

RESEARCH STUDY

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The Effect of Millet (*Setaria Italica*) Flour and Soybean (*Glycine Max L.*) Flour Composition on Dietary Fiber, Proximate Content, and Organoleptic Properties of Cereal for Diabetes Mellitus

Pengaruh Komposisi Tepung Jewawut (*Setaria Italica*) dan Tepung Kacang Kedelai (*Glycine Max L.*) terhadap Serat Pangan, Proksimat, dan Sifat Organoleptik Sereal untuk Diabetes Melitus

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ABSTRACT

Background: Based on International Diabetes Federation (2025), there are 20.4 million individuals in Indonesia (aged 20–79 years) suffering from diabetes mellitus as of 2024. Managing the amount and type of food consumption is required as a corrective measure to prevent complications. Dietary fiber and protein have been shown to be effective in controlling glucose and increasing satiety.

Objectives: To analyze the effects of millet flour and soybean flour composition on dietary fiber, proximate content, and organoleptic properties of cereal intended for individuals with diabetes mellitus.

Methods: This experimental study used a Completely Randomized Design (CRD) with 3 treatment levels based on millet flour and soybean flour, namely 100%:0% (F1), 75%:25% (F2), and 50%:50% (F3), with two replications for each. Analysis of chemical content employed one-way ANOVA, followed by Duncan test if significant differences were found. Furthermore, organoleptic properties were analyzed by Kruskal Wallis test and Mann-Whitney test to identify significant differences among formulas. The best formulation was selected using the De Garmo method.

Results: Chemical test results showed significant differences for ash, protein, fat, carbohydrate, and dietary fiber ($p\text{-value} < 0.05$) among formulas. Hedonic test showed significant differences ($p\text{-value} < 0.05$) in texture and cereal taste acceptance in each formula. The best formula was F3, which contained 4.91% water, 2.38% ash, 5.66% dietary fiber, 17.48% protein, 20.58% fat, and 54.76% carbohydrate.

Conclusions: The proportion of millet flour and soybean flour significantly increased ash, protein, fat, and dietary fiber content; significantly decreased carbohydrate content; and significantly influenced texture and taste acceptance, but did not influence water content, color, and aroma acceptance of cereals.

INTRODUCTION

Diabetes Mellitus (DM) is a chronic disease that constitutes a major public health concern in many countries. The overall number of people with diabetes is increasing globally, including in Indonesia. In 2024, an estimated 588.7 million people with diabetes in the world, and 20.4 million people with diabetes were in Indonesia¹. The data place Indonesia fifth globally in terms of diabetes prevalence¹. According to the Survei Kesehatan Indonesia (SKI) conducted in 2023, the province with the highest prevalence of type 1 diabetes was North Sulawesi and the province with the highest prevalence of type 2 diabetes was West Kalimantan².

Diabetes is a serious health problem that requires comprehensive treatment, especially in terms of early detection through blood sugar checks and lifestyle

management. Early detection helps people with diabetes access treatment more promptly. An important test for early diabetes detection is a blood sugar test³. Some blood sugar indicators that can be considered indicative of diabetes mellitus are blood sugar (GDS), which reaches 200 mg/dL, fasting blood sugar (GDP), which reaches 126 mg/dL, blood glucose 2 hours after meals, which reaches 200 mg/dL, and Hemoglobin A1c (HbA1c) which is more than 6.5%⁴.

Hyperglycemia can occur when blood sugar levels rise due to uncontrolled blood sugar. Uncontrolled hyperglycemia causes oxidative stress through the polyol pathway and the formation of glycated proteins, which contribute to complications such as hypertension, heart disease, and even death^{5,6}. One of the strategies for controlling blood sugar is nutritional therapy through

meal scheduling and food selection, such as dividing the total frequency of meals in a day into 6 times, with a division of three main meals and three light meals⁷. Additional approaches include selecting dietary fiber and protein sources that are slowly digested by the body. These efforts can reduce blood sugar spikes and increase satiety duration^{8,9}. The development of functional food products with these characteristics is essential to support a healthy diet for people with diabetes.

Cereals are food products made from flour, generally from grains or cereals that are rich in dietary fiber. Cereals can be formulated with a variety of other functional foods by utilizing local ingredients, such as millet and soybeans. Millet plants are local cereals with the potential to control DM due to their fiber content of 8% (foxtail millet type) and a relatively low glycemic index¹⁰. Meanwhile, soybeans with a vegetable protein content of 30.2%, low glycemic index, and high arginine content, which stimulates insulin secretion, are a functional food choice for helping regulate blood glucose^{11,12}.

Apart from the content, cereals have advantages in terms of simplicity and ease of consumption. This aspect is suitable for diabetics of all ages, from adults to the elderly. Formulating cereals with millet flour and

soybean flour also facilitates the development of products with the natural sweetness of soybeans and functional nutritional value for diabetics. Therefore, research on the development of cereal products formulated from millet and soybean flours was conducted to determine the effects of flour composition on dietary fiber, proximate content, and organoleptic properties of the cereal products for individuals with diabetes mellitus.

METHODS

Research Design

This research is an experimental study employing a Completely Randomized Design (CRD) with three treatment levels and two replications. The treatment applied to the cereal formulations in this study was variation in the proportion of millet flour relative to wheat flour. The three cereal formulations consisted of F1 (100%:0%), F2 (75%:25%), and F3 (50%:50%). This research received ethical approval from the Health Research Ethics Committee of Universitas Pembangunan Nasional "Veteran" Jakarta, with approval number 96/VI/2025/KEP, dated June 12, 2025. Table 1 shows the composition of cereals formulated from millet flour and soybean flour.

