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Acceptability and nutritional value of sorghum–mung bean cookies with variations in sweeteners and fats

Daya terima dan nilai gizi cookies sorgum-kacang hijau dengan variasi pemanis dan lemak

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Abstract

The main ingredient in cookies is typically wheat flour, which contains gluten and has a high glycemic index. This makes it unsuitable for individuals with gluten intolerance or those requiring low-glycemic index snacks. This study aimed to develop gluten-free cookies using a sorghum–mung bean flour combination while comparing two sweeteners (palm sugar and stevia) and two types of vegetable fats (margarine and virgin coconut oil (VCO)) in terms of sensory quality and nutritional content. The study employed an experimental design using a Randomized Complete Block Design (RCBD) with five treatment formulations and two replicates, totaling ten samples, conducted from May to August 2025. Organoleptic tests were performed at the Food Culinary Laboratory, Faculty of Health Sciences, Universitas Siliwangi, while proximate analyses were conducted at the Food and Nutrition Laboratory, Faculty of Agricultural Technology, Universitas Gadjah Mada, Yogyakarta, Indonesia. The formulations included F0 (wheat–sorghum flour, granulated sugar, margarine), F1 (sorghum–mung bean flour, palm sugar, margarine), F2 (sorghum–mung bean flour, palm sugar, virgin coconut oil (VCO)), F3 (sorghum–mung bean flour, stevia, margarine), and F4 (sorghum–mung bean flour, stevia, VCO). Data were analyzed using the Kruskal–Wallis and One-Way ANOVA tests. The results indicated significant differences in all hedonic parameters (color, texture, aroma, and taste) and nutrient content among the formulations ($p < 0.001$). Formulation F3, which consisted of sorghum–mung bean flour, stevia, and margarine, demonstrated the highest acceptability. In conclusion, cookies made from sorghum and mung bean flours with natural sweeteners and vegetable fats have the potential to be gluten-free, low-glycemic snacks suitable for functional food development.

Keywords: natural sweeteners, organoleptic, plant-based fats, proximate analysis, sorghum-mung bean cookies

Abstrak

Bahan utama *cookies* umumnya menggunakan tepung terigu yang mengandung gluten dan memiliki indeks glikemik tinggi. Sehingga kurang sesuai untuk individu dengan kondisi intoleransi gluten maupun orang yang membutuhkan kudapan rendah indeks glikemik. Penelitian bertujuan untuk mengembangkan *cookies* bebas gluten dengan kombinasi bahan sorgum-kacang hijau sekaligus membandingkan dua jenis pemanis, yaitu gula aren dan stevia, serta dua jenis lemak nabati, yaitu margarin dan VCO terhadap kualitas sensoris dan nilai gizinya. Penelitian menggunakan desain eksperimen dengan Rancangan Acak Kelompok (RAK) dengan lima faktor perlakuan dan dua kali ulangan, terdapat sepuluh sampel yang dilaksanakan pada bulan Mei-Agustus

2025. Uji organoleptik dilakukan di Laboratorium Kuliner Pangan Fakultas Ilmu Kesehatan Universitas Siliwangi, sedangkan analisis proksimat dilakukan di Laboratorium Pangan dan Gizi Fakultas Teknologi Pertanian Universitas Gadjah Mada. Formulasi yang digunakan yaitu F0 (tepung terigu-sorgum-gula pasir-margarin), F1 (tepung sorgum-kacang hijau-gula aren-margarin), F2 (tepung sorgum–kacang hijau, gula aren, VCO), F3 (tepung sorgum-kacang hijau-stevia-margarin), F4 (tepung sorgum-kacang hijau-stevia-VCO). Analisis menggunakan *Kruskal-Wallis* dan *One-Way ANOVA*. Hasil menunjukkan adanya perbedaan signifikan pada seluruh parameter uji hedonik (warna, tekstur, aroma, rasa) dan kandungan gizi antar formulasi ($p<0,001$). Formulasi F3 dengan kombinasi tepung sorgum–kacang hijau, stevia, dan margarin adalah yang memiliki daya terima terbaik. Kesimpulan, cookies berbahan sorgum dan kacang hijau dengan pemanis alami dan lemak nabati berpotensi menjadi alternatif kudapan bebas gluten dengan indeks glikemik rendah yang sesuai untuk pengembangan pangan fungsional.

