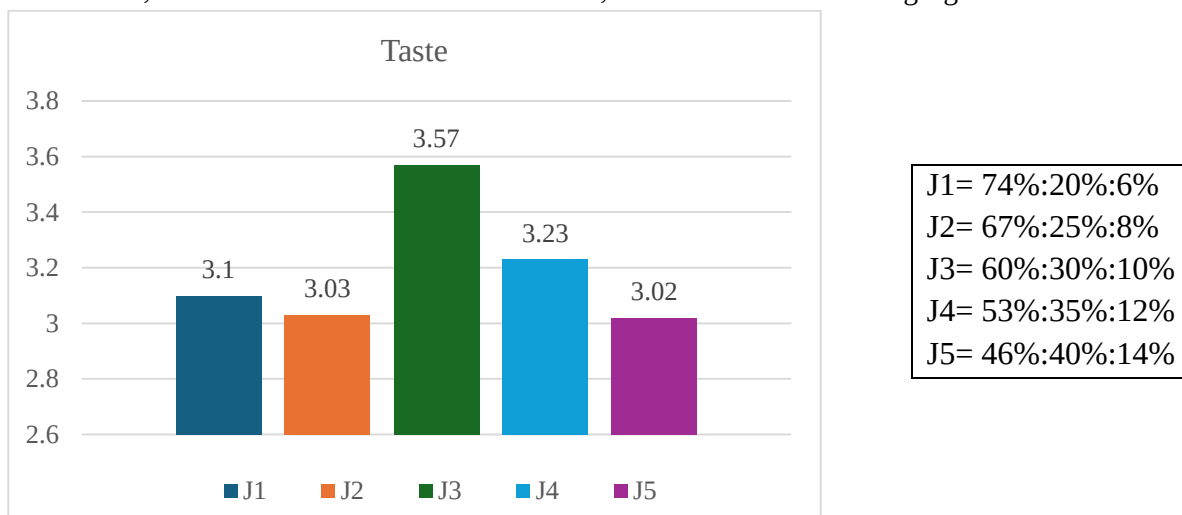
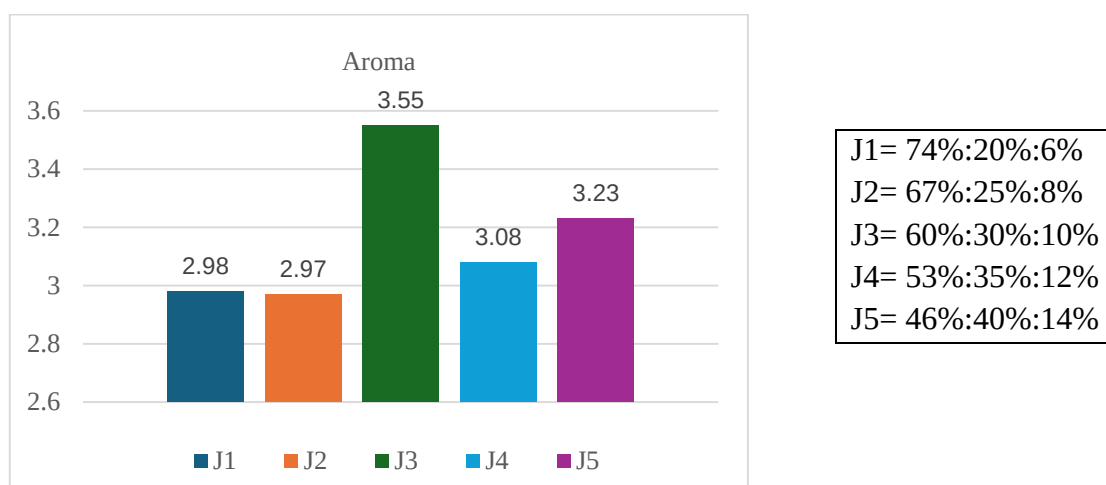


Figure 6. Sensory Evaluation: Taste

Based on the figure, the hedonic test results indicate that the highest average score for the taste attribute was obtained from the formulation consisting of 60% wheat flour, 30% sorghum flour, and 10% cornstarch. This formulation achieved a score of 3.57, which falls into the "Highly Liked" category. Conversely, the lowest average score was recorded in the treatment with a composition of 46% wheat flour, 40% sorghum flour, and 14% cornstarch, with a score of 3.02, placing it in the "Neutral" category. Taste remains one of the primary factors influencing the level of panelist acceptance toward a food product [23].