Table 1. Formulation of millet flour and soybean flour cereal

Ingredients	F1	F2	F3
Millet Flour (g)	100	75	50
Soybean Flour (g)	0	25	50
Cornstarch (g)	15	15	15
Margarine (g)	20	20	20
Sugar (g)	20	20	20
Vanilla Powder (g)	0,5	0.5	0.5
Water (ml)	60	60	60

Place and Time

The study was conducted over a five-month period, from February to June 2025. The production of millet flour and cereal products containing was carried out at the Food Technology Laboratory, Faculty of Health Sciences, Universitas Pembangunan Nasional "Veteran" Jakarta. The analysis of dietary fiber content was performed at the Balai Besar Standardisasi dan Pelayanan Jasa Industri Agro (BBSPJIA). Proximate analysis (water, ash, protein, fat, and carbohydrates) was performed at the Saraswanti Indo Genetech (SIG) Laboratory. Organoleptic testing was conducted among panelists in the Universitas Pembangunan Nasional "Veteran" Jakarta area.

Materials and Tools

The primary raw materials used for cereal production are millet flour derived from foxtail millet seeds marketed under the Four Brothers brand and soybean flour marketed under the "OSAMILK" brand.

Other materials used included cornstarch branded as "Maizenaku," granulated sugar branded as "Gulaku," margarine branded as "Palmia," vanilla powder branded as "Koepoe-koepoe," and water. Fiber content testing required reagents including buffer solution (MES-TRIS), α -amylase, protease, amyloglucosidase, HCl, 95% ethanol, 78% ethanol, acetone, and distilled water. Protein content testing required reagents including 0.02 N HCl solution, H₂SO₄ at a concentration of 95–98%, HgO (merck), low-grade NaOH–Na₂S₂O₃ solution ($\leq 5 \mu\text{g N/g}$), K₂SO₄, Na₂B₄O₇·10H₂O, H₃BO₃, methyl red indicator solution (100 mg methyl red solution in 100 ml methanol), bromocresol green indicator solution (100 mg bromocresol green solution in 100 ml methanol), boric acid solution, distilled water, and product samples. Fat content testing required reagents including hexane (boiling point 40°C–68.7°C), anhydrous diethyl ether, non-fat cotton, and product samples.

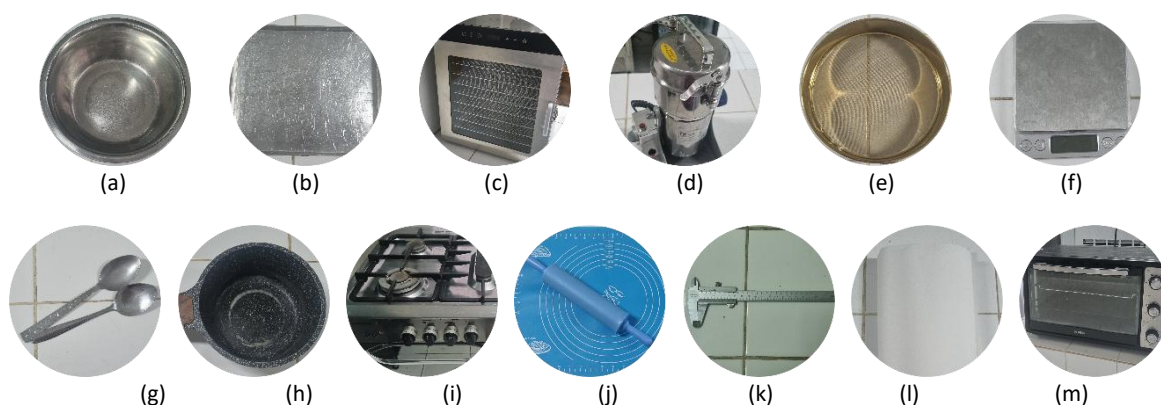


(a) Millet seeds, (b) Soybean flour, (c) Cornstarch, (d) Sugar, (e) Margarine, (f) Vanilla powder, (g) Water

Figure 1. Ingredients used in making millet flour and soybean flour cereal

The tools used included bowls, baking trays, a food dehydrator, a flour grinder, 70-mesh sieves, food scales, spoons, pans, a stove, a rolling pin, a caliper, baking paper, and an oven. Testing the fiber content required equipment including beakers, magnetic stirrers, aluminum foil, incubators, a furnace, desiccators, and analytical balances. Water testing required equipment including a closed weighing bottle, a desiccator, an oven, and an analytical balance. Testing ash levels required

equipment including porcelain crucibles, ovens, desiccators, a furnace, and analytical balances. Protein level testing required equipment including a 125 mL erlenmeyer flask, 25 mL/50 mL burettes, 30 mL/50 mL kjeldahl flasks, a kjeldahl heater, a distillation unit, an analytical balance, a digester, and digestion tubes with lids. Fat content testing required equipment including a Soxhlet extraction apparatus, a desiccator, fat-free filter paper, and an analytical balance.



