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The Effect of the Combination of Tempeh Flour and Kepok Banana Peel Flour (*Musa paradisiaca Linn.*) on the Chemical and Organoleptic Quality of Butter Cookies

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Keywords
Butter cookies; kepok banana peel flour; tempeh flour; functional food.

Abstract
Butter cookies are one of the most popular food products due to their crispy texture and distinctive flavor. Tempeh flour, as a source of plant-based protein, and kepok banana peel flour (Musa paradisiaca Linn.), as a source of dietary fiber, have significant potential to be utilized as functional ingredients in cookie product development. This study aimed to determine the effect of combining tempeh flour and kepok banana peel flour on the chemical and organoleptic quality of butter cookies. This research employed a laboratory experimental method using a Completely Randomized Design (CRD) with one factor, namely variations in flour combination concentrations: T1P1 (90% : 10%), T2P2 (80% : 20%), T3P3 (70% : 30%), and T4P4 (50% : 50%), each with three replications. The observed variables included chemical quality (moisture content, ash content, protein content, and fiber content) and organoleptic quality (color, aroma, taste, texture, and overall acceptability) of butter cookies. Parametric data were analyzed using Analysis of Variance (ANOVA) with the assistance of Statistical Product and Service Solutions (SPSS) software, while non-parametric data were analyzed using Duncan's Multiple Range Test (DMRT). Based on the effectiveness test using the De Garmo method, treatment T2P2 was selected as the best treatment with a total score of 0.626, producing the most optimal physicochemical and organoleptic characteristics.

INTRODUCTION

Butter cookies are among the most popular bakery products due to their crispy texture and savory taste. The main ingredients commonly used in making butter cookies are wheat flour, butter, sugar, and eggs. Although they have a desirable flavor, butter cookies are generally low in protein content because they are dominated by wheat flour, which nutritionally contains more carbohydrates than protein (Sari et al., 2020). Several studies have attempted to modify ingredient compositions to improve the nutritional value of cookies, such as by adding pumpkin flour (Putri, 2019), using local flours like cassava flour and taro flour as substitutes for wheat flour (Sari & Lestari, 2020), and utilizing mung bean flour, which has been shown to increase protein content and improve the organoleptic quality of cookies (Sari, Lestari, & Hidayat, 2022).

One promising local ingredient is tempeh flour. Arifah Madani et al. (2023) analyzed the proximate composition of cookies made from tempeh flour and found an increase in protein content compared to wheat flour–based cookies. Research by Annisa Putri Larasati (2016) demonstrated that the utilization of tempeh flour in cookies can produce products that serve as sources of protein and fiber. Furthermore, the combination of gaplek flour (dried cassava flour) and tempeh flour has been studied as an alternative food for individuals with celiac disease,

focusing on protein content and cookie hardness. These findings confirm that tempeh flour has strong potential as a high–nutritional-value local ingredient capable of improving the chemical quality of cookies.

On the other hand, kepok banana peel flour (Musa paradisiaca Linn.) has also been studied as a substitution ingredient in cookies. Research by Rahmi Holinesti and Ranny Santri (2022) showed that substituting kepok banana peel flour in choco chip cookies at levels up to 45% affected the product's shape, color, aroma, texture, and taste. Another study by Indah Nuraeni et al. (2022) examined the sensory characteristics of cookies substituted with kepok banana peel flour and supplemented with eggshell flour, resulting in improved nutritional value and consumer acceptability. In addition, the use of white kepok banana peel flour combined with mung bean flour in crispy cookies was shown to produce a fiber-rich and low-sodium product. These findings emphasize that kepok banana peel flour can serve as an alternative to wheat flour while enhancing the functional value of cookies.

More recently, studies have begun to explore the combination of tempeh flour and kepok banana peel flour in other food products (Dewi et al., 2023). For example, the formulation of food bars based on local soybean tempeh flour and kepok banana peel flour has been shown to produce products high in protein, carbohydrates, and fiber (Devy et al., 2023). Another study on snack bars made from tempeh flour and Ambon banana demonstrated good consumer acceptability and improved nutritional content (Fernanda et al., 2025; Purnasari et al., 2022; Sari et al., 2022). These findings indicate that combining these two local ingredients holds great potential for developing functional food products.