Kata Kunci: Cookies sorgum-kacang hijau, lemak nabati, organoleptik, pemanis alami, proksimat

Introduction

Functional foods are natural or processed foods that provide health benefits beyond basic nutrition (Temple, 2022). They contain one or more bioactive components that have been scientifically proven to exert positive physiological effects, such as enhancing immunity, reducing the risk of degenerative diseases, and controlling blood glucose levels (Essa et al., 2023; Vignesh et al., 2024). The functional food sector continues to expand as public awareness of healthy eating practices increases (Rashidinejad, 2024). This trend has driven innovation in functional foods derived from local ingredients, aiming to improve their nutritional value and diversify consumption patterns.

Cookies are widely recognized and popular snacks across all demographics (Kiin-Kabari et al. 2021). They are typically made from wheat flour, sugar, and fat, and undergo baking, resulting in a sweet taste, crisp texture, and characteristic aroma, depending on the ingredients used (Ardian et al., 2022). Traditional cookies are generally high in gluten and glycemic index (Lasaji et al., 2023; Aini et al., 2022), necessitating modifications to produce gluten-free cookies with a low glycemic index to enhance their nutritional value.

Sorghum (*Sorghum bicolor* L. Moench) is a local commodity with potential as an alternative ingredient for functional food products (Haryani et al., 2021). It is a gluten-free cereal frequently used as a flour substitute for wheat in various baked goods, including cookies, bread, and noodles (Budiarti et al., 2021). Sorghum flour is rich in fiber and has a low glycemic index (Atmadja & A'yunin, 2025). In addition, its phenolic compounds have antioxidant potential (Lee et al., 2023; Nagy et al., 2024). However, sorghum contains less protein than wheat (Atmadja, 2025), which can be compensated for by combining it with other protein-rich grains, such as mung beans.

Mung beans (*Vigna radiata* L.) are rich in protein and fiber and have a low glycemic index (Andriati et al., 2024; Chauhan et al., 2024). Its protein content is approximately 22.9%, whereas mung bean flour contains approximately 24.55% protein (Kementerian Kesehatan, 2017; Rahman, 2018). Mung bean flour is commonly used in various processed foods, including cookies, because its protein isolates provide good stability and consistency (Yi-Shen et al., 2018).

In addition to flour, sweeteners are essential for cookie production. Granulated sugar (sucrose) is commonly used but has a high glycemic index. Sweeteners not only enhance the flavor but also contribute to the cookie texture (Gao et al., 2016). Consumer preferences are increasingly shifting toward low-sugar foods. Alternatives such as palm sugar and stevia have lower glycemic indices than sucrose (Sarkar et al., 2023; Sustriawan et al., 2021). Stevia contains steviol glycosides, which are sweeter than sucrose and have fewer calories.

Fats are also critical for cookie quality, influencing the texture and dough stability

(Rosida et al., 2020). Although butter is a common animal fat, its high saturated fat content is associated with various health risks. Vegetable fats such as VCO and margarine can be used as butter substitutes. VCO is rich in medium-chain fatty acids, particularly lauric and capric acids, and contains bioactive compounds with antioxidant, antiviral, and antibacterial properties (Motamedzadegan et al., 2020). Margarine enhances the flavor, aroma, and softness of the dough, contributing to a crumbly cookie texture (Medho et al., 2022).

