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Formulation of Bagelen With Mung Bean Flour Substitution as an Alternative Snack for Obesity

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***Abstract*—Obesity remains a nutritional problem in Indonesia. Diet therapy for obesity can be achieved through a high-fiber diet. One potential source of fiber is mung bean flour. Bagelen products with mung bean flour substitution have the potential to be developed into high-fiber products for obesity. The purpose of this study was to analyze the sensory properties and nutritional content of Bagelen formulations with mung bean flour substitution. This study used a completely randomized experimental Design conducted from August to November 2025. Product development and organoleptic testing were carried out in the nutrition laboratory, Universitas Muhammadiyah Cirebon. There were three Bagelen formulation treatments with different ratios of wheat flour to mung bean flour, including F1 (80:20), F2 (70:30), and F3 (60:40). The variables analyzed included organoleptic properties (30 panelists) and nutritional content (moisture, ash, protein, fat, carbohydrate, crude fiber, and energy). Data was analyzed using the ANOVA and Kruskal-Wallis tests. The results showed that mung bean flour substitution significantly affected hedonic organoleptic characteristics, including color, aroma, taste, texture, aftertaste, and overall acceptability ($p<0.05$). F1 is a selected formula with a nutritional content of 418.70 kcal of total energy, 4.67 kcal of water, 1.38 kcal of ash, 15.64 g of fat, 8.36 g of protein, 62.71 g of carbohydrates, and 7.23 g of fiber per 100 g. F1 also qualifies as a high-fiber food product. A Bagelen made with a mung bean flour substitute has the potential to be a healthy, high-fiber snack alternative for obese individuals.**

Keywords— ***Bagelen; Formulation; Fiber; Mung bean flour; Obesity***

I. INTRODUCTION

Obesity remains a significant public health concern in Indonesia, with the prevalence among adults continuing to rise. Recent national health data indicate that the proportion of Indonesian adults classified as obese increased to approximately 23.4 % in 2023, reflecting an upward trend compared with earlier surveys [1]. Obesity is a complex, multifactorial condition characterised by excess adipose tissue accumulation resulting from sustained positive energy balance, whereby caloric intake consistently exceeds energy expenditure [2]. This imbalance predisposes individuals to an elevated risk of non-communicable diseases, reduced quality of life, and increased healthcare burden [3].

Dietary interventions constitute a core component of obesity management, with nutrient composition playing a crucial role in modulating energy intake and body weight [4]. High-fibre diets have been associated with beneficial effects on weight control through several mechanisms, including increased gastric distension, delayed gastric emptying, enhanced satiety, and modulation of gut microbiota fermentation, which can collectively reduce overall energy consumption and influence adiposity [5], [6]. Adequate daily intake of dietary fibre is recommended to support these effects, with global guidelines suggesting at least 30 g per day for adults to promote optimal digestive health and contribute to weight management. Furthermore, food products may be classified as high-fibre if they contain at least 6 g of fibre per 100 g [7].

Mung beans are rich in dietary fiber and resistant starch and can increase total fiber content [8]. Whole mung beans contain approximately 3.8% crude fiber. Several studies have shown that mung beans are a good source of dietary fiber and resistant starch, contributing to a low glycemic index and increased satiety [9]. The integration of high-fibre ingredients, such as mung bean flour, in energy-controlled food products offers a promising dietary strategy to address obesity by enhancing satiety and potentially reducing total energy intake, thereby aligning with broader nutritional interventions aimed at mitigating the growing burden of obesity in the general population.

Bagelen is a traditional Indonesian dry bread product widely consumed as a snack, typically made with wheat flour as the primary ingredient. In recent years, there has been a growing interest in improving the nutritional quality of bakery products by incorporating alternative flours with enhanced functional properties. Substituting a portion of wheat flour with mung bean flour is expected to enhance the dietary fibre content of Bagelen, thereby increasing its potential as a fibre-rich snack product. This modification not only diversifies the raw material base but also supports the development of value-added bakery products with improved nutritional profiles. This study aims to evaluate the sensory characteristics of various Bagelen formulations, determine their nutritional composition, and assess the nutrient contribution of the selected formulation.

