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Effect of the Proportion of Kepok Banana Flour (*Musa Acuminata* × *Balbisiana*) and Lima Bean Flour (*Phaseolus Lunatus* L.) on the Chemical, Physical, and Organoleptic Characteristics Of *Lidah Kucing* Cookies

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A B S T R A C T

Indonesia's dependence on imported wheat flour has encouraged the development of food products based on local raw materials. This study aimed to evaluate the effect of the proportion of kepok banana flour (*Musa acuminata* × *balbisiana*) and lima bean flour (*Phaseolus lunatus* L.) on the chemical, physical, and organoleptic characteristics of lidah kucing cookies and to determine the best formulation. The study employed a Completely Randomized Design (CRD) consisting of five treatments with three replications. Treatments were based on different proportions of wheat flour, kepok banana flour, and lima bean flour. Data were analyzed using Analysis of Variance (ANOVA), followed by Duncan's New Multiple Range Test (DNMRT) at a 5% significance level. The results showed that flour proportion significantly affected ($p < 0.05$) moisture content, ash content, protein content, fat content, carbohydrate content, crude fiber content, hardness, and color of lidah kucing cookies. However, it did not significantly affect panelists' preference levels for aroma, taste, and texture. The best formulation was treatment E, consisting of 50% wheat flour, 20% kepok banana flour, and 30% lima bean flour, which produced cookies with 3.62% moisture content, 2.05% ash content, 9.49% protein, 22.95% fat, 61.88% carbohydrates, 2.10% crude fiber, and a hardness value of 137.20 N/cm². The panelists' preference scores for color, aroma, taste, and texture were 3.84, 3.88, 4.16, and 4.20, respectively. These findings indicate that the use of kepok banana flour and lima bean flour as partial substitutes for wheat flour can enhance the protein and fiber content of lidah kucing cookies while maintaining consumer acceptability.

Contribution to Sustainable Development Goals (SDGs):

SDG 9: Industry, Innovation, and Infrastructure

SDG 11: Sustainable Cities and Communities

SDG 12: Responsible Consumption and Production

SDG 13: Climate Action

1. INTRODUCTION

1.1. Research Background

Lidah kucing cookies are one of the bakery products widely favored by consumers due to their crispy texture, sweet taste, and distinctive aroma. Generally, lidah kucing cookies are made using wheat flour as the main ingredient. The heavy dependence on

wheat flour, most of which is still imported, has encouraged the need for food diversification through the utilization of local raw materials with high nutritional value and easy accessibility. The use of non-wheat flours in bakery products is also in line with food diversification programs and efforts to increase the added value of local agricultural commodities.

One local food source with potential as a substitute for wheat flour is kepok banana flour (*Musa acuminata* × *balbisiana*). Kepok banana is one of the banana cultivars widely cultivated in



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Indonesia and is characterized by its high carbohydrate content, particularly starch and dietary fiber. Banana flour possesses favorable functional properties for bakery applications due to its high carbohydrate and dietary fiber contents and its ability to impart a distinctive flavor to processed products. Furthermore, the use of banana flour in food products has been reported to increase dietary fiber content and support food diversification based on local resources.(1-3)

However, banana flour is relatively low in protein content, making it necessary to incorporate another ingredient capable of improving the nutritional quality of the product, particularly its protein level. One promising ingredient is lima bean flour (*Phaseolus lunatus* L.). Lima bean is a local legume containing a relatively high protein content ranging from 15–26%, as well as dietary fiber, minerals, and essential amino acids beneficial to human health. Lima bean flour also exhibits favorable functional properties, including water and oil absorption capacities, making it suitable as a composite ingredient in bakery products.(4,5)

The use of banana flour and legume flours in bakery products has attracted considerable research interest. Substitution of banana flour in bakery products such as *bakpia* and cookies has been shown to increase fiber and carbohydrate contents; however, excessive levels may adversely affect texture and consumer acceptance. Meanwhile, the incorporation of legume flour into cookies has been reported to enhance protein and fiber contents without significantly reducing panelist acceptance when used in appropriate proportions.(6)

1.2. Literature Review

Lidah kucing cookies are a type of cookie characterized by a thin, elongated shape resembling a *lidah kucing*, with a crispy texture and low moisture content. This bakery product is typically made from wheat flour, sugar, butter, and egg whites. The quality of *lidah kucing* cookies is determined by physical, chemical, and sensory attributes, including texture, color, aroma, taste, and overall consumer acceptance. These characteristics are strongly influenced by the type and proportion of ingredients used in the formulation (3)