This study combined local flours with natural sweeteners and vegetable fats to produce healthy, low-glycemic, gluten-free cookies that meet the demands of contemporary health-conscious consumers. Previous research has often focused on substituting a single component, such as flour, sweeteners, or fat, without evaluating the combined effects on acceptability and nutritional value. Research on sorghum–mung bean cookie formulations as gluten-free, low-glycemic functional foods is limited. Therefore, this study aimed to assess the acceptability and nutrient content of sorghum–mung bean cookies with variations in sweeteners and fats, offering a nutritionally rich functional food alternative.

Methods

Research Design

This study employed an experimental design using a Randomized Complete Block Design (RCBD) with three treatment factors: (1) the addition of mung bean flour, (2) the use of two types of sweeteners, namely palm sugar and stevia, and (3) the use of two types of vegetable fats, virgin coconut oil (VCO) and margarine. Cookie formulation and organoleptic testing were conducted at the Food Culinary Laboratory, Faculty of Health Sciences, Universitas Siliwangi, while proximate analyses were performed at the Food and Nutrition Laboratory, Faculty of Agricultural Technology, Universitas Gadjah Mada, from May to August 2025.

The study involved five cookie formulations, each tested twice, resulting in a total of ten samples. The formulation details are listed in Table 1.

Table 1. Cookie Formulation Ingredients (g)

Ingredient	F0	F1	F2	F3	F4
Wheat flour	40	0	0	0	0
Sorghum flour	60	60	60	60	60
Mung bean flour	0	40	40	40	40
Granulated sugar	38	0	0	0	0
Palm sugar	0	38	38	0	0
Stevia	0	0	0	36	36
Virgin coconut oil (VCO)	0	0	50	0	50
Margarine	50	50	0	50	0
Salt	0.5	0.5	0.5	0.5	0.5
Baking soda	0.1	0.1	0.1	0.1	0.1

Equipment and Materials

Standard cookie production equipment and laboratory instruments were used for the proximate analysis. The primary ingredients included sorghum flour, obtained from the Indonesian Sorghum Farmers Association (SEPASI), and mung bean flour, sourced from Lingkar Organik Indonesia. Other ingredients, such as wheat flour, margarine, VCO, and palm sugar, were procured from the markets in Tasikmalaya.

Research Procedures

Sorghum grains were sorted and dehulled to obtain sorghum kernels. The kernels were washed thoroughly and soaked in water at a 1:1 ratio for one day. Following soaking, the kernels were dried until the moisture content reached 12–14%. The dried sorghum was then milled and sieved to produce fine flour that met standard specifications.

Cookie preparation involved three stages: mixing the ingredients according to the formulation, shaping the dough, and baking at predetermined temperatures and durations. Variations among the formulations were based on the type and proportion of flour, sweeteners, and fats.

Hedonic Test

The sensory panel consisted of 28 semi-trained female students from the Department of Nutrition, Faculty of Health Sciences, Universitas Siliwangi, Indonesia. The panelists met the Indonesian National Standard (SNI 01-2346-2006) for organoleptic testing. The evaluated parameters included color, aroma, texture, and taste, using a 5-point hedonic scale: 1 (dislike very much), 2 (dislike), 3 (neutral), 4 (like), and

5 (like very much) (Nursalma et al., 2021). Data from the questionnaires were tabulated, and mean scores were calculated for each panelist at a 95% confidence level according to the SNI guidelines.

Nutritional Content Analysis

The nutritional content of the cookies was analyzed using standard methods.

Moisture content was determined gravimetrically by oven-drying at 105°C, while protein content was measured using the Kjeldahl method. The fat content was assessed using Soxhlet extraction, and the carbohydrate content was calculated using the difference method, considering the measured values of moisture, ash, protein, and fat.

Data Analysis

The research data were processed using SPSS version 30.0. Hedonic data, which were not normally distributed ($p < 0.05$), were analyzed using the Kruskal–Wallis test to assess the differences in panelist preferences for color, aroma, texture, and taste. Nutrient contents, being quantitative and normally distributed, were analyzed using One-Way ANOVA followed by Duncan's multiple range test.

