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# Sponge Formula Based on Mung Bean Flour as a Functional Food Source of Iron for Preventing Anemia

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**Abstract**

Iron deficiency anemia is still a nutritional problem for adolescent girls and women of reproductive age because it reduces fitness, concentration in studies and readiness for pregnancy. This research aims to develop steamed sponge cake based on green bean flour as a functional snack source of iron and assess its sensory acceptability. The research is laboratory experimental with a repeated measurement design (within-subject); The main formulation uses 80% green bean flour, eggs, sugar, milk powder, margarine, vanilla and baking powder. Ten untrained panelists rated color, aroma, texture, and taste using a five-point hedonic scale. Because the data are ordinal in nature, come from a small panel (n = 10), and have a pairwise structure, inferential analysis uses the Friedman test (α = 0,05) as an alternative nonparametric repeated-measures ANOVA, followed by the Wilcoxon signed-rank test with Bonferroni correction and Kendall's W effect size. (Kendall's W = 0,69). Color received the highest mean (4,00±0,67) with 80% positive responses, followed by aroma (3,80±0,63; 70%), taste (3,50±0,85; 50%), while texture was the lowest attribute (3,00±0,67; 20%). Further tests showed that texture was significantly different from color (p-Bonferroni < 0,05). Mung bean flour sponge cake has the potential to be an iron-rich snack, but optimization of texture, taste, iron content testing and bioavailability are still needed before functional claims are applied more widely. Products also need to be tested on adolescent girls so that real acceptability, safety of consumption, and opportunities for integration with school nutrition education can be assessed comprehensively.

Keywords: Anemia, steamed sponge cake, mung bean flour, hedonic test, functional food, iron.

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## INTRODUCTION

Iron deficiency anemia is still a micronutrient problem that has far-reaching consequences for the quality of human resources. Iron deficiency biologically reduces hemoglobin levels and disrupts oxygen transport, energy metabolism, cognitive development, immunity, and physical productivity (Dev & Babitt, 2021; Kassebaum et al., 2014; Pasricha et al., 2021). In young women, this problem becomes more serious because the need for iron increases with rapid growth, blood volume expansion, and menstrual blood loss. If left untreated, iron deficiency in adolescence can continue into reproductive age and increase vulnerability to pregnancy complications. Studies in Indonesia show that anemia and iron deficiency in adolescent girls are related to low iron reserves, quality of intake, and limited consumption of foods rich in micronutrients. Prevention of anemia requires strategies that are not only curative, but also in harmony with daily eating habits (Aji et al., 2022; Sari et al., 2022).

The blood supplementation tablet program remains an important strategy in controlling anemia, but its success is greatly influenced by compliance, acceptance and continuity of education. A review of adolescent nutritional interventions shows that supplementation and fortification can improve indicators of iron status, but the results are stronger when combined with nutritional education and improved (Salam & Bhutta, 2016; Sun et al., 2024) consumption patterns. A local food-based approach has great opportunities because it can be applied in the form of snacks that are more easily accepted by teenagers. A study of iron-rich snacks in adolescent girls shows that snack products based on local ingredients have the potential to support increased hemoglobin levels, although their effectiveness is determined by iron content, frequency of consumption, sensory acceptability, and mineral bioavailability. Functional food innovations need to be designed as a complement to nutrition programs, not as a substitute for medical interventions or supplementation that have been recommended (Masanja et al., 2025).

Mung beans (Vigna radiata L.) are a local legume that is relevant for the development of functional food because it is widely available, relatively affordable, and is well known in the consumption patterns of Indonesian society. Nutritionally, green beans contain vegetable protein, complex carbohydrates, dietary fiber, minerals, B vitamins, phenolic compounds, polysaccharides and the bioactive peptide (Hou et al., 2019). Various studies also place green beans as a potential ingredient for food diversification because they have functional properties and bioactive components that can support health (Xue et al., 2016; Jha et al., 2025). The use of green beans as a source of iron needs to be interpreted critically. Iron in plant foods is generally in non-heme form, so absorption is lower and is influenced by the presence of phytate and polyphenol (Dhole & Reddy, 2015; Jha et al., 2025). This condition shows that functional claims must be supported by analysis of iron content and bioavailability, not just based on raw material composition.