The novelty of this research is fourfold. First, this study is the first to combine tempeh flour and kepok banana peel flour specifically in butter cookies, a product category with different processing requirements compared to food bars or conventional cookies. Second, this research systematically evaluates the synergistic effect of this combination on both protein content (from tempeh) and fiber content (from banana peel) simultaneously, providing a comprehensive nutritional profile. Third, this study applies the De Garmo effectiveness test method, which integrates multiple parameters with different weights to determine the optimal formulation objectively, rather than relying solely on subjective selection. Fourth, this research addresses the issue of banana peel utilization as agricultural waste, contributing to the circular economy by converting a byproduct into a high-value functional ingredient.

Although previous research has examined tempeh flour and kepok banana peel flour separately, as well as their combination in food bars or snack bars, the application of their combination in butter cookies remains limited. Therefore, this study was conducted to examine the effect of combining tempeh flour and kepok banana peel flour (Musa paradisiaca Linn.) on the chemical and organoleptic quality of butter cookies. This effort represents part of the innovation in utilizing high–nutritional-value local raw materials while supporting the development of modern food products that better meet consumer demands for health and nutritional content.

Butter cookies are a popular bakery product known for their crispy texture and savory flavor. The main ingredients typically include wheat flour, butter, sugar, and eggs. However, this product is relatively low in protein content due to the dominance of wheat flour, which nutritionally contains more carbohydrates than protein (Sari et al., 2020). Modifying the

composition using local flours such as cassava flour or taro flour has been widely studied to enhance nutritional value (Sari & Lestari, 2020).

Tempeh flour has significant potential as a high–nutritional-value local ingredient. Research by Arifah Madani et al. (2023) showed that the use of tempeh flour in cookies significantly increases protein content compared to wheat flour. Additionally, tempeh is a good source of dietary fiber, and its incorporation into food products may serve as an alternative for individuals with celiac disease due to its functional properties (Larasati, 2016).

Kepok banana peel contains high crude fiber and other nutrients that can be processed into flour. Substitution of kapok banana peel flour in bakery products such as choco chip cookies influences physical and organoleptic characteristics, including color and texture (Holinesti & Santri, 2022). Its use in combination with other ingredients such as eggshell flour or mung bean flour has also been shown to improve mineral content and consumer acceptability (Nuraeni et al., 2022).

The chemical quality of food products is determined through proximate analysis according to established standards to ensure that nutrient content such as protein and fiber meets expectations (Devy et al., 2023). In addition to chemical aspects, cookie quality strongly depends on organoleptic properties, including color, aroma, taste, and texture. This evaluation is essential to determine the extent to which innovative products based on local ingredients can be accepted by the wider community.

METHOD

This study employed a Completely Randomized Design (CRD) with a single factor consisting of five treatment levels of tempeh flour and kepok banana peel flour combinations, namely T1P1 (90% : 10%), T2P2 (80% : 20%), T3P3 (70% : 30%), and T4P4 (50% : 50%), each replicated three times. The main ingredients included tempeh flour, kepok banana peel flour, butter, powdered sugar, egg yolk, and vanilla. The preparation of kepok banana peel flour involved soaking the peels in ascorbic acid to prevent browning prior to drying. The butter cookie dough was mixed until homogeneous, molded, and baked at 150°C for 20–25 minutes.

The observed variables included chemical quality analysis (moisture content, ash content, protein content, fat content, and carbohydrate content) and organoleptic evaluation (color, aroma, taste, and texture) using a hedonic test. Data were statistically analyzed using Analysis of Variance (ANOVA) at a 5% significance level. If significant differences were found, a further Honestly Significant Difference (HSD) test was conducted. The best formulation was determined using the De Garmo effectiveness test method.

RESULT AND DISCUSSION

Chemical Quality of Butter Cookies

The results of the Analysis of Variance (ANOVA) showed that the use of tempeh flour and kepok banana peel flour in butter cookies had no significant effect on moisture content ($p = 0.377$), but had a significant effect on ash, protein, and fiber contents. This indicates significant differences among treatments in terms of ash, protein, and fiber levels due to the use of tempeh flour and kepok banana peel flour. The average chemical quality values of butter cookies are presented in Table 1.