3.5 Sensory Evaluation: Aroma

Aroma is a key parameter in sensory or organoleptic testing, evaluated through the olfactory sense. This parameter is inherently subjective, as the perception of aroma can vary significantly among individuals. A food product is generally well-received if it possesses a distinctive aroma characteristic that aligns with consumer expectations. Based on the analysis of variance (ANOVA), the substitution of wheat flour with red sorghum flour exerted a significant effect on the aroma of the resulting *kue kipas*. These results are presented in the figure below, which illustrates the differences in aroma acceptance levels across the various treatments.

**Figure 7. Sensory Evaluation: Aroma**

Based on the figure, the highest average score for panelist preference regarding aroma was obtained from the formulation containing 60% wheat flour, 30% red sorghum flour, and 10% cornstarch, with a score of 3.55, which falls into the "Highly Liked" category. Conversely, the lowest average score was recorded in treatment J2 (67% wheat flour, 25% red sorghum flour, and 8% cornstarch) with a score of 2.97, placing it in the "Neutral" category. Nonetheless, the aroma of the red sorghum-based *kue kipas* across all treatments generally exhibited relatively similar aromatic characteristics [11].

3.6 Sensory Evaluation: Color

The results of the hedonic test for color preference indicated that the highest average score was obtained in treatment J3 (60% wheat flour, 30% red sorghum flour, and 10% cornstarch) with a score of 3.7, falling into the "Liked" category. Conversely, the lowest average score was recorded in treatment J5 (46% wheat flour, 40% red sorghum flour, and 14% cornstarch) with a score of 2.23, which is categorized as "Disliked". Based on the analysis of variance (ANOVA), the formulation involving the substitution of wheat flour with red sorghum flour exerted a significantly different effect on the color of the resulting *kue kipas* [24]. The variations in color preference levels among treatments are illustrated in the following figure, which presents the mean results of the organoleptic color evaluation for the red sorghum *kue kipas*.

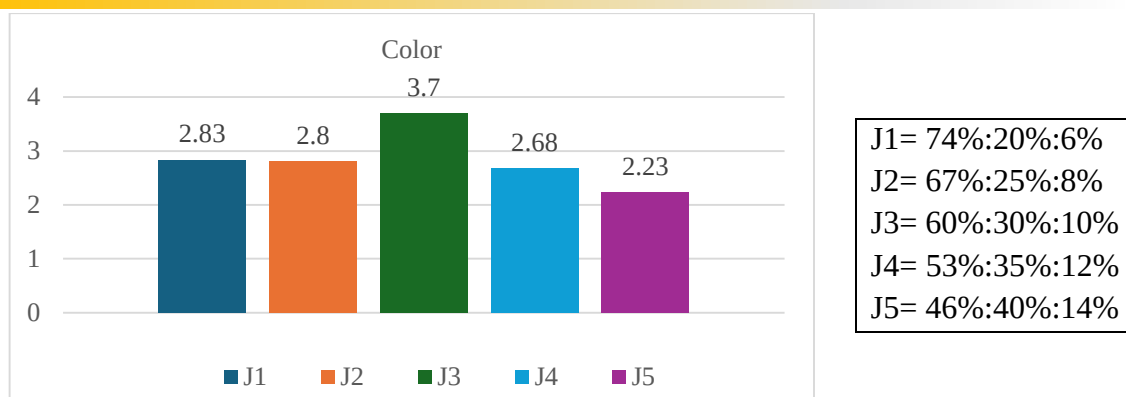


Figure 8. Sensory Evaluation: Color

Based on the figure, it is observed that the panelists' preference for the color of the red sorghum *kue kipas* reached its highest mean score in treatment J4 at 3.7, which falls into the "Highly Liked" category [11]. Meanwhile, the lowest mean score was obtained in treatment J5 (46% wheat flour, 40% red sorghum flour, and 14% cornstarch) at 2.23, which is categorized as "Neutral." These results indicate a distinct variation in panelist response toward the color of the product across each treatment [16-20].