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Processing green beans into flour opens up application opportunities in bakery products and snacks. Mung bean flour is more stable, easy to formulate, and has functional properties that are influenced by protein, starch, water absorption capacity, and gel formation ability (Liu et al., 2023). The use of legume flour in cake products presents technological challenges, the absence of gluten causes the dough's ability to hold gas and form a soft crumb to be limited. Studies on gluten-free and legume-based bakery products show a tendency to increase nutritional value, but also the risk of decreasing volume, increasing hardness, changing color, as well as the appearance of a typical aroma or taste of legumes that consumers may not necessarily like, because product formulation must consider the balance between nutritional goals and sensory quality (Bojňanská et al., 2021; Heetesonne et al., 2024; Xu et al., 2020).

Steamed sponge cake was chosen as a product model because it is close to people's consumption habits, has a texture that is expected to be soft, has a simple production process, and is easy to develop as a snack. Technologically, sponge cake is a foam-based product that relies on the formation of air bubbles from beating eggs and sugar, which is then stabilized during heating. Substituting flour high in protein and fiber can increase the viscosity of the dough, but at high levels it has the potential to produce a denser crumb. Several studies show that the use of hydrocolloids such as xanthan gum, guar gum, or HPMC can help improve the water retention and structure of gluten-free cakes, although excessive doses can result in an overly chewy or gummy texture. Preliminary tests on mung bean flour-based sponge cake are needed to determine the attributes that most require optimization of (Ismail et al., 2024; Sahi & Alava, 2003).

One common weakness of functional food development research is that it places too much emphasis on ingredient content, but not enough testing for consumer acceptance. In fact, products intended to prevent nutritional problems only have the opportunity to be consumed repeatedly if they have acceptable color, aroma, texture and taste. Hedonic testing is an important method in the early stages of product development because it provides information about the level of liking and directions for formulation improvement. Mung bean cake, based on organoleptic evaluation, not only serves to find out whether the panelists like the product, but also to read the relationship between the character of the legume ingredients and the final quality of the product. Interpretation of sensory results needs to be linked to aspects of food technology, so that the average numbers and distribution of assessments can become the basis for further, more measurable formulations of (Addo-Preko et al., 2023; Djekic et al., 2021).

The research gap underlying this study lies in the limited preliminary studies that link the potential of green beans as a local food ingredient rich in micronutrients with the sensory acceptance of steamed sponge products. Some previous studies discussed anemia, supplementation, or the potential of green beans in the form of drinks and other products, while the development of steamed sponge cake based on the dominance of green bean flour still requires systematic organoleptic proof.


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In addition, mung bean flour-based products often face texture and taste problems, so initial data is needed to determine reformulation strategies. The practical novelty of this research is that it places green bean cake as a local snack food candidate which is assessed based on the main organoleptic attributes, accompanied by a critical interpretation of the limitations of iron bioavailability and the need for further laboratory tests.

Based on this description, this research aims to develop an initial formulation of steamed sponge cake based on green bean flour and assess its sensory acceptability based on the attributes of color, aroma, texture and taste. The research also aims to identify the attributes that most require formula improvement and interpret the product's potential as a snack to support anemia prevention. The results of the research are expected to be the basis for optimizing the proportion of green bean flour, use of binding agents, testing iron levels, phytate analysis, bioavailability testing, and acceptance studies for young women as the target group. With this flow, research is not only oriented towards making products, but also builds a scientific basis for the development of local functional foods that are relevant, measurable, and have the opportunity to be applied in public nutrition education.