Ethical Approval

This study was approved by the Health Research Ethics Committee of Poltekkes Kemenkes Semarang on August 7, 2025 (approval number: 1066/EA/F). XXIII.38/2025.

Result and Discussion

Hedonic Test

Consumer acceptability, as related to color, aroma, texture, and taste of sorghum–mung bean cookies with different sweeteners and fats, was assessed through a hedonic test. The cookie characteristics are illustrated in Figure 1, and the hedonic analysis results are summarized in Table 2.

Statistical analysis revealed significant differences in all hedonic parameters—color, aroma, texture, and taste—among the five cookie formulations ($p < 0.01$). The color component was highest in F0 (4.07 ± 0.94) and lowest in F2 (2.68 ± 0.95). Aroma was highest in F0 (3.89 ± 0.74) and lowest in F1 (2.86 ± 0.85). Texture evaluation showed that F0 had the highest score (3.86 ± 0.97), followed by F3 (3.46 ± 0.96), and F4 had the lowest score (2.21 ± 0.79). The taste scores were highest for F0 (4.04 ± 0.99) and lowest for F1 (2.39 ± 1.10).

Based on the semi-trained panelist evaluation, formulation F3 was selected as the preferred formulation because of its highest overall hedonic ranking across color, aroma, texture, and taste. F3 comprised 60 g sorghum flour, 40 g mung bean flour, 36 g stevia, and 50 g margarine, achieving mean hedonic scores of 3.25, 3.29, 3.46, and 3.25 for color, aroma, texture, and taste, respectively.

F0 F1 F2 F3 F4

Figure 1. Appearance of cookies based on formulation variations (F0–F4)

Table 2. Hedonic test results

Nutrient	F0	F1	F2	F3	F4	p-value
Color	4.07 ± 0.94	2.86 ± 1.00	2.68 ± 0.95	3.25 ± 0.93	3.61 ± 1.13	<0.001
Aroma	3.89 ± 0.74	2.86 ± 0.85	3.21 ± 1.03	3.29 ± 0.76	3.21 ± 0.88	<0.001
Texture	3.86 ± 0.97	2.71 ± 0.85	2.96 ± 0.84	3.46 ± 0.96	2.21 ± 0.79	<0.001
Taste	4.04 ± 0.99	2.39 ± 1.10	2.46 ± 0.84	3.25 ± 1.18	2.68 ± 1.34	<0.001
Color	4.07 ± 0.94	2.86 ± 1.00	2.68 ± 0.95	3.25 ± 0.93	3.61 ± 1.13	<0.001

Table 3. Nutritional content of cookies (%)

Nutrient	F0	F1	F2	F3	F4	p-value
Moisture	7.25 ± 0.13^{a}	4.74 ± 0.02^{b}	4.21 ± 0.03^{c}	4.62 ± 0.04^{b}	3.52 ± 0.14^{d}	<0.001
Ash	1.21 ± 0.07^{a}	3.52 ± 0.14^{b}	1.66 ± 0.08^{c}	2.19 ± 0.01^{b}	1.53 ± 0.01^{c}	<0.001
Protein	5.65 ± 0.15^{a}	8.81 ± 0.25^{b}	8.77 ± 0.20^{b}	10.70 ± 0.06^{c}	10.76 ± 0.38^{c}	<0.001
Fat	22.03 ± 0.50^{a}	22.53 ± 0.17^{a}	22.68 ± 0.43^{a}	28.07 ± 0.12^{b}	31.14 ± 0.07^{c}	<0.001
Carbohydrate	63.86 ± 0.85^{a}	61.73 ± 0.47^{b}	62.67 ± 0.13^{ab}	54.41 ± 0.13^{c}	53.05 ± 0.46^{d}	<0.001

Hedonic Evaluation

Consumer preference was evaluated through hedonic testing of sorghum–mung bean cookies with varying sweeteners and fats. The control group (F0) consistently received the highest scores for color, aroma, texture, and taste, whereas F2 scored the lowest for all parameters. Visual appeal, particularly color, is a primary determinant of product acceptance (Setiawan et al., 2025). F0 was favored for its lighter, more attractive color, whereas F1 and F2 appeared darker owing to the presence of melanoidin pigments from palm sugar and Maillard and caramelization reactions during baking (Adna & Aini, 2021; Hikmawati, 2019; Wilberta et al., 2021).