(a) Bowl, (b) Baking tray, (c) Food dehydrator, (d) Flour grinder, (e) 70-mesh sieves, (f) Food scales, (g) Spoon, (h) Pan, (i) Stove, (j) Rolling pin, (k) Caliper, (l) Baking paper, (m) Oven

Figure 2. Tools for making millet flour and soybean flour cereal

Cereal Making

The process of making millet flour is the preliminary stage before cereal production. The millet flour production process was adapted from the optimized method reported by Sulistyaningrum et al. in 2017¹³ and is illustrated in Figure 1. The process begins with sorting to remove impurities. The seeds were then washed and soaked for 4 hours to facilitate endosperm softening, resulting in a finer flour texture. Subsequently, the seeds were dried in a food dehydrator at 60°C for 6 hours. The dried millet seeds were ground for 2 minutes to reduce particle size. The process concluded with sieving through a 70-mesh sieve to obtain a fine flour consistency.

The cereal production using millet flour and soybean flour illustrated in Figure 2 was adapted from the study by Kumalasari & Budiati in 2024¹⁴. The procedure began with weighing and combining millet flour and soybean flour according to the designated formulation in separate containers. Other dry ingredients, including cornstarch, sugar, and vanilla powder, were then added. After homogenizing the dry mixture, melted margarine and 60 ml of water were incorporated. All ingredients were mixed until a dough formed that was suitable for sheeting. The dough was flattened on baking paper to a thickness of <2 mm, cut into small squares, and baked at 145°C for 30 minutes.

