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The Effect of Substituting Uli Banana Flour on the Baking Loss and Sensory Quality of Shortbread Cookies

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Abstract
This study aims to analyze the effect of substituting uli banana flour on the physical and sensory quality of shortbread cookies. The study was conducted at the Pastry and Bakery Laboratory of the Culinary Arts Education Program at Jakarta State University. The experimental method was used in this study. Based on the results of the statistical hypothesis test for sensory quality using the Kruskal-Wallis test, it was found that substituting 20%, 30%, and 40% uli banana flour in shortbread cookies had no effect on the sensory quality aspects of color, butter aroma, banana aroma, banana flavor, sweetness, and texture (crispness). The results of the statistical hypothesis test for physical quality using the ANOVA test showed that there was no significant effect on baking loss. Substituting 20%, 30%, and 40% uli banana flour was also insufficient to produce a significant effect on the sensory quality of the shortbread cookies, which includes color, butter aroma, banana aroma, banana flavor, sweetness, and texture (crispness). Based on the descriptive results, it can be seen that the 30% treatment produced the best balance of product characteristics, as assessed by butter aroma, sweetness, and texture. The conclusion of this study is to recommend shortbread cookies made with 30% uli banana flour substitution for further development, as they are able to maintain the distinctive characteristics of shortbread cookies while increasing the utilization of local flour as a substitute for wheat flour.

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1. INTRODUCTION

The food industry is a sector that continues to grow as public awareness increases regarding the importance of consuming foods that are not only delicious but also nutritious and made from natural ingredients. One effort being made to support this trend is the use of local food ingredients as alternatives to conventional raw materials. Wheat flour, which has long been the main ingredient in the production of baked goods such as cookies, remains heavily dependent on imports. This underscores the need for innovation in identifying alternative carbohydrate sources derived from local ingredients.

Bananas are a horticultural product that rapidly deteriorates in quality due to the fruit's physiological processes. As an agricultural commodity, bananas are highly perishable, and their shelf life is very limited; therefore, the use of appropriate technology is necessary to process bananas into food products that enhance their value and shelf life (Afriani et al., 2024). According to the Central Statistics Agency, banana production in Indonesia in 2024 totaled 9.26 million metric tons. Based on data from the Central Statistics Agency of Indonesia for 2024, there are three provinces that are the largest banana producers in Indonesia: first, East Java Province with 2.76 million metric tons; second, Lampung

Province with 1.58 million metric tons; and third, West Java Province with 1.24 million metric tons.

This relatively high banana production is not commensurate with the level of public consumption, resulting in a large number of bananas that are not utilized optimally (Nuraeni et al., 2023). Bananas have a relatively short shelf life and spoil easily. Therefore, efforts are needed to prevent bananas from being wasted by processing them into products that are longer-lasting and offer greater added value (Anggraeni, 2019).

One local resource that has not yet been fully utilized is the uli banana (Musa paradisiaca L. ABB). Uli bananas are widely available in the market, and their relatively low price makes them a promising candidate for processing into flour as a substitute for wheat flour. Banana flour is made from unripe bananas that are sufficiently mature. Young, mature, or ripe bananas can all be processed into flour, but bananas that are young and approaching maturity are processed more quickly because their water and sugar content is lower, allowing for a faster drying process (Yasin, 2018). With proper processing, uli bananas can be turned into flour and used as a substitute for wheat flour in the production of baked goods, such as cookies.

Cookies in Indonesia are known as "kue kering." There are many different types of cookies, one of which is shortbread cookies. These cookies originated in Scotland, where they are typically enjoyed with a cup of tea or coffee. Shortbread cookies have a crisp and crumbly texture. They have a distinctive buttery aroma because they contain a significant amount of butter in the baking process (Svetanoff, 2021).

Shortbread cookies are a type of dry cookie originating from Scotland that evolved from a type of biscuit bread from the Middle Ages, which was later adapted into cookies; Furthermore, these cookies are also considered the ancestors of all types of cookies that use butter as their main ingredient; therefore, it can be concluded that shortbread cookies have existed for hundreds of years (Svetanoff, 2021). Shortbread cookies are made from a dough prepared by mixing flour, fat, and sugar. Additional ingredients that can be used include eggs or egg yolks, cream, flavorings, potato starch, and chemical leavening agents. The highest-quality shortbread cookies are produced by maintaining a weight ratio of 3:2:1 between flour, fat, and sugar (Sławińska et al., 2024).