## METHODOLOGY

### Research type and design

This research is laboratory experimental research within the framework of food product development. The controlled treatment was a steamed sponge cake formulation with a dominant substitution of green bean flour (80% to total flour), while the response variable was sensory quality in four attributes, namely color, aroma, texture and taste. The design is a repeated measurement (within-subject/repeated measures) because each panelist evaluates all the attributes of the same product sample, so that the assessment between attributes is paired (related). This approach is in accordance with the research objectives, namely to obtain an overview of organoleptic quality before carrying out nutritional content tests, iron bioavailability tests, and intervention tests on target groups. The main variables observed include color, aroma, texture and taste, with supporting indicators in the form of distribution of favorite categories, mean, standard deviation, average ranking and Friedman test results.

### Time and place of research

Formulation, product manufacturing and organoleptic testing activities are carried out on a laboratory scale or food processing practice room, D-III Nutrition Study Program, Health Polytechnic, Ministry of Health, Banjarmasin in 2026. The entire manufacturing process is carried out under uniform conditions, starting from weighing ingredients, sifting flour, kneading dough, steaming, cooling, to cutting samples. This process control is needed so that differences in panelist


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assessments reflect more the character of the formula, rather than technical variations in product manufacture.

**Population and sample**

The research target population is potential consumers of green bean-based snack products, especially groups who need alternative snack sources of iron. The organoleptic test sample consisted of 10 untrained panelists selected purposively. The criteria for panelists are that they are willing to take the test, are able to fill out the assessment sheet, are not experiencing taste or smell problems, and are not allergic to eggs, milk, margarine or green beans. The number of panelists is used for a preliminary study so that the results are interpreted as a basis for improving the formula, not generalization to the wider population.

**Data collection techniques and instruments**

The product is made using the main formulation of 80% green bean flour to the total flour ingredients, with the addition of eggs, sugar, milk powder, margarine, vanilla, baking powder and salt. Beat the eggs and sugar for 7-10 minutes until they reach the ribbon stage, then add the flour mixture gradually using the back-stirring technique. The dough is steamed for ± 30 minutes over medium heat and cooled before serving. Samples were given to panelists in uniform pieces at room temperature. The instrument used was a five-point hedonic test sheet, namely 1 = dislike, 2 = somewhat dislike, 3 = somewhat like, 4 = like, and 5 = like very much. Panelists assess each attribute separately and can write short notes regarding the impression of color, aroma of beans, softness and taste.

**Data analysis techniques**

Data on organoleptic test results are tabulated based on frequency and percentage in each assessment category; Positive responses are determined from a combination of like and really like categories. The mean value and standard deviation are calculated to describe the trend and distribution of assessments for each attribute. Hedonic data are ordinal, come from a small panel (n = 10), and have a repeated measures structure because each panelist rates all four attributes on the same sample. With these characteristics, the assumptions of normality and homogeneity of variance for parametric statistics are difficult to fulfill, and the Chi-Square test only tests the uniformity of distribution within one attribute, not comparing the level of liking between attributes.

Therefore, the inferential analysis uses the Friedman test, which is a nonparametric alternative to repeated measurement ANOVA, to test differences in the level of liking between attributes at a significance level of 0,05. Effect sizes were calculated with Kendall's concordance coefficient (Kendall's W; 0,1 small, 0,3 medium, ≥0,5 large). If the Friedman test is significant, a further pairwise Wilcoxon signed-rank test with Bonferroni correction is carried out to identify different pairs of attributes. The entire results table is then given a narrative interpretation so that the


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statistical findings can be linked to the implications of improving the formula. Verbal consent was obtained before the test was conducted, and panelist data was recorded anonymously.