The application of banana flour in bakery products has been widely studied. Substitution of banana flour in *bakpia* products has been reported to increase fiber content and provide a distinctive banana aroma, although excessive use may result in a harder texture and darker color. The major advantages of kepok banana flour include its high carbohydrate and dietary fiber contents (82–83% carbohydrates, 8–9% dietary fiber), the presence of health-promoting resistant starch low fat content, its contribution to local food diversification, and its potential to partially replace wheat flour in bakery products (7,8)

Lima bean is a legume with relatively high protein content that remains underutilized. Protein levels in lima bean seeds range from approximately 15–26%, while carbohydrate content reaches about 69%. In addition, lima beans contain dietary fiber, minerals such as calcium, phosphorus, magnesium, and iron, as well as essential amino acids that are important for human nutrition. Lima bean flour also possesses desirable functional properties, including high water absorption, oil absorption, and swelling capacity. These characteristics make it a suitable ingredient for bakery formulations aimed at improving protein content and overall nutritional quality.(3). The advantages of lima bean flour include its relatively high protein content, richness in dietary fiber and minerals, favorable functional properties for food processing,

and its potential use as a protein fortification ingredient in bakery products (5,8,9)

1.3 Research Objective

This study aimed to evaluate the effect of different proportions of kepok banana flour (*Musa acuminata* × *balbisiana*) and lima bean flour (*Phaseolus lunatus* L.) on the chemical, physical, and organoleptic characteristics of *lidah kucing* cookies and to determine the optimum formulation capable of producing the best overall product quality.

2. MATERIALS AND METHODS

2.1. Research Design

This study employed a Completely Randomized Design (CRD) consisting of five treatments with three replications. The treatments were formulated using different proportions of wheat flour, kepok banana flour (*Musa acuminata* × *balbisiana*), and lima bean flour (*Phaseolus lunatus* L.). The formulations were as follows:

A = 100% wheat flour (control)

B = 50% wheat flour + 50% kepok banana flour

C = 50% wheat flour + 40% kepok banana flour + 10% lima bean flour

D = 50% wheat flour + 30% kepok banana flour + 20% lima bean flour

E = 50% wheat flour + 20% kepok banana flour + 30% lima bean flour

2.2. Materials

The main raw materials used in this study were wheat flour, unripe kepok bananas, lima beans, margarine, powdered sugar, egg whites, powdered milk, and baking powder. All ingredients were obtained from local markets in Padang, West Sumatra, Indonesia. Chemicals used for proximate analyses were of analytical grade.

2.3. Preparation of Kepok Banana Flour

Unripe kepok bananas were washed, steamed for 10 min, peeled, and sliced into thin pieces. The slices were dried in a food dehydrator at 60°C for 8 h until a constant weight was achieved. Subsequently, the dried banana slices were milled and sieved through a 60-mesh screen to obtain uniform flour particles.

2.4. Preparation of Lima Bean Flour

Lima beans were sorted to remove damaged seeds and foreign materials, soaked in water for 2–3 h, and manually dehulled. The dehulled beans were dried at 60°C for 6 h, milled, and sieved through a 60-mesh sieve to obtain fine flour.

2.5. Formulation of *Lidah Kucing* Cookies

The formulation of *Lidah Kucing* cookies for each treatment is presented in Table 1.

Table 1. Formulation of *Lidah Kucing* Cookies

Ingredients (g)	A	B	C	D	E
Wheat flour	270	135	135	135	135
Kepok banana flour	0	135	108	81	54
Lima bean flour	0	0	27	54	81
Margarine	200	200	200	200	200
Powdered sugar	150	150	150	150	150
Egg white	140	140	140	140	140
Milk powder	26	26	26	26	26
Baking powder	0.8	0.8	0.8	0.8	0.8

2.6. Preparation of *Lidah Kucing* Cookies

Margarine and powdered sugar were whipped until creamy, followed by the gradual addition of egg whites. The flour mixture according to each treatment formulation, together with powdered milk and baking powder, was then incorporated and mixed until a homogeneous batter was obtained. The batter was molded on a baking tray and baked at 170°C for 8 min, followed by baking at 120°C for 15 min until golden brown. After cooling to room temperature, the cookies were packed in airtight containers prior to analysis.

2.7. Physicochemical Analysis

The resulting cookies were analyzed for moisture content, ash content, protein content, fat content, carbohydrate content (by difference), and crude fiber content using standard AOAC methods. Texture analysis was performed using a Texture Analyzer and expressed as hardness (N/cm²).