II. METHOD

Research Design

This study was a laboratory experiment using a completely randomized design with one factor and two replications. The factors used were the addition of mung bean flour at three levels (20%, 30%, and 40%). This study was carried out from August to November 2025. Product preparation and sensory evaluation were conducted at the Nutrition Laboratory of the Nutrition Study Program, Muhammadiyah University of Cirebon. Analysis of the nutritional content was conducted at Chem-Mix Pratama Laboratory in Yogyakarta.

Bagelen Preparation

The ingredients for Bagelen were purchased at traditional markets in Cirebon Regency, West Java, Indonesia. The ingredients included mung bean flour, wheat flour, eggs, granulated sugar, powdered milk, margarine, yeast, salt, and

wheat flour were F1 (20:80), F2 (30:70), and F3 (40:60). The formula for making Bagelen is shown in Table 1. The product was made by mixing all the ingredients, including eggs, granulated sugar, powdered milk, and yeast, according to the specified measurements. These ingredients were then mixed on low speed with a mixer. Margarine was then added to the dough and mixed until smooth. The dough was then poured into molds and left to rest for 40 minutes. The dough was baked at 150 degrees Celsius for 45 minutes. It is then allowed to rest at room temperature for 30 minutes, and then sliced into 1.5-centimeter-thick slices. The bread was then smeared with cream and baked at 120 degrees Celsius for 60 minutes.

TABLE 1. FORMULATION (g) OF BAGELEN WITH DIFFERENT RATIOS OF MUNG BEAN FLOUR AND WHEAT FLOUR

Ingredient	**Formula**		
	F1 (20:80)	**F2 (70:30)**	**F3 (60:40)**
Mung bean Flour	80	120	160
Wheat Flour	320	280	240
Eggs	40	40	40
Sugar	81	81	81
Milk Powder	13	13	13
Margarine	76	76	76
Yeast	5	5	5
Salt	2	2	2
Fresh Milk	130	130	130

Sensory Evaluation

The sensory evaluation used was a hedonic test. This test was conducted on 30 semi-trained panelists. The panelists were nutrition students from Universitas Muhammadiyah Cirebon who met the inclusion criteria. Inclusion criteria included having received a one-hour lecture on sensory evaluation methods, having no allergies, being in good health, not being color blind, and having no deficiencies in the sense of taste or smell. Before the test, the panelists were asked to sign an informed consent after an explanation. The sensory evaluation was conducted in an organoleptic testing laboratory with individual testing booths equipped with adequate lighting and free from odors. The panelists were given drinking water during the sensory testing to neutralize their taste perception. Samples were presented to the panelists on plastic plates. Each sample was randomly assigned a three-digit code to prevent panelists from identifying each sample. The panelists were asked to provide a hedonic test for each sample using the provided testing form. The hedonic test form uses a scale of 1 to 9, with 1 being the lowest and 9 the highest.

Nutrient Analysis

The nutrients evaluated in this study consisted of moisture, ash, protein, fat, carbohydrates, crude fiber, and total energy. Moisture content was measured by oven-drying. Ash content was determined by incinerating the sample. Fat levels were assessed using the Soxhlet extraction technique. Protein content was analyzed by the Kjeldahl method. Carbohydrate levels were calculated by difference. Crude fiber was measured gravimetrically after acid and alkaline hydrolysis. Total energy content was estimated using standard calculation methods.

Analysis of Selected Formula

The selected formula was evaluated using an exponential comparison approach. The parameters considered included the results of the hedonic (sensory preference) test and the nutritional composition. Each parameter was assigned a specific weight based on product considerations, as follows: color (5%), aroma (10%), taste (10%), texture (10%), aftertaste (5%), moisture (5%), ash (5%), fat (10%), carbohydrates (10%), protein (10%), and fiber (20%). Each component was then ranked. The formula that showed the highest preference and nutrient content for a given parameter received the lowest rank value. The final score was determined by multiplying each parameter's assigned weight by its ranking. The formula with the lowest overall score was selected as the best formulation.