Table 1. Recapitulation of the Average Chemical Quality of Butter Cookies

Treatment	Water Level (%)	Ash Level (%)	Protein Level (%)	Fiber Level (%)
T1P1	$3,60^{a} \pm 0,40$	$1,86^{a} \pm 0,06$	$5,91^{a} \pm 0,14$	$2,54^{a} \pm 0,02$
T2P2	$3,19^{a} \pm 0,17$	$2,44^{a} \pm 0,23$	$6,37^{ab} \pm 0,55$	$2,72^{ab} \pm 0,14$
T3P3	$3,49^{a} \pm 0,15$	$2,40^{a} \pm 0,07$	$7,33^{b} \pm 0,66$	$3,33^{b} \pm 0,07$
T4P4	$3,71^{a} \pm 0,30$	$2,15^{b} \pm 0,14$	$9,73^{c} \pm 0,51$	$3,74^{c} \pm 0,06$

The absence of a significant effect on moisture content was due to the uniform baking temperature and duration applied to all treatments. Although the proportions of tempeh flour and kepok banana peel flour varied, the evaporation process inside the oven occurred at the same intensity, resulting in a similar moisture equilibrium point. Furthermore, both substitute ingredients were dry materials that had undergone a milling process; thus they did not contribute contrasting amounts of free water to the final dough.

Based on Table 1, ANOVA results showed a significance value of 0.381 ($p > 0.05$), indicating no significant effect of the flour combination on moisture content. The average moisture content ranged from 3.19% to 3.71%, and all treatments shared the same letter notation ("a"), meaning that statistically the moisture content remained stable and consistent across all treatment levels. These findings indicate that the product meets the quality standards for dry products. According to Indonesian National Standard (SNI 01-2973-2011), the maximum moisture content for biscuits or cookies is 5%. With the highest value recorded at 3.71% (T4P4), all butter cookie formulations are categorized as safe due to their low moisture content, which is essential for maintaining crispness and extending shelf life by inhibiting microbial growth. This finding is consistent with Wulandari and Prasetyo (2018), who stated that moisture content in baked products is more influenced by the efficiency of water removal during baking than by variations in composite flour types. Additionally, Indrawati (2020) explained that fiber in kepok banana peel flour and protein in tempeh have water-binding capacity; however, at high baking temperatures, the bound water still evaporates to reach a safe level for biscuit products.

The significant effect on ash content was caused by the high mineral content of both substitute ingredients, namely tempeh flour and kepok banana peel flour. Tempeh flour contains important minerals such as iron, calcium, and magnesium derived from soybeans and the fermentation process. Meanwhile, kepok banana peel is known to have very high mineral content, particularly potassium, phosphorus, and calcium. The use of these two flours as substitutes for wheat flour, which naturally has lower ash content, significantly increased the total inorganic residue (minerals) remaining after the incineration process in the final product.

Based on Table 1, ANOVA results showed a significance value of 0.001 ($p < 0.05$), indicating a significant effect of the flour combination on ash content. The average ash content ranged from 1.86% to 2.44%. The HSD post-hoc test showed that treatment T1P1 (1.86%) differed significantly from the other treatments, while T2P2 and T3P3 showed the highest ash values. This confirms that the greater the proportion of plant-based composite flour added, the higher the mineral content in the butter cookies. This finding is in line with Astuti (2015), who explained that ash content is an indicator of total mineral content in food materials, and the use of local raw materials such as fruit peels and legumes effectively increases the ash value of composite products. Pratiwi and Hidayat (2020) also added that banana peel has higher mineral density compared to the fruit flesh, so its utilization in flour form significantly contributes to

the micronutrient composition of biscuit products. The increase in ash content indicates that the produced butter cookies have added value in terms of mineral content. According to Sari and Lestari (2020), dry processed products enriched with high-fiber and high-protein plant materials are generally accompanied by increased ash content, indicating potential as an additional mineral source for consumers.