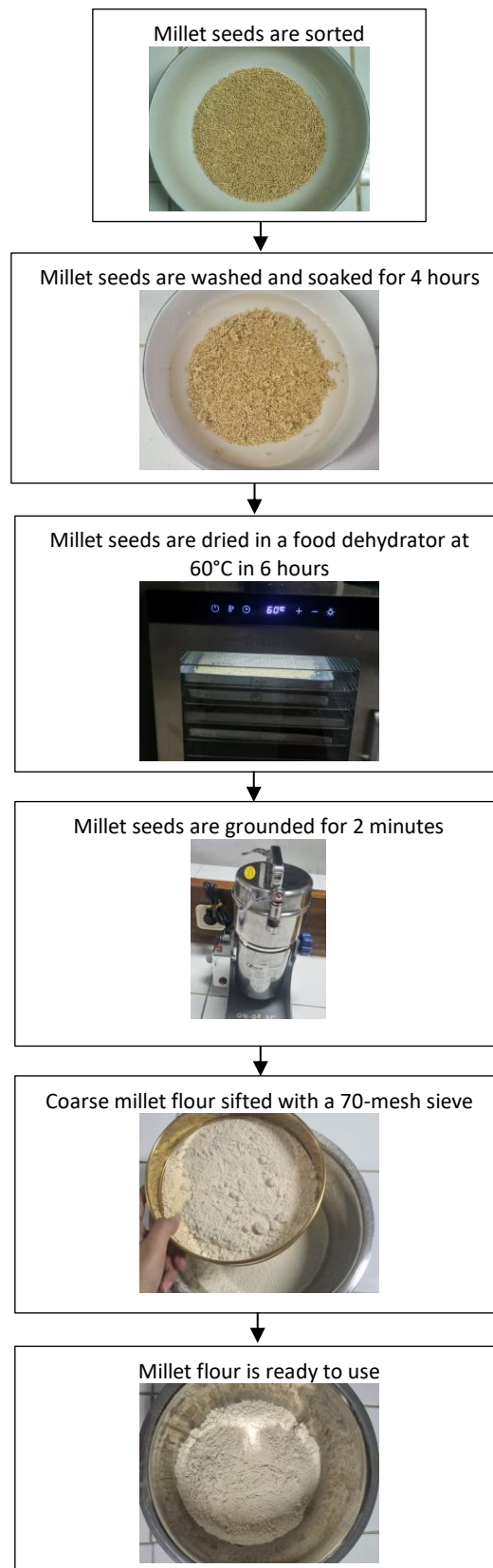


Figure 3. Flowchart for making millet flour

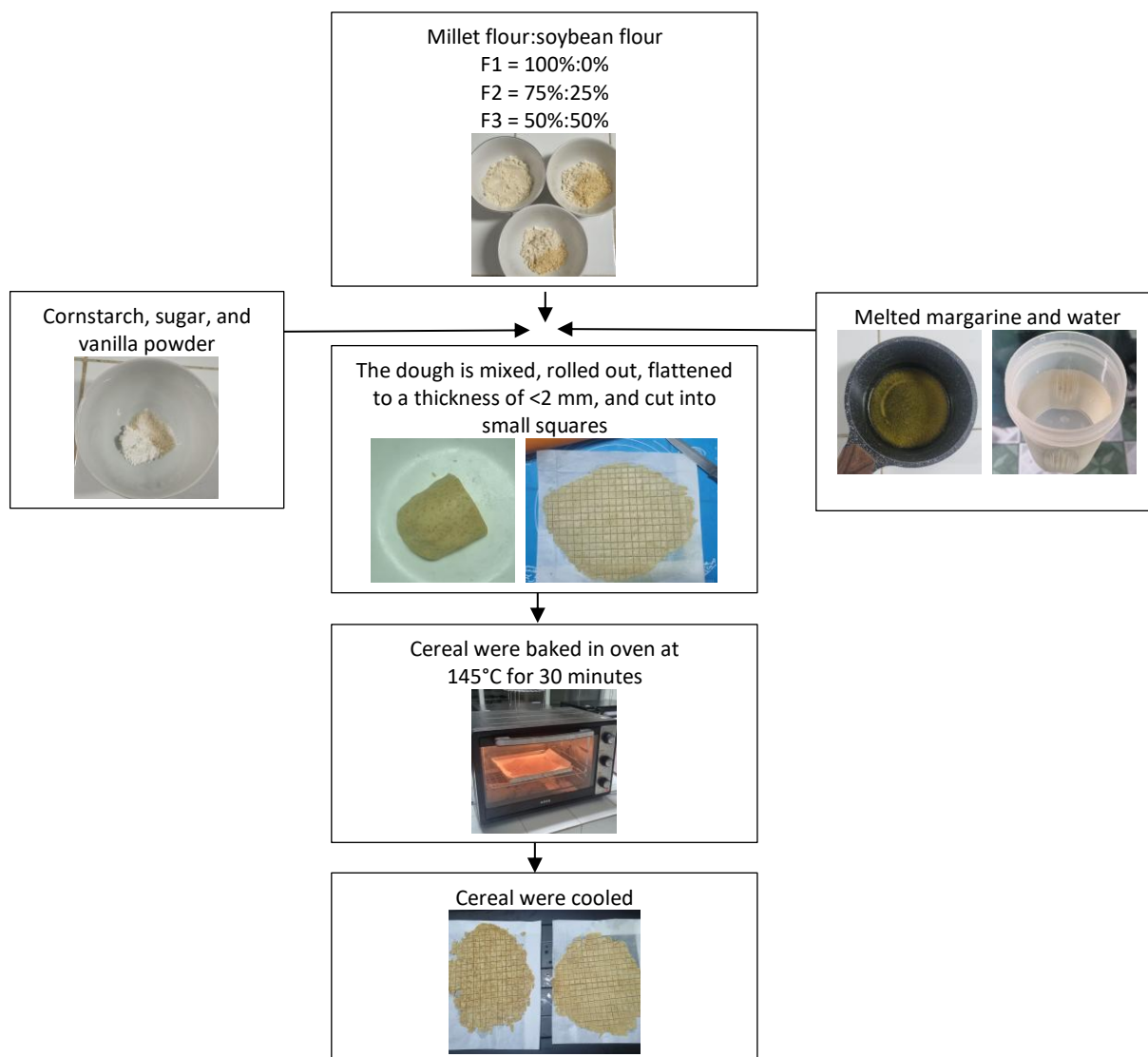


Figure 4. Flowchart for making millet flour and soybean flour cereal

Chemical Analysis

Dietary fiber analysis was carried out using an enzymatic–gravimetric method. The analysis process commenced with enzymatic digestion of the sample. One gram of the sample was dissolved in a MES–TRIS buffer (pH 8.2) and initially digested with α -amylase at 95–100°C. After cooling, digestion continued with the addition of protease and incubation at 60°C. The solution was then adjusted to pH 4–4.7, followed by the addition of amyloglucosidase and further incubation at 60°C to

complete starch hydrolysis. Subsequently, 95% ethanol was added to the solution (at a 4:1 ratio) to precipitate dietary fiber for 1 hour. The resulting residue was sequentially washed with 78% ethanol, 95% ethanol, and acetone. The washed residue was oven-dried at 105°C overnight, cooled, and weighed. In the final step, the residue was ashed at 525°C for 5 hours, cooled, and reweighed to determine the final residue weight. Dietary fiber content is calculated based on the following formula.

$$\text{Dietary fiber content (\%)} = \frac{\text{Sample weight after drying (g)} - \text{Sample weight after ashing (g)}}{\text{Initial sample weight (g)}} \times 100$$

The determination of water content is based on the principle that the sample's mass decreases as a result of moisture evaporation. The process begins with weighing 2 grams of a homogenized sample in an aluminum weighing dish. The sample was subsequently

dried in an oven maintained at 35±2°C for approximately 2 hours and 5 minutes. After drying was completed, the beaker was removed and cooled in a desiccator until it reached room temperature. The water content was calculated using the following formula.

$$\text{Water content (\%)} = \frac{\text{Final crucible+sample weight (g)} - \text{Initial crucible+sample weight (g)}}{\text{Initial sample weight (g)}} \times 100$$

Ash content was analyzed by incinerating the sample until white ash was obtained. This procedure begins with weighing 2 grams of the sample in a porcelain crucible, followed by incineration in a muffle furnace at 600°C for 2 hours until complete ash formation occurred.

$$\text{Ash content (\%)} = \frac{\text{Sample weight after ashing (g)}}{\text{Initial sample weight (g)}} \times 100$$

Protein levels were determined using the Kjeldahl method to measure total nitrogen as crude protein. The process commences with the digestion stage, during which the sample is weighed and digested for 60–90 minutes in a Kjeldahl flask with K₂SO₄, HgO, and H₂SO₄ until the digest became clear. After cooling and dilution, the solution was alkalized by adding NaOH–Na₂S₂O₃

$$\% \text{ Kjeldahl nit} = \frac{(\text{Sample titration} - \text{Blanko titration}) \times N \text{ Hcl} \times 14,01}{\text{Initial sample weight (g)}} \times 100$$

$$\text{Protein content (\%)} = \% \text{ Kjeldahl nit} \times \text{Conversion factor (5,70)}$$