2.8. Sensory Evaluation

Sensory evaluation was conducted using a hedonic test involving 30 semi-trained panelists. The evaluated attributes included color, aroma, taste, and texture. A five-point hedonic scale was used, where 1 = dislike very much, 2 = dislike, 3 = neither like nor dislike, 4 = like, and 5 = like very much.

2.9. Statistical Analysis

All experimental data were analyzed using Analysis of Variance (ANOVA) at a 95% confidence level ($\alpha = 0.05$). Significant differences among treatments were further tested using Duncan's New Multiple Range Test (DNMRT) at the 5% significance level. Statistical analyses were performed using appropriate statistical software.

3. RESULT AND DISCUSSION

3.1. Characteristics of Raw Materials

The chemical composition of kepok banana flour and lima bean flour is presented in Table 2. Kepok banana flour exhibited a high carbohydrate content (87.42%), whereas lima bean flour contained substantially higher protein (25.77%) and crude fiber (3.09%) contents. These differences indicate that kepok banana flour primarily serves as an energy source, while lima bean flour contributes protein and dietary fiber to the product formulation.

Table 1. Chemical Characteristics of Kepok Banana Flour and Lima Bean Flour

Parameter	Kepok Banana Flour (%)	Lima Bean Flour (%)
Moisture	5.06 ± 0.24	8.23 ± 0.22
Ash	4.28 ± 0.08	5.17 ± 0.09
Protein	2.19 ± 0.26	25.77 ± 0.14
Fat	1.08 ± 0.04	2.12 ± 0.08
Crude Fiber	2.20 ± 0.17	3.09 ± 0.13
Carbohydrates	87.42 ± 0.32	58.58 ± 0.18

The differences in chemical composition indicate that kepok banana flour has potential as an energy source due to its high carbohydrate content, whereas lima bean flour can serve as a source of plant-based protein and dietary fiber in *lidah kucing* cookie formulations. The combination of these two flours is expected to provide a more balanced nutritional profile than the use of wheat flour alone.(7) Furthermore, the flour yields obtained were 33.46% for kepok banana flour and 36.02% for lima bean flour, demonstrating their potential as alternative raw materials for the local food industry. Flour yield is an important parameter because it is closely associated with processing efficiency and production costs(8–10)

3.2. Chemical and Physical Characteristics of *Lidah kucing* Cookies

The analysis of *lidah kucing* cookies included moisture, ash, protein, fat, carbohydrate by difference, and crude fiber content, as well as a hardness test. Based on the analysis of variance at the 5% level, it was found that the formulation of wheat flour, banana flour, and lima bean flour significantly affected the moisture, ash, carbohydrate, protein, fat, and fiber content of the resulting *lidah kucing* cookies. The analysis results are shown in Table 2.

Table 2. Chemical and Physical Characteristics of *Lidah kucing* Cookies

Parameter	A	B	C	D	E
Moisture (%)	4.67 ± 0.86 ^c	4.15 ± 0.05 ^{bc}	1.85 ± 0.13 ^a	2.82 ± 1.17 ^{ab}	3.62 ± 0.87 ^{bc}
Ash (%)	1.17 ± 0.03 ^a	1.85 ± 0.02 ^b	2.01 ± 0.03 ^c	2.03 ± 0.05 ^c	2.05 ± 0.03 ^c
Carbohydrates (%)	65.19 ± 0.11 ^{bc}	66.94 ± 0.19 ^d	66.08 ± 0.34 ^{cd}	64.46 ± 1.12 ^b	61.88 ± 1.37 ^a
Protein (%)	8.64 ± 0.18 ^b	7.14 ± 0.06 ^a	8.47 ± 0.33 ^b	9.02 ± 0.66 ^{bc}	9.49 ± 0.31 ^c
Fat (%)	20.13 ± 0.52 ^a	19.92 ± 0.17 ^a	21.59 ± 0.25 ^b	21.66 ± 0.30 ^b	22.95 ± 0.70 ^c
Crude Fiber (%)	1.08 ± 0.07 ^a	1.68 ± 0.21 ^b	1.81 ± 0.21 ^{bc}	2.03 ± 0.14 ^c	2.10 ± 0.08 ^c
Hardness (N/cm ²)	269.99 ± 40.67 ^c	222.30 ± 42.16 ^{bc}	175.05 ± 28.91 ^{ab}	143.57 ± 42.10 ^a	137.20 ± 19.98 ^a

Noted: Values followed by different superscript letters within the same row differ significantly at $p < 0.05$ according to DNMRT.