Several studies have focused on banana flour, either as an additive or a substitute in processed products, as described below. A study evaluating the physicochemical and organoleptic properties of cookies made with jackfruit banana flour substitution found that cookies containing 25%, 50%, and 75% raw banana flour had preference scores equivalent to those of standard cookies. Chemical analysis results indicated that cookies with a 75% substitution of raw jackfruit banana flour were the best formulation (Anggraeni, 2019).

The next study evaluated the expansion capacity, ash content, and sensory properties of cookies made with modified banana flour as a substitute. This study aimed to determine and analyze the effect of modified banana flour substitution on expansion capacity, ash content, and sensory properties, including color, aroma, taste, and texture. The results of this study indicate that the substitution of modified banana flour—even at the highest percentage of 100%—still allows for the production of high-quality cookies (Kalsum et al., 2025).

A study analyzing the organoleptic characteristics of cookies made with jackfruit banana flour substitution. This study was conducted using a Completely Randomized Design (CRD) with 4 treatments and 3 replicates. The treatment variations were as follows: P1: 25% banana flour and 75% wheat flour; P2: 50% banana flour and 50% wheat flour; P3: 75% banana flour and 25% wheat flour; P4: 100% banana flour without wheat flour. The results of the organoleptic test—which evaluated color, aroma, taste, and texture—

showed that the best results were obtained from cookies made with a 25% substitution of banana flour and 75% wheat flour.

The use of uli banana flour as a substitute for wheat flour is expected to affect the physical characteristics of shortbread—such as color, texture, and volume—as well as its sensory qualities, such as taste and aroma. Therefore, it is important to conduct research to determine the extent to which substituting uli banana flour affects the physical and sensory qualities of shortbread cookies. This study is expected to provide a healthier, locally sourced alternative formulation for bakery products, as well as support the development of functional foods and reduce dependence on imported wheat flour.

2. RESEARCH METHODS

2.1 Research methods

The research method used in this study was an experimental method to analyze the effect of banana flour substitution on shortbread cookies. The study population consisted of shortbread cookies made with uli banana flour at varying substitution levels. The sample consisted of shortbread cookies made with uli banana flour at three different levels of substitution: 20%, 30%, and 40%. The sampling technique used was random sampling, in which each sample was assigned a unique three-digit random code known only to the researcher to ensure an unbiased evaluation during sensory assessment.

2.2 Data Collection and Analysis Techniques

This study used an experimental method aimed at developing the optimal shortbread cookie formula using uli banana flour as a substitute. In this study, experiments were conducted using different percentage formulations. After determining the optimal shortbread cookie formulation, a validation test was conducted to assess the product's quality and suitability by a panel of experts consisting of five faculty members from the Culinary Arts Education Program, Faculty of Engineering, Jakarta State University. Following the completion of the expert panel's validation test, physical and sensory quality tests were performed.

The sensory test was conducted by 45 moderately trained panelists. These panelists were students in the Culinary Arts Education Program at Jakarta State University who had taken the Organoleptic Assessment course. Meanwhile, the physical characteristic test was conducted solely by the author by observing the physical properties of the shortbread cookies made with banana uli flour substitution, specifically regarding baking loss.

2.3 Making Uli Banana Flour

The production of banana flour begins with selecting bananas that meet the criteria for making banana flour. The bananas used are those that are mature but not yet ripe, or have not yet undergone the ripening process. The next step is to steam the bananas for 5 minutes to make it easier to peel them. After peeling the bananas, soak the banana flesh in clean water mixed with sodium metabisulfite at a 1:1 ratio—that is, 1 liter of water to 1 gram of sodium metabisulfite. This soaking prevents the bananas from browning, ensuring the resulting flour is clean and white in color. Next, slice the bananas using a mandoline and soak them again in the same solution used in the previous step for 20 minutes. After soaking, drain the bananas and arrange them on a dehydrator tray to dry at 70°C for 5 hours. Once the bananas are dry, grind them using a grinder. When the bananas are finely ground into a powder, sift the mixture through a 100-mesh sieve to produce a fine banana flour.