The fat content was determined by the Soxhlet method, which is based on the principle of repeated reflux extraction using organic solvents. The procedure began with the hydrolysis of 5–10 g of the sample using concentrated HCl (at a 4:1 ratio) to liberate fat. After neutral filtration and oven drying, the sample was wrapped in filter paper, and fat-free cotton was placed

$$\text{Fat content (\%)} = \frac{\text{Sample weight after extraction (g)}}{\text{Initial sample weight (g)}} \times 100\%$$

The calculation of carbohydrate content in millet flour and soybean flour cereal was conducted using the by-difference method. The method determines

$$\text{Carbohydrate content (\%)} = 100\% - (\text{water} - \text{ash} - \text{protein} - \text{fat})\%$$

Organoleptic Trait Test

Organoleptic testing, also known as sensory testing, involves the use of sensory perception to evaluate a product's color, aroma, taste, and texture. The selected sensory test was the hedonic method to assess panelists' liking for the product. In this test, panelists were asked to provide subjective evaluations of the product's characteristics based on personal preference. The hedonic scale ranged from 1–5 (very dislike, dislike, neutral, like, and very like).

The panelists involved in organoleptic testing were untrained, with a total of 30 panelists, in accordance with the Standar Nasional Indonesia (SNI) 01-2346-2006¹⁵, which stipulates 30 non-standard panelists for organoleptic testing. The panelists in this research were students from the Nutrition Study Program, Undergraduate Program, at the Universitas Pembangunan Nasional "Veteran" Jakarta, who had received prior instruction or experience in organoleptic testing. The criteria for panelist participation were that they were willing to take part in the organoleptic test, in good health, had no allergies to the raw materials of the product being tested, and possessed normal sensory functions of sight, smell, and taste.

The organoleptic test flow began with an explanation of the product, including its raw materials

After the incineration was completed, the dish was cooled in a desiccator to room temperature. The ash residue was weighed, and the ash content was calculated using the following formula.

prior to distillation. The distillate was collected in 5 mL of boric acid (H₃BO₃) in an Erlenmeyer flask. The final step involved titration of the distillate (approximately 15 mL) using HCl 0.02 M until a gray endpoint was achieved, and the results were used to calculate protein content using the following formula.

into the Soxhlet apparatus. The extraction process (reflux) was subsequently performed using hexane as the solvent for approximately 5 hours. In the final step, the fat extract was transferred to the pre-weighed flask, and the solvent was evaporated to obtain the fat residue, which was weighed to calculate fat content using the following formula.

carbohydrate content by subtracting the contents of water, ash, protein, and fat. The carbohydrate content was calculated as follows.

that may cause allergies. Furthermore, prospective panelists were asked about allergy history, and only respondents without allergies to cereal ingredients were included. Panelists completed an informed consent form to serve as respondents in the organoleptic test of this study. Then, the panelists tasted three cereal formulations and completed an evaluation form indicating their level of preference for each cereal. The management of allergic reactions involved administering antihistamines and, if necessary, referring the respondent to the nearest health facility; all medical costs were borne by the researcher.

Data Analysis

The datasets were analyzed using Microsoft Excel and SPSS (Statistical Package for the Social Sciences). ANOVA (Analysis of Variance) was performed on proximate and dietary fiber data, followed by the Duncan Multiple Range Test (DMRT) when p-value < 0.05. Meanwhile, organoleptic test data were analyzed using the Kruskal–Wallis test and the Mann–Whitney post hoc test when a significant difference was observed (p-value < 0.05).

RESULTS AND DISCUSSIONS

Dietary Fiber

Dietary fiber is a component of a complex carbohydrate that is resistant to breakdown by digestive enzymes, because humans lack specific enzymes required for its digestion¹⁶. The results of the dietary fiber content of the three cereal formulas are presented in Table 2. The analysis showed that the dietary fiber content of F1–F3 ranged between 2.88% and 5.66%. Variance analysis

(ANOVA) yielded a p-value = 0.000 (p-value<0.01), indicating a very significant difference in the average dietary fiber among the three cereal formulas. This indicates that the variation in the composition of millet flour and soybean flour significantly affects the dietary fiber content of cereal products. In Duncan's post hoc test, it was found that the average dietary fiber content of each cereal formula differed significantly.

Table 2. Dietary fiber test results from the three cereal formulas of millet flour and soybean flour using the gravimetric enzyme method

Parameter	F1	F2	F3	Other Product ¹⁴
Dietary Fiber (%)	2.88±0.04 ^a	4.00±0.06 ^b	5.66±0.01 ^c	11.1%

a, b, c = similar letter notation on the same line means that there is no significant difference between formulas (p-value>0.05)

¹⁴ Kumalasari, I. D. & Budiarti, R. Analisis Sifat Fisiko-Kimia, Mikrobiologi, Dan Organoleptik Flakes Berbahan Dasar Tepung Sorgum (*Sorghum bicolor* L. Moench) dan Tepung Kacang Kedelai (*Glycine max.* L). JST (Jurnal Sains dan Teknologi) 13, 99–109 (2024). <https://doi.org/10.23887/jstundiksha.v13i1.69487>

The increase in dietary fiber content from F1 to F3 occurred in parallel with the increase in the proportion of soybean flour containing 30% dietary fiber and the decrease in millet flour with a dietary fiber content of 8.21%¹³. The formula with the highest soybean flour content resulted in the highest fiber content. The statement is consistent with the findings of Altiner & Hallaç in 2020¹⁷ and Baraja et al. in 2023¹⁸, which demonstrated that the cereal with the highest dietary fiber corresponded to the formula containing the greatest proportion of soybean flour. The high fiber content in soybeans is attributed to the outer cell wall (aryan shell), which contains high levels of cellulose, hemicellulose, and lignin, which constitute the main components of insoluble fiber^{19,20}. However, the dietary

fiber content of cereals in this study (2.88%–5.66%) remains lower than the results of the Kumalasari & Budiarti study in 2024¹⁴, which reported 11.1% for the 50:50 formula of sorghum flour and soybeans.