## RESULTS AND DISCUSSION

### RESULTS

The results of the research show that steamed sponge cake based on green bean flour can be produced in a whole form, with a greenish yellow color, a light legume aroma, and a relatively dense crumb. The panelists' assessments illustrate that visual and aroma attributes are easier to accept compared to texture attributes. This finding is in accordance with the character of legume-based bakery products which often experience increased nutritional value but face challenges in the softness and distinctive taste of beans. Details of the distribution of organoleptic assessments are presented in Table 1.

Table 1. Distribution of Panelists' Organoleptic Assessments

| Attribute | SS | S | US | ATS | T. S | Response Positive (%) |
|---|---|---|---|---|---|---|
| Color | 2 | 6 | 2 | 0 | 0 | 80 |
| Aroma | 1 | 6 | 3 | 0 | 0 | 70 |
| Texture | 0 | 2 | 6 | 2 | 0 | 20 |
| Flavor | 1 | 4 | 4 | 1 | 0 | 50 |

Table 1 shows that color is the attribute with the strongest acceptance, because eight out of ten panelists are in the like or very like category. The aroma was also well received by seven panelists, indicating that the use of green bean flour did not cause a dominant unpleasant aroma after the steaming process. Taste was in the middle position with five panelists responding positively, while four panelists only liked it somewhat. Texture was the main weak point because only two panelists said they liked it, while the majority voted they liked it somewhat and two panelists somewhat disliked it. This pattern shows that the product already has visual and aromatic appeal, but the crumb structure and softness need to be optimized before the product is directed for routine consumption.

Table 2. Descriptive Statistics, Mean Ranking, and Friedman Test

| Attribute | Mean | Elementary school | Average rating | Category |
|---|---|---|---|---|
| Color | 4,00 | 0,67 | 3,35 | Like |
| Aroma | 3,80 | 0,63 | 2,95 | Close to like |
| exture | 3,00 | 0,67 | 1,35 | Kinda like it |
| Flavor | 3,50 | 0,85 | 2,35 | Kinda like it |

*Note: SD = standard deviation. Friedman test: $\chi^2(3) = 20,64$; $p < 0,001$; Kendall's W = 0,69 (large effect size). A higher mean rating indicates a greater degree of liking.*


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**Table 3. Paired Wilcoxon Signed-Rank Advanced Test (Bonferroni Correction)**

| Attribute pairs | P | P (Bonferroni) | Information |
|---|---|---|---|
| Color vs Scent | 0,180 | 1,000 | No different |
| Color vs Taste | 0,043 | 0,259 | No different |
| Color vs Texture | 0,005 | 0,030 | Really different * |
| Aroma vs Taste | 0,109 | 0,653 | No different |
| Aroma vs Texture | 0,012 | 0,070 | Tends to be different |
| Taste vs Texture | 0,043 | 0,259 | No different |

**significant at p (Bonferroni) < 0,05; Corrected significance thresholds for six pairwise comparisons.*

The Friedman test shows a significant difference in the level of liking between the attributes ($\chi^2(3) = 20,64$; $p < 0,001$) with a large effect size (Kendall's W = 0,69), which means the panelists relatively agree on the order of preference for the attributes. The highest average rating was obtained by color (3,35), followed by aroma (2,95), taste (2,35), and texture (1,35). The average color of 4,00 places this attribute in the like category, aroma is close to like (3,80), taste is between somewhat like and like (3,50) with the largest standard deviation so that the variation in panelists' tastes is the widest, while texture (3,00) is in the somewhat like category. The Wilcoxon further test with Bonferroni correction (Table 3) shows that texture is significantly different from color (p-Bonferroni = 0,030) and tends to be different from aroma (p-Bonferroni = 0,070), while other attribute pairs are not significantly different. These findings confirm that texture is the main priority for statistical formula improvement, not just based on averages.

Technologically, the low texture score is thought to be related to the dominance of green bean flour in the formula. This flour does not form a gluten network like wheat flour, so the dough's ability to hold gas and maintain fine pores is limited. Legume protein and fiber can increase viscosity, but at high levels it can also produce a denser crumb and a heavier chewing sensation. These conditions explain why color and aroma are well received, while texture is not as strong as other attributes. These results are in line with reports that legume flour in cake products can improve the nutritional profile, but the formula composition needs to be adjusted so that volume, springiness and softness do not decrease.