3.7 Optimal Treatment

The results of the effectiveness index calculation indicate that the formulation consisting of 60% wheat flour, 30% red sorghum flour, and 10% cornstarch represents the optimum treatment, achieving a total Net Value (NV) of 0.83. The contribution of each parameter to this value is derived from a protein content of 9.95%, texture of 12.90 N, moisture content of 5.54%, and ash content of 1.89%. Furthermore, the sensory evaluation parameters (hedonic test) contributed scores of 3.57 for taste, 3.52 for texture, 3.55 for aroma, and 3.70 for color.

Treatment	NH								Total NH
	Protein	Texture	Moist	Ash	Taste	Texture	Aroma	Color	
J1	0,19	0,08	0,09	0,13	0,02	0,02	0,00	0,02	0,56
J2	0,14	0,14	0,15	0,00	0,00	0,02	0,00	0,02	0,49
J3	0,08	0,17	0,12	0,11	0,12	0,10	0,08	0,06	0,83
J4	0,06	0,11	0,07	0,12	0,05	0,01	0,02	0,02	0,44
J5	0,00	0,00	0,00	0,13	0,00	0,00	0,04	0,00	0,17

3.8 Financial feasibility

The business feasibility analysis in this study was based on the optimum treatment, specifically formulation J3, which consists of 60% wheat flour, 30% sorghum flour, and 10% cornstarch. On a laboratory scale, formulation J3 utilized 200 grams of primary raw materials, comprising 120 grams of wheat flour, 60 grams of sorghum flour, and 20 grams of cornstarch. Additional ingredients included 61 grams of egg (equivalent to one egg), 22 grams of granulated sugar, 1 gram of salt, and 1 gram of vanilla, bringing the total raw material weight to 285 grams. This production process yielded approximately 200 grams of

final product (*kue kipas*), indicating a weight loss (shrinkage) of $\pm 28\%$. The total output was equivalent to 25 units, with each unit weighing approximately 8.3 grams.

For the feasibility analysis, a production simulation was conducted using 10,000 grams of primary raw materials (6,000 grams of wheat flour, 3,000 grams of sorghum flour, and 1,000 grams of cornstarch). The requirement for supporting ingredients was calculated by scaling up the initial formulation by a factor of 50, resulting in 50 eggs, 1.10 kg of granulated sugar, 50 grams of salt, and 50 grams of vanilla. Consequently, the total weight of all ingredients used in a single production cycle reached 14,250 grams.

Assuming a weight shrinkage of 28–29% (approximately 4,250 grams) during the production process, the estimated total finished product is 10,000 grams of *kue kipas*. The product is packaged in 100-gram units, resulting in 100 packages per production cycle. If production is carried out daily for 25 working days per month, the monthly production capacity is estimated at 2,500 packages, reaching an annual output of approximately 30,000 packages.

4. Conclusion

Based on the results of this study, it can be concluded that the formulation consisting of 60% wheat flour, 30% red sorghum flour, and 10% cornstarch is the best treatment compared to the other formulations. This treatment produced the most optimal chemical and physical characteristics, with a moisture content of 5.54%, protein content of 9.95%, ash content of 1.89%, and a texture value of 12.90 N. Furthermore, sensory evaluation by panelists indicated a "Liked" preference, with scores of 3.57 for taste, 3.52 for texture, 3.55 for aroma, and 3.70 for color. The production of red sorghum-based *kue kipas* using this optimal formulation demonstrates financial feasibility, with a Cost of Goods Sold (COGS) of Rp 7,925. This business activity has the potential to generate an annual profit of Rp 122,240,722. An R/C ratio of 1.51 confirms that the red sorghum *kue kipas* enterprise is feasible and profitable to operate. Further research is required to evaluate the shelf life of sorghum flour-based *kue kipas* to determine the product's quality stability during storage. Additionally, a more detailed study on production cost analysis is necessary to obtain more accurate calculations for the Cost of Goods Sold (COGS), Break-Even Point (BEP) in units and price, and the R/C ratio for industrial-scale operations.

Acknowledgment

The author thanks to the Agroindustrial Technology Program, University of Tribhuwana Tunggaladewi, for academic support and encouragement during the development of this manuscript. Sincere appreciation is also extended to peers and reviewers for valuable comments that strengthened the final version of the paper.

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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