3.2.1. Moisture Content

The moisture content of *lidah kucing* cookies ranged from 1.85% to 4.67%, and all treatments complied with the Indonesian National Standard (SNI) requirement for cookies (<5% moisture content). The significant differences in moisture content among treatments may be attributed to variations in the water-binding capacity of the composite flours. Wheat flour contains gluten

proteins that form a viscoelastic matrix capable of retaining water during dough development, whereas banana flour is predominantly composed of starch, which tends to release water more readily during baking. Moreover, the addition of lima bean flour may increase water retention due to the presence of proteins and dietary fiber, both of which possess hydrophilic functional groups capable of binding water molecules.(6)

The lower moisture content observed in treatment C may also be associated with the more efficient evaporation of water during baking as a result of reduced gluten formation and a more porous structure. Similar findings have been reported in composite-flour bakery products, where substitution with non-wheat flours reduced moisture retention and enhanced product crispness (11). Therefore, differences in moisture content among treatments can be explained by the interaction between starch, protein, fiber, and the gluten network during baking.(12,13)

3.2.2. Ash Content

Ash content increased significantly as the proportions of kepok banana and lima bean flours increased. Ash content is commonly used as an indicator of the mineral content of food products. Kepok banana flour contains important minerals such as potassium, magnesium, and phosphorus, while lima bean flour also contains higher mineral levels than wheat flour. Consequently, substitution with these flours significantly increased the mineral content of *lidah kucing* cookies (14). The findings indicate that incorporating local flours not only replaces wheat flour but also enhances nutrition by increasing mineral content.

3.2.3. Protein Content

Protein content increased significantly with increasing levels of lima bean flour, reaching the highest value in treatment E (9.49%). This increase is directly related to the high protein concentration in lima bean flour (25.77%) compared with those of wheat and kepok banana flours. Legumes are widely recognized as valuable protein sources because of their relatively high concentrations of lysine and other essential amino acids that are often limiting in cereal-based products. (15). The increase in protein content observed in the present study is consistent with previous reports indicating that legume flour incorporation significantly improves the nutritional quality of bakery products. Enhanced protein levels not only increase nutritional value but may also contribute to flavor development during baking through Maillard reactions involving amino groups and reducing sugars. Consequently, the addition of lima bean flour can serve dual functions as a nutritional fortifier and a flavour-enhancing ingredient in cookies (6,15,16).

3.2.4. Fat Content

Fat content increased significantly with increasing substitution of lima bean flour. The highest fat content was observed in treatment E (22.95%), whereas treatment B showed the lowest value (19.92%). The increase was primarily due to the naturally higher lipid content of lima bean flour compared with banana flour. Additionally, the consistent use of margarine across all treatments contributed substantially to the overall fat content of the cookies. Fat plays an important role in flavor development, texture

improvement, and the creation of a desirable crispy mouthfeel in bakery products (16).

3.2.5. Carbohydrate Content

A significant decline in carbohydrate content was observed with increasing substitution of lima bean flour. Treatment B had the highest carbohydrate content (66.94%), whereas treatment E had the lowest (61.88%). This trend is expected because kepok banana flour contains a substantially higher carbohydrate content (87.42%) than lima bean flour. As the proportion of lima bean flour increased, carbohydrates were partially replaced by proteins, minerals, and dietary fiber, resulting in a lower overall carbohydrate concentration (11–13,15). From a nutritional perspective, this shift may be beneficial because increasing protein and fiber while reducing available carbohydrates improves nutrient density and may contribute to a lower glycemic response. Legume-based bakery products have frequently been associated with enhanced nutritional quality due to their balanced composition of protein, fiber, and slowly digestible carbohydrates.

3.2.6. Crude Fiber Content

Crude fiber content increased significantly from 1.08% in treatment A to 2.10% in treatment E. This finding confirms the contribution of both banana flour and lima bean flour as dietary fiber sources. The increase is primarily associated with the fiber-rich cell wall components of lima beans, including cellulose, hemicellulose, and lignin, as well as resistant starch and dietary fiber present in banana flour. Dietary fiber is recognized for its beneficial physiological effects, including improvement of gastrointestinal function, enhancement of satiety, and regulation of blood glucose levels (17). In bakery products, fiber also affects texture by altering dough structure and reducing gluten network continuity. Consequently, the increased fiber levels observed in treatments containing composite flour may have contributed to the lower hardness values recorded in those formulations (18).