Data Analysis

Microsoft Excel and SPSS Statistics for Windows were used to process and analyze the data. Descriptive analysis of sensory and nutritional parameters was performed by determining the mean and standard deviation (SD). Further statistical evaluation was conducted using Analysis of Variance (ANOVA) with Duncan's post hoc test, provided the data met the assumptions of normality and homogeneity of variance. When these assumptions were not met, the non-parametric Kruskal–Wallis test was applied, followed by the Mann–Whitney post hoc test. Statistical significance for all parameters was established at a 95% confidence level ($p < 0.05$).

III. RESULTS AND DISCUSSION

Sensory test results

The sensory evaluation analyzed in this study was a hedonic test. This test was conducted to determine the panelists' preferences and level of liking for the product. The results of the hedonic test analysis are presented in Table 2. The results of the difference test showed significant differences in color, aroma, taste, texture, and overall attributes (p-value < 0.05). Formulas 1 and 2, containing 20% and 30% mung bean flour, respectively, had the highest hedonic test scores and did not differ significantly across all test attributes. However, the addition of 40% mung bean flour to formula F3 showed the lowest test scores and was significantly different from F1 and F2.

TABLE 2. SENSOY EVALUATION OF BAGELEN WITH DIFFERENT RATIOS OF MUNG BEAN FLOUR AND WHEAT FLOUR

Sensory attributes	Formula			p-value
	F1 (20:80)	F2 (30:70)	F3 (40:60)	
Color	6,8±1,6 [a]	7,2±0,9 [a]	4,9±0,9 [b]	0,000
Aroma	6,6±1,3 [a]	6,5±1,2 [a]	5,1±1,0 [b]	0,000
Taste	6,8±1,4 [a]	6,9±1,1 [a]	5,1±1,2 [b]	0,000
Texture	6,4±1,7 [a]	6,8±1,2 [a]	5,0±1,4 [b]	0,000
Overall	6,7±1,5 [a]	6,9±1,0 [a]	5,3±1,3 [b]	0,000

[a,b]Means with the same letters in the same row indicate no significant difference at $\alpha = 5\%$

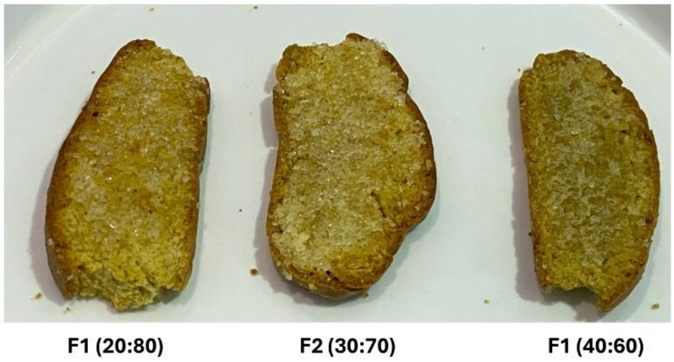

FIGURE 1. BAGELEN PRODUCT WITH DIFFERENT RATIOS OF MUNG BEAN FLOUR AND WHEAT FLOUR

The findings of this study reveal that formulations F1 and F2, which had the lowest proportions of mung bean (20% and 30%), received the highest preference ratings from panelists across all hedonic attributes compared with F3. The result suggests that products made with lower levels of mung bean flour are more appealing to panelists. Similarly, other study reported that substituting wheat flour with higher levels of mung bean flour decreased panelists' acceptance of aroma, taste, and overall product preference. A formulation using a mung bean flour-to-wheat flour ratio of 25:50 was the most favored and was suggested as a potential alternative to reduce the proportion of wheat flour in brownie products [10]. In a study on pie crust formulations, the incorporation of 25% mung bean flour achieved the highest hedonic ratings for colour, aroma, taste, and texture. In contrast, higher levels of mung bean flour were associated with lower consumer acceptance [11]. The study by Nurhayati et al. also reported that mung bean flour can be effectively incorporated into dry choux pastry at moderate substitution levels (25–50%). The result also revealed that preference decreased at higher substitution levels, mainly because of significant changes in taste induced by the added mung bean flour [12].