Proximate

As shown in Table 3, the parameters for water, ash, and proximate content are presented relative to the SNI standard for cereals 01-4270-1996²¹. The ANOVA analysis of ash, fat, protein, and carbohydrate content yielded p-values <0.05, indicating that each formula differs significantly. The Duncan test was subsequently performed and identified significant differences in the average levels of ash, protein, fat, and carbohydrates among each cereal formula.

Table 3. Proximate test results from the three cereal formulas of millet flour and soybean flour

Parameter	Proximate Test Results			SNI 01-4270-1996 ²¹
	F1	F2	F3	
Water (%)	3.92±0.42 ^a	4.50±0.90 ^a	4.81±1.43 ^a	Maks. 3.0
Ash (%)	0.90±0.92 ^a	1.52±0.28 ^b	2.38±0.50 ^c	Maks. 4.0
Protein (%)	8.20±0.35 ^a	12.07±0.44 ^b	17.48±0.95 ^c	Min. 5.0
Fat (%)	12.97±0.49 ^a	17.11±0.08 ^b	20.58±0.04 ^c	Min. 7.0
Carbohydrate (%)	74.02±0.33 ^a	64.80±1.39 ^b	54.76±2.46 ^c	Min. 60.0

a, b, c = similar letter notation on the same line means that there is no significant difference between formulas (p-value>0.05)

²¹Badan Standardisasi Nasional. SNI 01-4270-1996 Syarat Mutu Susu Sereal. (1996)

The water content of cereals in formulas F1, F2, and F3 was 3.92%, 4.5%, and 4.81%, respectively, showing an increase in parallel with the addition of soybean flour, which exhibited a higher water content (8.52%–9.15%) than millet flour (6.23%)^{13,22}. Despite the trend of increasing water content, ANOVA analysis indicated a p-value of 0.696 (p-value > 0.05), indicating that the difference between the formulas was not statistically significant and that a follow-up DMRT was not required. The increased water content is likely associated with the hydrophilic properties of the proteins and soluble fiber in soybeans, which bind greater amounts of water^{23,24}. These results are consistent with the findings of Puspita et al. in 2021²⁵ demonstrating that the addition of soybean flour increases the water content of biscuit products. The water content observed in the present study was lower than that of cereals made from 100% millet flour reported by Indrastuti et al. in 2023²⁶.

However, the water content of all formulas (3.92%–4.81%) exceeded the maximum limit of 3% specified by SNI 01-4270-1996²¹ for ready-to-consume cereals.

The ash content of cereals F1, F2, and F3 was 0.9%, 1.52%, and 2.38%, respectively, indicating an increase with increasing proportions of soybean flour, which possesses a higher ash content than millet flour. The ANOVA analysis (p-value = 0.000) demonstrated a very significant difference between the formulas, and the Duncan test confirmed that all formulas differed significantly in average ash levels. This increase in ash content is directly associated with the mineral content of the raw material. Soybean flour contains about 5.71% more ash than millet flour (2.12%–2.91%)^{27,28}. The higher ash content can be attributed to soybean plants ability to absorb and store minerals from the soil²⁹. This is consistent with the research by Suriany et al. in 2020³⁰, which reported an increase in ash content in noodles as

soybean flour use increased. All cereal formulas in this study remain compliant with the SNI 01-4270-1996 standard²¹, which sets a maximum ash content of 4%, and exhibit lower ash content than the control formula of 100% sorghum (3.26%) reported in the Kumalasari & Budiati study in 2024¹⁴.

The protein content of cereal formulas F1, F2, and F3 ranged from 8.2%-17.48%. These results indicated a significant increase with increasing proportions of soybean flour, as shown by the ANOVA (p -value=0.002) and the Duncan test, which revealed significant differences between the formulas. This is consistent with the characteristics of the raw materials. Soybean flour contains a high protein content (53.37%) compared to millet flour (7.3%-9.17%)^{28,31}, so its addition directly enhances the protein content of the product. Supporting evidence is provided in Utomo & Muslimah study in 2019³², which reported an increase in protein levels in bronchi in accordance with the increased use of soybean flour. All formulas in this study fulfilled the SNI 01-4270-1996 quality standard²¹, which stipulates a minimum of 5% protein per 100 grams of product. Moreover, the F1–F3 protein levels in this study were higher than those of cereals made from 100% sorghum reported in the Kumalasari & Budiati study in 2024¹⁴ which only contained 4.79% protein.

The fat content of cereal formulas F1, F2, and F3 ranged from 12.97% to 20.58%, respectively. A statistically significant increase from F1 to F3 was observed based on the ANOVA results (p -value=0.000), which indicates that the difference in the amount of millet flour and soybean flour significantly affects fat content. Duncan's further test confirmed that the differences between the formulas were statistically significant. This increase in fat content is consistent with the higher fat content of soybean flour (23.10%) than millet flour (3.48%)^{31,33}. Research by Serafialy et al. in 2024²⁷ supports the conclusion that adding soybean flour increases the product's fat content. All three cereal

formulas comply with the SNI 01-4270-1996 standard²¹, which establishes a minimum fat content of 7%. Nevertheless, the fat content of this product remains lower than that of the 100% sorghum flour control cereals reported in the Kumalasari & Budiati research in 2024¹⁴ that reached 23.7%.