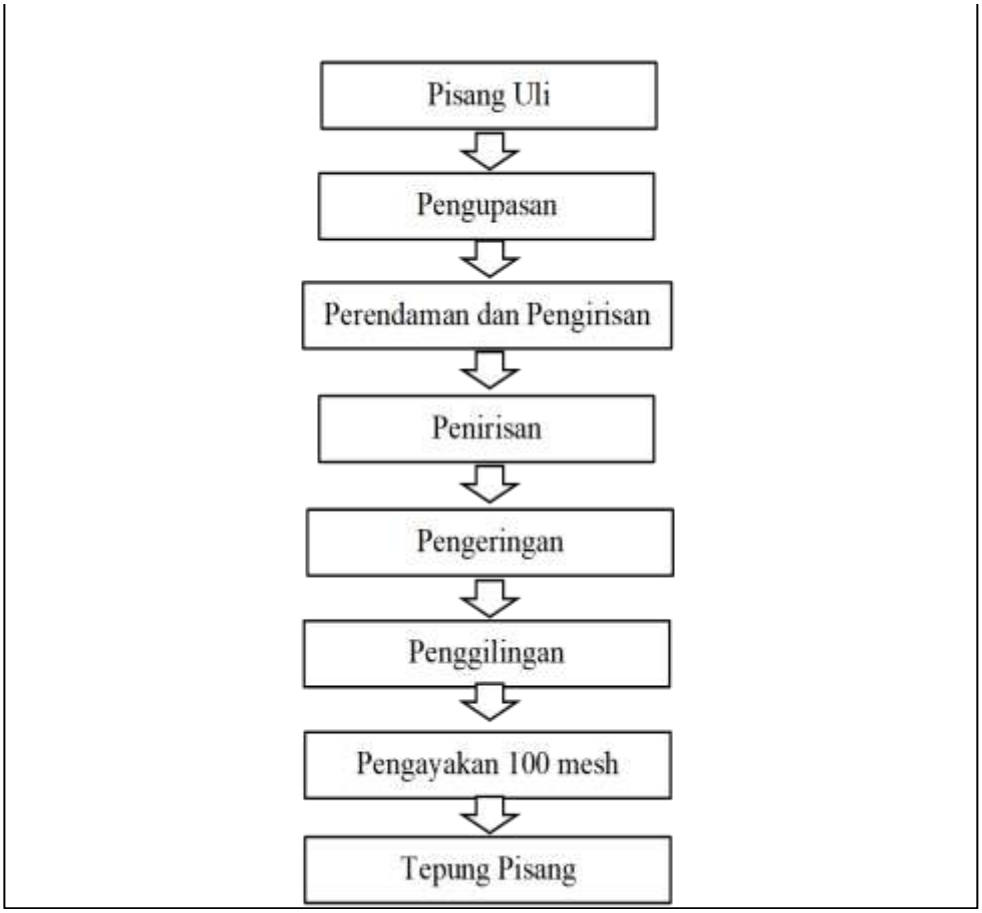


Figure 1. Process of Making Uli Banana Flour

2.4 Making Shortbread Cookies with the Addition of Uli Banana Flor

Table 1: Recipe for Shortbread Cookies Using Uli Banana Flour as a Substitute

Bahan	**20 %**		**30%**		**40%**	
	Gram	**%**	**Gram**	**%**	**Gram**	**%**
Tepung terigu	120	80	105	70	90	60
Tepung pisang uli	30	20	45	30	60	40
Mentega	100	66,6	100	66,6	100	66,6
Gula Halus	50	33,3	50	33,3	50	33,3
Garam	1	0,6	1	0,6	1	0,6

The shortbread cookie making process began with preparing the equipment and ingredients, including medium-protein wheat flour, uli banana flour, butter, sugar, and salt. The ingredients were weighed according to the proportions stated in the formula. This process begins by combining all the dry ingredients—such as flour, sugar, and salt—in a single bowl. Next, add the cold butter and gently rub the flour and butter together until the dough takes on a sandy texture. Then, press the sandy mixture together until it comes together and forms a ball of dough. After mixing, roll out the dough with a rolling pin until it is 0.5 cm thick. Then cut the dough into rectangles measuring 5 cm long by 3 cm wide. Next, transfer the dough to a baking sheet, and prick it several times with a toothpick or fork to allow air to circulate beneath the dough during baking. The shortbread cookies are baked in an oven at 140˚C for 20 minutes.