Higher proportions of mung beans in the formulation were associated with a stronger beany taste and can reduce preference scores. Panelists often regard the characteristic beany flavour of mung beans and other legumes as an undesirable off-flavour, which can restrict product acceptance, particularly when used at elevated levels. These beany characteristics are largely attributed to volatile aldehydes formed through lipid oxidation, especially hexanal, which originates from linoleic acid via the lipoxygenase pathway during processing and storage [13]. During storage, mung bean–based products may accumulate hexanal and related volatile compounds, intensifying the "bean-like" aroma and diminishing overall flavour quality [13], [14].

Nutrient Content

The results of the product nutritional content analysis are presented in Table 3. The results show significant differences in all product content attributes ($p<0.05$). The highest water, ash, and fat content was found in formula 3, while the highest protein, carbohydrate, crude fibre, and energy content was found in formula 1.

TABLE 3. NUTRIENT CONTENT OF BAGELEN WITH DIFFERENT RATIOS OF MUNG BEAN FLOUR AND WHEAT FLOUR

Nutrient attributes	Formula			p-value
	F1 (20:80)	F2 (30:70)	F3 (40:60)	
Moisture (g)	4,7±0,1 [a]	7,6±0,1 [b]	8,3±0,1 [c]	0,000
Ash (g)	1,4±0,0 [a]	1,5±0,0 [ab]	1,7±0,1 [b]	0,050
Protein (g)	8,4±0,2 [a]	7,6±0,1 [b]	7,2±0,0 [c]	0,006
Fat (g)	15,6±0,1 [a]	15,9±0,1 [a]	17,0±0,0 [b]	0,001
Carbohydrate (g)	62,7±0,4 [a]	61,9±0,2 [a]	59,5±0,4 [b]	0,005
Crude Fiber (g)	7,2±0,4 [a]	5,6±0,1 [b]	6,3±0,1 [c]	0,000
Energy (kcal)	418,7±0,4 [a]	414,1±0,3 [b]	413,3±1,1 [b]	0,008

According to the moisture analysis, F3 exhibited the highest moisture level among the formulations (8,3%). The moisture content of baked products is affected by baking temperature and duration. The higher temperatures and longer heating times increase the amount of heat transferred by the air, thereby promoting greater water evaporation from the product surface [15]. In addition to processing conditions, the formulation itself may also influence moisture levels. F3, which contains the greatest proportion of mung bean flour, may have contributed to its higher moisture content [8], [16]. Moreover, the inclusion of ingredients with naturally high moisture content, such as milk and eggs, could further explain the elevated moisture level observed.

The ash content analysis revealed that F3 had the highest ash level among all formulations (1.7%). This finding suggests that increasing the proportion of mung bean flour in the formulation contributes to a higher ash content in the final product. Ash content in food is an indicator of total mineral composition. Mung bean flour is recognized as a good source of minerals, with reported contents of mung bean samples in mg/kg dry weight were in the range of calcium (1418.02-1698), magnesium (2422-2492.4), sodium (88.9-106.7), potassium (3670-3716.8), iron (196.2-235.5), and zinc (72-103) [17].

Formula 1 contained the highest protein level among the samples (8.4%). The protein content of Bagelen products is affected by the formulation of the ingredients used. In this product production, major protein sources include mung bean flour, eggs, fresh milk, and wheat flour. In this study, the protein content declined from F3 to F1 as the proportion of wheat flour decreased and was increasingly replaced by mung bean flour. Other research also shows that reducing the proportion of wheat flour lowers the protein content of purple sweet potato cookies [18]. The overall protein level is also associated with the protein contribution of wheat flour, particularly its gluten content. Gluten proteins constitute approximately 75–80% of the total protein content in wheat and are of critical importance due to their unique viscoelastic properties. These functional characteristics play a fundamental role in the structure and quality development of a wide range of food products, particularly baked goods [19].