The carbohydrate content in cereals from F1 to F3 declined from 74.02% to 54.76%. The ANOVA (p -value=0.003) and Duncan test indicated significant differences between the formulas attributable to variations in flour composition. This decrease in carbohydrate content is consistent with the reduction in the proportion of high-carbohydrate millet flour (75.33%) and the increase in soybean flour, which has a lower carbohydrate content (21.74%)^{31,33}. This finding is supported by Aryanti et al. in 2024^{34–34} regarding the increase in millet flour in noodle products resulting in an increase in carbohydrate content. According to SNI 01-4270-1996²¹, quality cereals are required to contain at least 60% carbohydrates, so only F1 and F2 satisfy the quality criteria. Meanwhile, when compared with 100% millet cereals reported by Indrastuti et al. in 2023²⁶ that contain 75.52% carbohydrates, the carbohydrate content in cereal products in this study is lower.

Organoleptic Test

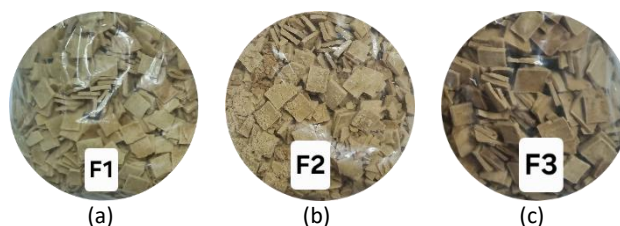
The results of the hedonic analysis of cereal jelly flour and soybean flour formulations are presented in Table 4. The result indicated a p -value>0.05 in the Kruskal-Wallis test for the color and aroma parameters, while a p -value<0.05 was observed in texture and taste. The Mann-Whitney test indicated that, for the texture parameters, significant differences were observed between F1 and F2, and between F1 and F3, but not between F2 and F3. In the taste parameters, significant differences were observed between F1 and F2, and between F1 and F3, while no significant difference was observed between F1 and F3.

Table 4. The test results of the preference level of millet flour and soybean flour cereal based on untrained panelists

Parameter	Median Value of Hedonic Test		
	F1	F2	F3
Color	3(2-5) ^a	4(3-5) ^a	3(1-5) ^a
Texture	3(2-5) ^a	4(2-5) ^{bc}	4(2-5) ^c
Aroma	3(2-5) ^a	3-4(2-5) ^a	3(2-5) ^a
Taste	3(2-4) ^a	4(1-5) ^{bc}	4(1-5) ^c

1 = very dislike, 2 = dislike, 3 = neutral, 4 = like, 5 = very like

a, b, c = similar letter notation on the same line means that there is no significant difference between formulas (p -value>0.05)



(a) F1=100% millet flour:0% soybean flour, (b) F2=75% millet flour:25 soybean flour,
(c) F3=50% millet flour:50% soybean flour

Figure 5. Millet flour and soybean flour cereal

With a p-value > 0.05 in the Kruskal-Wallis test, it can be inferred that there is no significant difference in cereal color between the formulas, so a follow-up Mann-Whitney test is not required. The light brown color is attributed to the millet flour as main ingredients, which exhibits a high degree of whiteness (white degree value 76.47–79.17), and soybean flour, which has a creamy appearance and a lower white degree value of 29.82^{35,36}. Flour with a lower degree of whiteness produces a darker color; therefore, an increased proportion of soybean flour results in a browner cereal appearance. F1 has the lightest color, and F3 is the darkest. In addition, browning is influenced by the Maillard reaction that occurs during baking, a reaction induced by high temperatures involving reducing sugars and amino acids. The intensity of the resulting color increases with increasing temperature and heating time^{22,37}.

The results of the Kruskal-Wallis test indicated a p-value<0.05, demonstrating that the cookie texture differed significantly between the formulas. Mann-Whitney's follow-up test identified significant differences between F1 and F2 and between F1 and F3, while the textures of F2 and F3 did not differ significantly. Cereals made from millet flour and soybean flour exhibit a hard texture and a slightly crunchy characteristic, but are softer in F2 and F3 due to the increased soybean flour content. The texture is influenced by baking time, cereal thickness, and raw materials. Starch is the primary determinant of product hardness; millet flour contains 57–61% starch, while soybean flour contains only 14.85%^{38,39} so formulas with more millet flour exhibit greater hardness. This finding is consistent with Setyawan & Purwani's research in 2024⁴⁰, which reported that bread becomes harder with the addition of millet flour. Amylose in starch, which has a linear structure and strong intramolecular bonding, limits water absorption, thereby increasing product hardness. In addition to starch, the fat content also influences texture. Fat functions as a shortening, enhancing porosity and binding water^{41,42}. Millet flour contains 1.09% fat¹³, while soybean flour contains a substantially higher fat content of 38.65%³¹, so the increase in soybean flour in the formula results in a softer cereal texture.