3.2.7. Hardness

Hardness decreased significantly as the proportions of banana and lima bean flours increased. Treatment A exhibited the highest hardness value (269.99 N/cm²), whereas treatment E recorded the lowest (137.20 N/cm²). The reduction in hardness may be explained by the dilution of gluten-forming proteins as wheat flour was replaced with non-gluten ingredients. Gluten is responsible for the formation of a continuous and elastic network that contributes to the structural integrity of baked products (18). In addition, dietary fiber present in banana flour and lima bean flour may interfere with gluten development and promote the formation of a more open and porous crumb structure. Such structural changes generally reduce the force required to fracture the product, resulting in improved crispness and lower hardness values. Similar observations have been reported in bakery products formulated with composite flours and legume-based ingredients (12,13).

3.3. Sensory Characteristics

Sensory evaluation was conducted using 30 semi-trained panelists who assessed color, aroma, taste, and texture. Hedonic scores ranged from 1 to 5, where 1 = dislike extremely, 2 = dislike, 3 = neither like nor dislike, 4 = like, and 5 = like

extremely. Analysis of variance indicated significant differences in color and aroma, while taste and texture were not significantly affected by treatment.

Table 3. Hedonic Scores of *Lidah kucing* Cookies

Treatment	Color	Aroma	Taste	Texture
A	4.32 ± 0.56 ^c	3.40 ± 0.71 ^{ab}	3.92 ± 1.00	4.00 ± 0.91
B	3.44 ± 0.82 ^a	3.24 ± 0.78 ^a	4.04 ± 0.61	4.20 ± 0.76
C	3.72 ± 0.54 ^{ab}	3.68 ± 0.63 ^{bc}	4.00 ± 0.76	4.04 ± 0.73
D	3.76 ± 0.60 ^{ab}	3.80 ± 0.58 ^c	4.00 ± 0.70	4.24 ± 0.58
E	3.84 ± 0.69 ^b	3.88 ± 0.60 ^c	4.16 ± 0.94	4.20 ± 0.66

Values followed by different superscript letters in the same column are significantly different at $p < 0.05$.

3.3.1. Color

The brownish-yellow color observed in cookies containing banana flour and lima bean flour was influenced by the natural color of the flours and by non-enzymatic browning reactions during baking. Banana flour generally possesses lower lightness than wheat flour, which contributed to the darker appearance of the final products. Furthermore, Maillard reactions occurring between reducing sugars and amino groups produced melanoidin pigments responsible for the characteristic brown color of bakery products. The darker color observed in cookies containing higher proportions of banana flour and lima bean flour can be attributed to both the intrinsic color of the raw materials and the occurrence of Maillard browning during baking. The Maillard reaction involves interactions between reducing sugars and amino compounds, resulting in the formation of melanoidins that impart desirable brown pigments and characteristic bakery flavors (12).

Furthermore, the increase in protein content associated with lima bean flour may enhance Maillard reaction intensity because a greater amount of amino groups is available to participate in browning reactions. This mechanism explains the gradual reduction in color preference compared with the control treatment while still maintaining acceptable sensory scores (12,13).

3.3.2. Aroma and Taste

Treatment E received the highest aroma and taste scores, indicating that the combination of kepok banana flour and lima bean flour generated a flavor profile preferred by panelists. The characteristic banana aroma originates from volatile compounds that remain detectable after flour processing. In addition, proteins and lipids present in lima bean flour contribute to flavor development through Maillard reactions during baking, producing a richer and more complex taste profile (16).

3.3.3. Texture

Texture is one of the most important sensory attributes affecting consumer acceptance of cookies. The highest texture score was observed in treatment E, indicating that the combination of kepok banana flour and lima bean flour produced an optimum level of crispness. The fiber content of both flours

likely interfered with gluten network formation, resulting in a lighter and more brittle product structure (19).

The results suggest that composite flour formulations can improve textural characteristics while maintaining consumer acceptability when used within appropriate substitution levels. Treatment E (50% wheat flour, 20% kepok banana flour, and 30% lima bean flour) demonstrated the most favorable balance between nutritional enhancement (9.49% protein and 2.10% crude fiber) and sensory acceptance, making it the recommended formulation for the development of locally sourced functional *lidah kucing* cookies (20).

4. CONCLUSION

The results demonstrated that the incorporation of kepok banana flour and lima bean flour significantly influenced the physicochemical properties of *lidah kucing* cookies and improved their nutritional value. Increasing the proportion of lima bean flour enhanced protein, fat, and crude fiber contents while reducing carbohydrate content and hardness. The optimum formulation was obtained at 50% wheat flour, 20% kepok banana flour, and 30% lima bean flour, producing cookies with improved nutritional quality and acceptable sensory properties. These findings highlight the potential of kepok banana flour and lima bean flour as partial substitutes for wheat flour in bakery products and support the development of sustainable local food diversification strategies.

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