The functional potential aspect in mung bean-based formulations provides a positive direction because the main ingredient is known to contain minerals, protein, fiber and bioactive components. However, this study has not measured actual iron levels, losses during steaming, or bioavailability. Thus, organoleptic results should be positioned as evidence of initial acceptability, not evidence of the effectiveness of anemia prevention. Functional food claims need to be strengthened through proximate analysis, iron levels using standardized laboratory methods, phytate tests, as well as simulations or absorption tests. Formula improvements can be made by adding low doses of hydrocolloids, combining green bean flour with starch or wheat, using natural flavors, as well as pre-treatment such as soaking, germination or fermentation to suppress anti-nutritional compounds.


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Based on the overall results, the product is best developed for appearance and aroma, while the taste and texture aspects require further experimentation. Interpretation of the table shows that sensory data not only provides favorability figures, but also directs optimization strategies. If the target product is teenage girls, then soft texture, balanced sweet taste, practical portion sizes, and clear nutritional information are important factors. This initial formula can be maintained as a research basis, but the next stage needs to compare several variations in the proportions of mung bean flour, binders, and processing techniques to obtain sensory qualities that are more stable and easily replicated by other researchers. This improvement becomes the basis before conducting an in-depth nutritional content test.

## DISCUSSION

The high color acceptance shows that the substitution of green bean flour in steamed sponge cake does not always reduce the visual appeal. The greenish yellow color that appears can be read as a characteristic of local ingredients, not a product defect, as long as the intensity is uniform and the surface of the cake is not dull. In functional food development, visual attributes act as a gateway to acceptance because consumers often assess the suitability of a product before tasting it. These findings are consistent with sensory studies that place appearance as an early factor in forming taste expectations (Addo-Preko et al., 2023; Djekic et al., 2021). The relatively favorable color also indicates that the process of steaming and mixing the ingredients is sufficient to maintain the appearance of the product, although further research needs to measure objective color parameters using a colorimeter in the next test with an objective method that is calibrated and easy to compare between samples.

The aroma received a positive response because the heating process, vanilla, margarine and egg components probably balanced the typical aroma of legumes. Mung beans contain beneficial bioactive compounds, but legume-based products often face the risk of a beany aroma due to certain volatile compounds. The steaming process can reduce unpleasant sensations, while the combination of aromatic ingredients helps create a familiar sponge cake impression. The literature on mung beans emphasizes that processes such as soaking, germination, heating, and fermentation can change the phenolic components, antioxidant activity, and sensory characteristics of the material. Good aroma scores need to be maintained through consistent process standards (Hou et al., 2019).

Texture is the main problem and can be scientifically explained by the properties of green bean flour. In foam-based cakes, the protein network of eggs and flour must be able to hold air until the starch undergoes gelatinization. When legume flour is used in high proportions, there is no gluten available which provides the elasticity of wheat flour. Legume fiber and protein can absorb water, increase dough density, and limit swelling. Studies on the addition of legume flour to bakery products show that there is a trade-off between increasing protein-fiber and decreasing crumb quality if the


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formula is not corrected for (Heetesonne et al., 2024). The finding of an average texture of 3,00 is not a product failure, but rather a formulation signal for the optimization stage. Statistical confirmation via the Friedman test and the Wilcoxon follow-up test (texture is significantly different from color, p-Bonferroni = 0,030) shows that the low texture score is not a random variation, but rather a signal of a formulation that needs to be corrected.