Aroma analysis using the Kruskal-Wallis test yielded non-significant findings (p-value > 0.05), indicating no difference in aroma between the formulas, so the Mann-Whitney test was not conducted. The cereals in this study exhibited a savory aroma with a slight sweetness, influenced by raw materials such as margarine. Millet flour imparts a dominant unsalted aroma, while soybean flour contributes a strong peanut aroma⁴⁰. F1 formulas that contain only millet flour tend to emphasize margarine and milk aromas, while F2 and F3 exhibit a nuttier profile. The aroma of F2 was preferred to F3 due to its lower soybean flour content. These results are consistent with the study of Anindita et al. in 2023⁴⁸, which reported that increasing soybean flour in the product reduced panelists preference for aroma.

The final Kruskal-Wallis test was applied to flavor

parameters and indicated a p-value<0.05, demonstrating a significant difference between the cookie formulas. The Mann-Whitney follow-up test confirmed a significant difference between F1 and F2 and F3, while F2 and F3 did not differ significantly. F1 cereal exhibits a savory flavor with a milky note, consistent with its aroma. F2 and F3 exhibit a soybean flavor that intensifies with the addition of soybean flour. All three formulas produce a gritty mouthfeel, likely attributable to the coarse fibers in millet flour that do not fully dissolve and remain perceptible during mastication⁴³.

Best Formula

The weight of the specified value for dietary fiber and protein is 0.2; for fats and carbohydrates is 0.1; for taste and texture is 0.15; and for color and aroma it is 0.05. The Productivity Value (NP) produced by cereals F1 to F3 is 0.13 consecutively; 0.67; and 0.8. The lowest NP is in F1, and the highest NP is in F3. Therefore, the best formula for cereals in this study, based on nutritional and organoleptic properties, is formula 3, which differs in composition by 50% millet flour and 50% soybean flour.

Serving Size

The nutritional cereal content of millet flour and soybean flour, per serving, is presented in Table 5. In this study, the product dosage was established based on the best formula, namely F3. BPOM regulations in 2021⁴⁴ stipulate that the ideal serving size for cereals is 20–50 grams. Table 5 presents the nutritional value of F3 cereals based on the serving size (50 grams) and a comparison with the Acuan Label Gizi (ALG). F3 cereal of 50 grams contains 236.61 kcal of energy (11% ALG), 8.74 grams of protein (14.57% ALG), 10.29 grams of fat (15.36% ALG), 27.38 grams of carbohydrates (8.43% ALG), and 2.83 grams of dietary fiber (9.43% ALG). Compared with other foods, one serving of F3 cereal is nutritionally equivalent to 2 whole loaves of bread, 1 chicken egg, and 1 tablespoon of butter^{45,46}.

This cereal product of millet flour and soybean flour may be consumed with low-sugar liquids, such as cow's milk without added sugar and pure soy milk without added sugar. Milk is selected because it contains protein and is recommended to be low in sugar, to avoid increasing daily sugar intake and reduce the risk of blood glucose spikes. In addition, milk helps to soften cereals, facilitating consumption, especially for the elderly.

According to BPOM Regulation Number 1 of 2022⁴⁷ regarding Pengawasan Klaim pada Label dan Iklan Pangan Olahan, food is classified as a source of dietary fiber if it contains 3% dietary fiber. F3 cereals contain 5.66% dietary fiber, so it can be concluded that cereal products in this study qualify as foods that are sources of dietary fiber. Furthermore, protein sources are defined as foods containing 20% ALG. F3 cereals in this study contain 17.48% protein, or the equivalent of 29% ALG, so it can be concluded that cereal products in this study also qualify as protein sources.

Table 5. Nutritional value of the best cereal formula of millet flour and soybean flour based on serving measurements according to BPOM Regulation Number 1 of 2022

Nutritional Value	Nutritional Value/ 100 g	Nutritional value/ 50 g	ALG ⁴⁷	%ALG/ Serving Dosage
Energy	473.21	236.61	2150	11%
Protein	17.48	8.74	60	14.57%
Fat	20.58	10.29	67	15.36%
Carbohydrate	54.76	27.38	325	8.43%

⁴⁷Badan Pengawas Obat dan Makanan. Peraturan Badan Pengawas Obat Dan Makanan Nomor 1 Tahun 2022 Tentang Pengawasan Klaim Pada Label Dan Iklan Pangan Olahan. (2022)

Research Advantages and Disadvantages

The advantage of this study is that the fiber assessed was dietary fiber, whose analysis results include soluble fiber and insoluble fiber, as opposed to crude fiber, whose method removes soluble fiber. Soluble fiber plays a crucial role in individuals with diabetes because it helps regulate blood glucose levels by slowing postprandial absorption. Meanwhile, a limitation of this study is that the consumption trial of cereal made with millet flour and soybean flour was not conducted among individuals with diabetes. Therefore, the product's efficacy in glycemic regulation among individuals with diabetes has not been clinically evaluated.

CONCLUSIONS

The comparison of the composition of millet flour and soybean flour significantly influences the dietary fiber, ash, protein, fat, carbohydrates, texture, and taste of cereals. However, the composition does not significantly influence water content, color, or aroma. Formula 3 was identified as the optimal cereal formulation using the de Garmo method, based on superior dietary fiber content, proximate content, and organoleptic characteristics.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The first author and the other authors declare no conflicts of interest with respect to this article. The study was entirely self-funded.

AUTHOR CONTRIBUTIONS

SSM: concepthor, methodology, data collector, analysis and interpretation, manuscript drafting, revision and editing; AF: concepthor, methodology, writing-review, supervision, editing; NN: writing-review, supervision, editing.

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