The significant effect on protein content was due to the high plant-based protein content in tempeh flour. Tempeh is a fermented soybean product rich in essential amino acids and has a much higher protein density compared to wheat flour or kepok banana peel flour. Increasing the proportion of tempeh flour in the composite formulation directly increased the total organic nitrogen in the dough, resulting in higher crude protein content in the final product. In addition, the fermentation process in tempeh makes its protein more readily broken down and measurable in proximate analysis.

Based on Table 1, ANOVA results showed a significance value of 0.001 ($p < 0.05$), indicating a significant effect of the flour combination on protein content. The average protein content increased significantly with treatment variation, ranging from 5.91% to 9.73%. The 5% HSD post-hoc test showed that treatment T4P4 had the highest protein content (9.73%) and differed significantly from other treatments. This indicates that T4P4 was the best formulation for improving the protein nutritional quality of butter cookies.

This finding is consistent with Kusuma et al. (2021), who stated that substituting food ingredients with soybean-based flours (such as tempeh or edamame flour) effectively increases protein content due to their naturally high protein levels. Furthermore, Sudarmadji (2012) explained that in composite products, selecting raw materials with high nitrogen content strongly determines the percentage of total protein in the final product. The increase in protein content up to 9.73% in these butter cookies provides better functional value for consumers. According to Aminah and Wulandari (2021), biscuits enriched with plant-based protein not only function as an energy source from fat and carbohydrates but also help meet daily protein requirements, especially in healthy snack products.

The significant effect on the fiber content of butter cookies was attributed to the high dietary fiber contribution from kepok banana peel flour and tempeh flour. Kepok banana peel is a rich source of insoluble fiber, such as cellulose and hemicellulose, as well as significant amounts of pectin. On the other hand, tempeh contains crude fiber derived from soybean hulls and structural carbohydrate modifications during fermentation by the mold Rhizopus oligosporus. Increasing the proportion of these two ingredients in the dough effectively increased the total unhydrolyzed fiber residue, thereby enhancing the functional value of the product as a high-fiber snack. Based on Table 1, the Analysis of Variance (ANOVA) results showed a significance value of 0.001 ($p < 0.05$), indicating a significant effect of the combination of tempeh flour and kepok banana peel flour on the fiber content of butter cookies. The average fiber content increased consistently from 2.54% to 3.74%. The 5% HSD post-hoc test showed that treatment T4P4 achieved the highest value at 3.74%, with notation “c,” which was significantly different from the other treatments. This upward trend demonstrates that the simultaneous addition of kepok banana peel flour and tempeh flour provides a synergistic effect on the crude fiber content of the product. These findings are consistent with Indrawati (2020), who stated that the utilization of fruit peel waste in biscuit production can significantly increase fiber content because fruit peels contain much higher fiber levels than wheat flour.

Furthermore, Sania (2023) explained that fiber in tempeh remains stable during the baking process, making the combination of these two ingredients highly effective for producing functional food products that support digestive health. The increase in fiber content in these butter cookies is highly beneficial from a health perspective. According to Sari and Lestari (2020), consuming biscuits with fiber content above 3% can contribute to meeting daily fiber requirements, which helps regulate the glycemic index and improve the excretory system.

Organoleptic Quality of Butter Cookies

The organoleptic test results using the Kruskal–Wallis method showed that butter cookies made with tempeh flour and kepok banana peel flour exhibited significant differences in all organoleptic parameters (color, taste, texture, and aroma) among the treatment variations. The median values for all organoleptic parameters are presented in Table 2.