Based on the fat content test results, F3 had the highest fat content (17.0%). Mung bean flour is naturally low in fat. The fat content of mung beans ranged from 0.33 to 2.45 % [8]. The increased fat content can also be influenced by the composition of other supporting ingredients, namely, margarine and eggs. In gluten-free mung bean biscuits, each formulation contained the same amount of margarine (125 g), which contributed substantially to the overall fat and energy content [20]. In complementary food products formulated with mung beans and supplemented with palm oil, the total fat content frequently surpassed regulatory standards, with the excess fat clearly associated with the added oil rather than the legume-based flour [21].

The results of the carbohydrate and dietary fiber analyses indicated that Formula 1 (F1) had the highest levels of both carbohydrates (62,7%) and crude fiber (7,2%) among the test formulas. This elevated carbohydrate content is likely associated with the greater proportion of wheat flour in F1, as wheat flour is characterized by high starch content and contributes significantly to total carbohydrate in composite products. Recent studies on flour blends have demonstrated that variations in the cereal-to-legume ratio can markedly influence the carbohydrate and fiber composition of the final product, with higher cereal proportions generally increasing carbohydrate levels [22]. Additionally, the elevated dietary fiber content in F1 may be attributed to the inclusion of mung bean flour, which has a higher intrinsic fiber concentration than wheat alone, thereby enhancing the overall fiber content of the composite formulations.

Consistent with these compositional differences, F1 also had the highest energy content among the tested formulas (418,7 kcal). The total energy in food products depends on the combined contributions of macronutrients (carbohydrates, proteins, and fats), which serve as the primary sources of metabolizable energy. Carbohydrates and proteins each provide approximately 4 kcal per gram, while fats provide about 9 kcal per gram, making the relative proportions of these macronutrients key determinants of total energy value. In the present study, F1's relatively higher carbohydrate and protein content likely contributed significantly to its greater energy content compared with the other formulas, reflecting established relationships between proximate composition and caloric value in food product development [23].

Selected Formula

The selected formulations were evaluated using an exponential comparison method, a weighted scoring approach that integrates multiple criteria to identify the most suitable formulation. This type of multi-criteria evaluation is conceptually similar to established multi-criteria decision analysis techniques, which are frequently applied in food product development to balance sensory and nutritional attributes across alternative formulations systematically. This approach enables researchers to prioritize formulations by assigning relative weights to each criterion and ranking alternatives based on composite scores derived from those weights. In this study, the exponential comparison analysis (Table 4) revealed that Formula 1 (F1) achieved the lowest total score (1.4), indicating superior performance across the evaluated parameters and warranting its selection as the optimal formulation. The exponential comparison method effectively synthesized sensory and nutritional criteria into a single comparative index, facilitating objective selection of the best formula among multiple options. The use of weighted ranking and scoring in such decision frameworks has been demonstrated to improve the rigor and transparency of formulation selection in food science research [24].

TABLE 4. SELECTED FORMULA OF BAGELEN WITH DIFFERENT RATIOS OF MUNG BEAN FLOUR AND WHEAT FLOUR

Attributes	Weight value	Rank			Score		
		F1	F2	F3	F1	F2	F3
Color	5%	2	1	3	0,1	0,05	0,15
Aroma	10%	1	2	3	0,1	0,2	0,3
Taste	10%	2	1	3	0,2	0,1	0,3
Texture	10%	2	1	3	0,2	0,1	0,3
Aftertaste	5%	2	1	3	0,1	0,05	0,15
Moisture	5%	1	2	3	0,05	0,1	0,15
Ash	5%	1	2	3	0,05	0,1	0,15
Fat	10%	1	2	3	0,1	0,2	0,3
Carbohydrate	10%	2	3	1	0,2	0,3	0,1
Protein	10%	1	2	3	0,1	0,2	0,3
Fiber	20%	1	2	3	0,2	0,4	0,6
Total Score					1,4	1,8	2,8