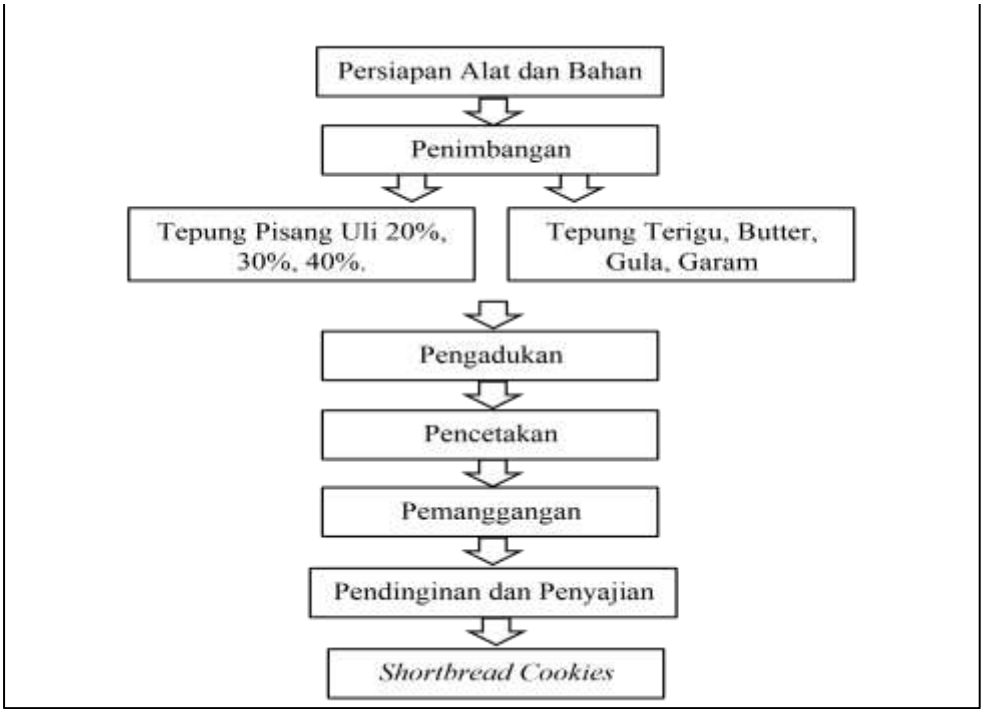


Figure 2. Process of Making Shortbread Cookies with the Addition of Uli Banana Flor

3. RESULTS AND DISCUSSION

3.1. Sensory Quality

1. Color

Color is a sensory parameter that influences consumer acceptance of food products, as color serves as the first visual indicator before consumers assess taste, aroma, and texture (Kurniawan et al., 2020). The results of the sensory quality test showed that the highest average color score was obtained in the 20% substitution treatment, with a score of 4.5, which falls into the cream to light brown category. As the percentage of uli banana flour substitution increases, the color of the cookies tends to become browner, although the Kruskal–Wallis test revealed no significant difference. The brownish color in shortbread cookies is also caused by the Maillard reaction. The Maillard reaction is a reaction between reducing sugars and amino acids in the presence of heat.

Based on the results of the Kruskal–Wallis test, the addition of uli banana flour did not have a significant effect on the crust color attribute. This was indicated by the calculated value of x^2_{count} = 3,38 and which was lower than the critical table value of x^2_{table} = 5,99.

Table 2 Results of the Color Aspect Hypothesis

Testing Criteria	x count	x tabel
Crust color	3,38	5,99

2. Aroma

The average scores for the butter aroma ranged from 4.3 to 4.5, while those for the banana aroma ranged from 3.07 to 3.40. The results of the Kruskal–Wallis test showed that there were no significant differences between treatments for these two parameters. The dominance of the butter aroma indicates that the use of butter in

the formulation is still able to mask the characteristic aroma of uli banana flour. Meanwhile, the banana aroma remained detectable by the panelists, but its intensity did not increase significantly even though the substitution percentage was raised to 40%. This was due to the presence of degraded starch during the drying process of the cookie dough substituted with banana flour (Hasyanah, 2022).

Based on the results of the Kruskal–Wallis test, the addition of uli banana flour did not have a significant effect on the butter and banana aroma attribute. This was indicated by the calculated value of x^2_{count} was lower than the critical table value of x^2_{table}.