Table 2. Recapitulation of the Average Organoleptic Scores of Butter Cookies

Treatment	Color	Taste	Texture	Aroma
T1P1	$3^{a} \pm 0,72$	$3^{a} \pm 0,76$	$3^{a} \pm 0,73$	$3^{a} \pm 0,69$
T2P2	$4^{a} \pm 0,43$	$4^{a} \pm 0,81$	$4^{a} \pm 0,32$	$3,5^{ab} \pm 0,66$
T3P3	$3^{ab} \pm 0,55$	$3^{ab} \pm 0,57$	$3^{b} \pm 0,35$	$2,5^{b} \pm 0,55$
T4P4	$3^{b} \pm 0,56$	$3^{b} \pm 0,68$	$3^{b} \pm 0,43$	$2^{b} \pm 0,55$

The significant difference in color was caused by the use of kepok banana peel flour, which has naturally dark pigments and tends to undergo oxidation during processing. Kepok banana peel flour contains high levels of phenolic compounds that, when exposed to heat during baking, undergo enzymatic and non-enzymatic browning reactions (caramelization and Maillard reaction). The higher the proportion of kepok banana peel flour in the formulation, the darker or deeper brown the resulting cookies become, creating a noticeable visual difference compared to cookies made solely from wheat flour. Based on Table 2, the Kruskal–Wallis test showed a significance value of 0.001 ($p < 0.05$), indicating a significant effect of the flour combination on color. The median color scores ranged from 3 to 4. The post-hoc test showed that treatment T2P2 had the highest median value (4) with notation “a,” while T4P4 had a median value of 3 with notation “b.” This difference indicates that panelists could significantly detect changes in color intensity as the flour formulation varied. These findings are consistent with Putri and Santosa (2018), who reported that adding food ingredients high in fiber and phenolic compounds, such as fruit peels, significantly darkens the final product. In addition, Rachmawati (2019) explained that the color characteristics of composite biscuits are strongly influenced by the interaction between baking temperature and the type of carbohydrates in substitute ingredients, where local flours often produce a more distinctive and intense color compared to wheat flour.

The significant difference in taste was due to the unique flavor characteristics contributed by tempeh flour and kepok banana peel flour. Tempeh flour provides a distinctive savory fermented soybean (nutty) flavor, while kepok banana peel flour tends to impart a slightly astringent taste when used in high concentrations due to its tannin content. The combination of these two ingredients creates a new flavor profile different from conventional biscuits, where the interaction between the savory tempeh taste and banana aroma influences overall panelist preference. Based on Table 2, the Kruskal–Wallis test showed a significance value of 0.001 ($p < 0.05$), indicating a significant effect on taste. The median taste scores ranged from 3 to 4.

Treatment T2P2 had the highest median (4) with notation "a," while T4P4 had a median of 3 with notation "b." This indicates that increasing the concentration of tempeh flour and kepok banana peel flour beyond a certain level significantly reduced panelist preference for taste. These findings align with Asih (2022), who reported that adding plant-based ingredients with strong flavor profiles, such as tempeh, can enhance product palatability as long as the proportion does not overpower the butter flavor in biscuits. However, according to Handayani (2011), the use of local ingredients high in phenolic compounds, such as banana peel, must be carefully limited because excessive amounts can produce a bitter or astringent taste that reduces acceptability.

The significant difference in texture was caused by the fiber and protein characteristics of the substitute ingredients, which affected dough structure formation. Kepok banana peel flour has a high crude fiber content that can disrupt gluten network continuity (if wheat flour is still used) or starch bonding, resulting in a denser or harder texture. Meanwhile, protein from tempeh flour contributes to the firmness of the biscuit structure. The interaction between banana peel fiber and tempeh protein determines the level of crispiness and hardness perceived by panelists. Based on Table 2, the Kruskal–Wallis test showed a significance value of 0.001 ($p < 0.05$), indicating a significant effect on texture. The median texture scores ranged from 3 to 4. Treatment T2P2 received the highest evaluation with a median of 4 (notation "a"), while T3P3 and T4P4 showed decreased median values of 3 (notation "b"). This suggests that increasing the proportion of kepok banana peel flour and tempeh flour beyond a certain ratio tends to reduce texture acceptability, possibly due to excessive hardness or reduced crispiness. These findings are consistent with Sania (2023), who stated that high levels of plant fiber can increase biscuit hardness because fiber has high water absorption capacity, affecting dough expansion during baking. Moreover, Sari (2022) explained that cookie texture quality strongly depends on the balance between fat and fiber components, where excessive fiber may mask the melt-in-the-mouth characteristic typical of butter cookies.