The nutritional composition of the selected formula was further contextualized using the Nutrition Label Guideline (%NLG) for the general adult population (Table 5) [25]. The %NLG calculation converts quantitative nutrient data into a standardized reference format that helps assess a food product's contribution to daily nutrient requirements. Systems that express nutrient amounts relative to guideline daily amounts, such as %NLG or %DV, enhance consumer understanding and regulatory compliance in nutritional labelling. In the present study, the %NLG for dietary fibre in F1 was 24.1%, indicating a substantial contribution to the recommended daily intake (Table 5). According to the current Indonesian Food and Drug Authority regulatory criteria, a product may be labelled as a "source of fiber" if it contains at least 3 g of fiber per 100 g of product. A "high-fiber" claim is supported when the product contains at least 6 g of fiber per 100 g [7]. The results indicate F1 meets the nutritional content claims as a high fiber. The fiber content demonstrated in F1 therefore supports its classification as a product with meaningful fiber content, consistent with these nutrient content claim standards and public health objectives to increase dietary fiber intake.

TABLE 5 NUTRIENT CONTRIBUTION OF SELECTED FORMULA (F1)

Nutrient	Nutrient content per 100 g	% NLG per 100 g[1]
Moisture (g)	4,7±0,1	-
Ash (g)	1,4±0,0	-
Protein (g)	8,4±0,2	13,9
Fat (g)	15,6±0,1	23,3
Carbohydrate (g)	62,7±0,4	19,3
Fiber (g)	7,2±0,4	24,1
Energy (kcal)	418,7±0,4	19,5

[1]NLG = nutritional label guidelines

Beyond nutrient labelling, F1's high fiber content may affect public health outcomes. The role of dietary fiber in regulating body weight and energy balance has been widely acknowledged. Mechanistically, fiber affects the composition of gut bacteria and the production of short-chain fatty acids, both of which have been linked to a lower risk of obesity and related metabolic problems. It also enhances satiety and delays gastric emptying, thereby reducing total energy intake. Furthermore, epidemiological data supports an inverse relationship between increased dietary fiber intake and the risk of obesity, indicating that higher dietary fiber intake is associated with lower body mass index and adiposity across populations [5], [6]. As a result, F1's high fiber content not only supports its designation as a high-fiber product but may also have positive effects on weight management when incorporated into regular eating habits, consistent with current nutritional strategies aimed at lowering the prevalence of obesity.

This study has several limitations, including the fact that the Bagelen product has not yet incorporated a non-caloric sweetener, which may be more appropriate for consumers with obesity. Sensory evaluation was conducted under controlled laboratory conditions and may therefore not fully reflect general consumer preferences. In addition, clinical evidence regarding the product's effectiveness in improving obesity-related outcomes has not yet been established. Considering these limitations, further research is warranted to expand and strengthen the existing findings. Future studies should consider incorporating non-caloric sweeteners into the Bagel formulation. Moreover, sensory evaluations with a broader consumer population and well-designed clinical trials in individuals with obesity are necessary to assess the product's effectiveness in increasing fiber intake and improving nutritional status.

IV. CONCLUSIONS

The results indicated that substitution with mung bean flour significantly influenced both the hedonic sensory properties and the nutritional composition of the product ($p < 0.05$). Among the tested formulations, Formula F1 was selected as the optimal, providing a total energy value of 418.70 kcal, with moisture contributing 4.67 kcal and ash contributing 1.38 kcal. The macronutrient composition of F1 consisted of 15.64 g of fat, 8.36 g of protein, 62.71 g of carbohydrates, and 7.23 g of dietary fiber. Based on its dietary fiber content, F1 can be categorized as a high-fiber food product for obesity. Further research is needed to explore the use of non-caloric sweeteners in bagel formulations. Additionally, sensory assessments involving general consumer populations and clinical trials in individuals with obesity are needed to evaluate the product's potential to increase fiber intake and improve nutritional status.

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