Table 3 Results of the Butter aroma Aspect Hypothesis

Testing Criteria	x count	x tabel
Butter cassava aroma	0,26	5,99

Table 4 Results of the Banana aroma Aspect Hypothesis

Testing Criteria	x count	x tabel
Butter cassava aroma	0,66	5,99

3. Taste

The results of the taste analysis showed that the banana flavor received an average score of 3.7–3.9, while the sweetness received a score of 4.1–4.4. The Kruskal–Wallis test indicated that there were no significant differences between treatments for these two attributes. This indicates that adding up to 40% uli banana flour still produces a flavor acceptable to the panelists without significantly altering the flavor characteristics of the shortbread cookies. The sweet flavor remains dominated by the use of sugar and butter, so the banana flavor profile is not particularly prominent. The flavor profile of the cookies is influenced by various factors, including the composition of raw materials, chemical interactions, and processing methods (Uliyanti et al., 2024). Therefore, increasing the amount of banana flour does not necessarily result in an increase in the intensity of the banana flavor if other components remain more dominant.

Based on the results of the Kruskal–Wallis test, the addition of uli banana flour did not have a significant effect on the banana and sweetness flavor attribute. This was indicated by the calculated value of x^2_{count} was lower than the critical table value of x^2_{table}.

Table 5 Results of the Banana Flavor Aspect Hypothesis

Testing Criteria	x count	x tabel
Butter Cassava Puree Flavor	0,12	5,99

Table 6 Results of the Sweetness Aspect Hypothesis

Testing Criteria	x count	x tabel
Sweetness	0,17	5,99

4. Texture

The texture of cookies is influenced by the presence of fat and the amylose content. The fat in cookies breaks down their structure and coats the starch and gluten, resulting in crispy cookies (Oktaviana et al., 2017). The results of the study showed that the average texture score ranged from 4.6 to 4.9, falling into the "very crispy" category. The 30% substitution treatment achieved the highest average score of 4.9. However, the Kruskal–Wallis test results indicated no significant difference among the treatments (calculated $\chi^2 = 2.62 <$ table $\chi^2 = 5.99$). This indicates that substituting up to 40% uli banana flour still produces a crisp texture preferred by the panelists, even though the 40% treatment resulted in a slightly more brittle texture. The use of banana flour as a wheat flour substitute leads to a reduction in gluten content, making the cookies easier to break (Nuaeni et al., 2022).

Based on the results of the Kruskal–Wallis test, the addition of uli banana flour did not have a significant effect on the crispness texture attribute. This was indicated by the calculated value of $x^2_{count} = 2,62$, which was lower than the critical table value $ox^2_{table} = 5,99$.

Table 7 Results of the Texture Aspect Hypothesis

Testing Criteria	x count	x tabel
Texture	2,62	5,99

3.2 Baking Loss

The results of the study showed that the average baking loss values for 20%, 30%, and 40% substitutions of uli banana flour were 11.9%, 11.6%, and 9.4%, respectively. Descriptively, it was observed that as the substitution level of uli banana flour increased, the baking loss values tended to decrease. This indicates that uli banana flour has fairly good water-binding capacity, resulting in lower weight loss during the baking process. Based on the ANOVA test results, the calculated F-value of 3.88 was smaller than the critical F-value of 5.14 ($\alpha = 0.05$), indicating no significant differences among the treatments. Thus, adding up to 40% uli banana flour did not have a significant effect on the baking loss of shortbread cookies. The substitution of banana flour in cookies did not significantly affect baking loss because the water-binding characteristics of banana flour are relatively effective at maintaining moisture content during the baking process (Putri et al., 2021).

Table 8 ANOVA Test of Baking Loss.

Table 7 Results of the Texture Aspect Hypothesis

SK	Db	JK	KT	F_{hitung}	F_{tabel}
Treatment	2	11,27	2,39	3,88	5,14
Error	6	9,26	0,62		
Total	8	20,52			

The data in the table above was analyzed to determine the percentage of baking loss in shortbread cookies made with uli banana flour as a substitute, using the following formula :

$$\text{Baking Loss} = \frac{\text{Before baking (a)} - \text{After baking (b)}}{} \times 100$$

Before baking (a)

4. CONCLUSION

Overall, the results of the study indicate that substituting 20%, 30%, and 40% uli banana flour had no significant effect on the physical or sensory quality of the shortbread cookies. This was confirmed by the results of the ANOVA test for the baking loss parameter and the Kruskal-Wallis test for all aspects of sensory quality. Nevertheless, based on the descriptive results, it appears that a 30% substitution yields the best balance of product characteristics, as evidenced by the butter aroma, sweetness, and texture, which received the highest average scores compared to the other treatments. Therefore, a 30% substitution of uli banana flour can be considered an optimal formulation because it preserves the distinctive characteristics of shortbread cookies while increasing the use of local flour as a substitute for wheat flour.

5. ACKNOWLEDGMENTS

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