The significant difference in aroma observed in the butter cookies was attributed to the strong characteristic aromas of tempeh flour and kepok banana peel flour, which interacted with one another. Tempeh flour imparts a distinctive beany flavor derived from lipoxygenase enzyme activity, while kepok banana peel flour contributes a characteristic fruity aroma that tends to be slightly sour or astringent. As the concentration of both flours increases, the butter aroma— which should be the primary characteristic of the product— becomes increasingly masked by the distinctive aromas of the substitute ingredients, which at certain levels are less preferred by panelists. Based on Table 2, the Kruskal–Wallis statistical test showed a significance value of 0.001 ($p < 0.05$), indicating a significant effect of the combination of tempeh flour and kepok banana peel flour on the aroma of butter cookies. The highest median aroma score was obtained in treatment T2P2 (3.5) with notation "ab," while the lowest median value was found in treatment T4P4 (2) with notation "b." The decline in median score from 3.5 to 2 indicates that the addition of composite flour in large quantities significantly reduced panelist acceptability of the product's aroma, as the original biscuit aroma deviated too far from the typical butter cookie standard. These findings are consistent with Nurhasanah and Sari (2019), who reported that the use of fermented legume flours introduces volatile compounds such as ammonia and alkanals that influence the final product's aroma profile. Furthermore, Yuliani and Pramitasari (2018) explained that the baking process can amplify aromas derived

from fruit peels, which, if not balanced with other flavoring agents, may produce an aroma perceived as unfamiliar by panelists.

Best Formulation (Effectiveness Test)

Based on Table 3, the effectiveness test calculation using the De Garmo method showed that treatment T2P2 had the highest total Yield Value (NH) of 0.626. This was followed by T4P4 (0.380), T3P3 (0.259), and T1P1 (0.191). The analysis indicated that T2P2 was selected as the best treatment because it dominated both organoleptic and physical parameters. T2P2 achieved the maximum Index Value (I) of 1.00 for taste, color, texture, aroma, and moisture content. Although treatment T4P4 had the highest nutritional content, with NH Protein of 0.180 and NH Fiber of 0.160, it failed to provide overall effectiveness because its organoleptic scores (color, taste, aroma, and texture) were at the minimum or lowest levels. The moisture content in T2P2 (3.19%) was the lowest among all treatments, contributing the maximum value (NH 0.080) to the physical parameter. Conversely, for the aroma parameter, there was a significant decline in score as the concentration of tempeh flour and kepok banana peel flour increased, with T4P4 achieving only a median score of 2. This explains why T2P2, with a balance between preferred sensory quality (median 3.5–4) and adequate nutritional value, became the most effective formulation for butter cookies. The effectiveness test calculation results are presented in Table 3.

Tabel 3 Effectivity Test Results

Parameter	Weight	Weight Score	NH (T1P1)	NH (T2P2)	NH (T3P3)	NH (T4P4)
Protein	9	0,18	0	22	67	180
Fiber	8	0,16	0	24	106	160
Taste	7	0,14	0	140	0	0
Aroma	7	0,14	94	140	46	0
Color	6	0,12	0	120	0	0
Texture	5	0,1	0	100	0	0
Water	4	0,08	17	80	34	0
Ash	4	0,08	80	0	6	40
TOTAL	50	1	191	626	259	380

CONCLUSION

The study demonstrates that while variations in the combination of tempeh flour and kepok banana peel flour did not significantly affect moisture content, they had a highly significant impact on improving key chemical quality parameters of butter cookies. Increasing the proportion of these substitute ingredients consistently enhanced ash, protein, and fiber contents, with the T4P4 treatment yielding the best nutritional profile (9.73% protein and 3.74% fiber), meeting the criteria for a functional snack. Organoleptically, the composite flour was well accepted at certain levels without substantially altering the characteristic qualities of butter cookies, and the effectiveness test method confirmed the product's strong potential as a nutrient-dense, fiber-rich local alternative. Future research should focus on optimizing processing techniques for kepok banana peel to reduce dark coloration and improve visual appeal, as well as investigating shelf life, antioxidant stability, and the use of natural binding agents to further enhance texture and overall product quality.

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