Texture improvements can be directed at several strategies. First, the proportion of green bean flour can be compared at several levels, for example 40%, 60%, and 80%, to determine the optimum point between nutritional content and acceptability. Second, the addition of hydrocolloids such as xanthan gum, guar gum, or HPMC at low doses can help increase water retention, foam stability, and crumb softness. However, the dosage should be tested because excessive use risks producing a texture that is too chewy or sticky (Ismail et al., 2024; Sahi & Alava, 2003). Third, the use of germinated or fermented mung bean flour can be evaluated because changes in starch, protein and phytate can affect the functional properties as well as the potential bioavailability of mineral (Acun, 2026; Gupta et al., 2015).

Flavors that are in the middle category indicate acceptance, but are not yet strong enough to claim a market-ready product. The distinctive taste of green beans may be liked by some panelists because it is familiar in traditional foods, but may be considered too dominant by other panelists. The largest standard deviation of taste indicates heterogeneity of preferences. This condition is common in functional food development because increasing the active ingredient content often comes with a compromise in palatability. Anemia prevention products for adolescent girls must not only be nutritious, but must also be tasty enough to be consumed repeatedly. Reformulation of sugar, vanilla, milk, margarine, or the addition of natural flavors such as pandan can be tested, while maintaining the nutritional profile and not increasing energy excessively.

The choice of green beans is relevant because this legume provides vegetable protein, complex carbohydrates, fiber, minerals and various bioactive compounds. However, iron from plant foods is in non-heme form, so its absorption is more influenced by phytates, polyphenols, calcium, and the presence of enhancers such as vitamin C. Research on nuts shows that phytates and polyphenols can reduce the bioavailability of iron, while dephytinization, soaking, germination, and fermentation can help improve the availability of the mineral (Dhole & Reddy, 2015). This article does not state sponge cake as an anemia therapy, but as a supporting snack candidate that still requires laboratory evidence and intervention.

The public health implications of this research lie in the possibility of expanding anemia prevention approaches through local products. Adolescent nutrition intervention studies suggest that supplementation, fortification, education, and dietary diversification can complement each other, but success in the field depends on compliance and acceptance of (Masanja et al., 2025; Salam & Bhutta, 2016; Sun et al., 2024). Mung bean cake can be included as a component of local food


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education in schools, youth posyandu, or community nutrition activities, especially if portion sizes, iron content, and consumption messages are clearly formulated. However, its use must be accompanied by education that preventing anemia requires a varied diet, consumption of animal protein or sources of vitamin C if possible, and adherence to blood supplement tablets when recommended.

Limitations of this research include the small number of panelists, panelists who do not represent the target population at large, there is no comparison formula, and food chemical measurements have not been carried out. Although the Friedman and Kendall's W tests provide strong statistical evidence of differences between attributes, the results on small panels remain exploratory in nature so generalization to the population of adolescent girls is limited. Additionally, studies have not calculated the iron contribution per serving, have not measured phytate, and have not assessed product stability during storage. The next stage is recommended to use a multiformula experimental design (for example a completely randomized design with Friedman or Kruskal-Wallis tests between formulas), more panelists, proximate analysis, iron tests, instrumental texture tests, as well as evaluation of acceptance among young women as the target group. With this design, the relationship between sensory quality, iron content and opportunities for regular consumption can be tested more strongly.

## CONCLUSION

Steamed sponge cake based on green bean flour shows potential as a local functional snack to support anemia prevention due to its content of vegetable protein, minerals, fiber and bioactive components. Through an experimental design of repeated measurements and the Friedman test, significant differences in liking levels were found. The Wilcoxon follow-up test with Bonferroni correction confirmed that texture was significantly different from color, so that texture and taste were priorities for reformulation, for example through varying flour proportions, adding low doses of hydrocolloids, natural flavors, and pre-treatment (soaking, germination, or fermentation). Green beans as a source of iron must be proven through analysis of iron levels, phytate, bioavailability, and consumption tests in target groups, and further research is needed with a larger number of panelists and comparison formulas before functional claims are widely published. The main recommendation of this research is to optimize the formula before functional claims are widely published.

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