Aromas influence consumer appetite and willingness to consume products. F1 was less preferred because of its rancid odor, likely caused by lipoxygenase activity in legumes that produce aldehydes and ketones (Damayanti et al., 2020). Texture, perceived through mouthfeel or touch, affects consumer preferences. F3 achieved the highest experimental texture score, similar to that of F0. Sorghum and mung bean flours are gluten-free, which limits dough expansion. The addition of margarine improves the fat content, resulting in fine, uniform crumbs and stable dough (Merlino et al., 2022). Conversely, VCO-containing formulations (F2 and F4) were rated poorly for texture due to a more fluid dough, leading to brittle cookies (Sustriawan et al., 2025).

Taste, perceived via the gustatory sense, was rated the highest in F3. Stevia provides sweetness without the aftertaste associated with palm sugar, and margarine contributes a savory flavor, creating a familiar and acceptable taste profile (Hajar & Nurhayati, 2025; Rachma et al., 2025).

Nutritional Evaluation

Moisture content affects the shelf life, texture, and crispness of food (Astuti et al., 2023). F0 exceeded the 5% moisture limit due to the water-retaining properties of gluten proteins in wheat flour, whereas sorghum–mung bean formulations remained below this threshold. Ash content increased with the substitution of sorghum and mung bean flours, reflecting their higher mineral content, including phosphorus, magnesium, potassium, zinc, manganese, and iron (Kumalasari & Budiati, 2024; Adam & Xyzquolyna, 2020).

The protein content was influenced by the flour composition. Mung bean flour, which contains approximately 22.75% protein, significantly increased the protein content in F1–F4 compared to F0, meeting the >5% standard for cookies (Lestari & Wibisono, 2023; Lestari et al., 2017; Sparvoli et al., 2016). Essential amino acids, such as lysine, threonine, and tryptophan, contributed to this improvement.

The fat content ranged from 22.03% to 31.14%, meeting the SNI >18% standard. Formulations with VCO (F2, F4) had higher fat content due to its 100% medium-chain saturated fatty acids, whereas margarine is 80% fat with additional water and emulsifiers (Assah, 2018; Mela & Bintang, 2021).

The carbohydrate content was highest in F0 due to the wheat flour and sucrose content. Substituting wheat with sorghum and mung bean flour and replacing sucrose with stevia reduced the carbohydrate content in F1–F4, making them suitable low-glycemic, gluten-free snacks for individuals with diabetes (Khoddami et al., 2023).

This study was limited to two natural sweeteners and two vegetable fats; alternative ingredients were not tested in this study. Additionally, all hedonic panelists were nutrition students, which could introduce bias due to prior knowledge influencing their perception.

Conclusion

The results of this study demonstrate that cookie formulations using a combination of sorghum and mung bean flours with variations in sweeteners and fats can produce gluten-free cookies that significantly affect the sensory characteristics and nutritional content. The formulation consisting of 60 g sorghum flour, 40 g mung bean flour, 36 g stevia, and 50 g margarine was the most preferred by the panelists and met the SNI standards for all nutritional parameters of cookies. Using non-gluten carbohydrate sources with a low glycemic index, combined with natural sweeteners and vegetable fats, can result in healthier cookies with potential as functional foods for individuals with specific health concerns such as diabetes mellitus.

For future research, it is recommended to involve a panel with a more diverse background to obtain more representative hedonic test results. Additionally, increasing the number of cookie formulations may help identify differences that influence nutritional value, thereby determining the optimal formulation.

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