

Development of Crispy Brownies Enriched with Mung Bean Flour and Spinach Flour as an Alternative Snack for Pregnant Women

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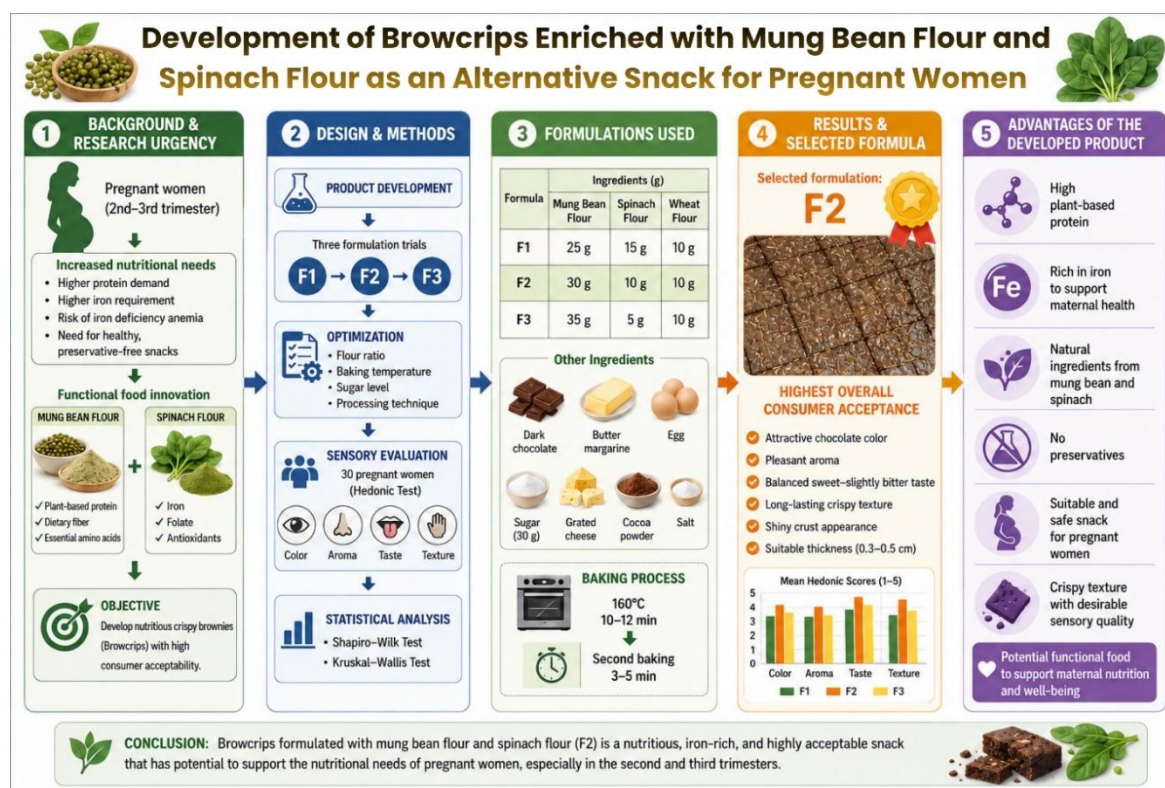
ABSTRACT

Protein and iron intake play an essential role in supporting fetal growth and development during pregnancy. Adequate protein intake helps reduce the risk of stunting and chronic energy deficiency (CED) among pregnant women. Crispy Brownies (Crispy Brownies) is a processed food product that can serve as an alternative snack for pregnant women. This study aimed to develop crispy brownies enriched with mung bean flour and spinach flour as an alternative snack, particularly for pregnant women with indications of chronic energy deficiency (CED) and anemia. The study was conducted through a series of product development stages, including nutrient composition analysis, nutritional adequacy assessment, and production cost analysis using three formulations (F1, F2, and F3). The results showed that formulation F2 (60% mung bean flour : 20% spinach flour) was the most preferred by the panelists, providing 535 kcal energy; 8.68 g protein; 30.7 g fat; 56.1 g carbohydrates; and 8.16 mg iron per 100 g. This product has the potential to serve as an iron-rich, protein-containing alternative snack for pregnant women as well as the general population.

Key Messages:

- The enriched of mung bean flour and spinach flour to Crispy Brownies increases the product's protein and iron content, making it a nutrition alternative snack for pregnant women.
- A 100 g portion of Crispy Brownies contributes to the daily iron requirements of pregnant women, thereby offering the potential to help reduce the risk of anemia during pregnancy.

GRAPHICAL ABSTRACT



INTRODUCTION

Pregnancy is a crucial period in determining the health of the baby at birth. The intake of macronutrients and micronutrients during pregnancy increases as the pregnancy progresses. Adequate nutritional intake in pregnant women is essential for optimal physical and mental development. Nutritional problems that still frequently occur among pregnant women in Indonesia include chronic energy deficiency (CED) and anemia. According to data from the 2018 Basic Health Research (Riskesdas), the prevalence of chronic energy deficiency (CED) among pregnant women reached 17.3% (1). This figure has decreased compared to the 2013 Riskesdas data, but it remains in the high category because it exceeds the threshold (>10%) for public health issues requiring priority intervention. Data from the 2023 SKI survey indicate a CED rate of 14.1% in West Java Province. Chronic Energy Deficiency (CED) is a condition characterized by insufficient food intake that leads to health complications in mothers, which can result in preterm birth and low birth weight (2,3). This condition can hinder the growth of toddlers, thereby contributing to higher rates of stunting (4).

The intake of micronutrients such as iron also plays a crucial role in meeting the nutritional needs of pregnant women. This is because pregnant women are more prone to anemia than non-pregnant women. Anemia occurs when the body does not have enough red blood cells—which are responsible for carrying oxygen—to meet its needs (5). The prevalence of anemia among pregnant women reached 48.9% in 2018 according to Riskesdas, and SKI 2023 data indicate that 27.7% of pregnant women suffer from anemia (6). This percentage exceeds the threshold of >20% and falls into the moderate category (7). Anemia in pregnant women affects maternal health throughout pregnancy and can lead to postpartum hemorrhage. A pregnant woman's iron requirements increase as the pregnancy progresses. The estimated increase in iron requirements for pregnant women is 15–18 mg/day during pregnancy. The increase in protein and iron requirements for pregnant women differs by trimester; protein requirements increase by 1 g, 10 g, and 30 g per day in the first, second, and third trimesters, respectively. Meanwhile, iron requirements increase by 9 mg/day in the second and third trimesters (8).

Adequate nutritional intake must be ensured to guarantee the nutritional needs of both the mother and the fetus are met during pregnancy. Nutritional interventions for pregnant women must be carefully planned and innovative to support the health of both mother and child (9). Such interventions can be implemented by providing

nutritious foods that are easily accessible and can be consumed regularly; one example is snacks. Snacks have now become a practical and popular alternative for pregnant women to meet their daily nutritional needs. Consuming nutritious snacks rich in protein and essential micronutrients can help meet daily nutritional requirements without relying solely on main meals. One easily accessible and familiar source of plant-based protein in Indonesian society is mung beans. Mung beans are a food source derived from the seeds of the mung bean plant and belong to the legume family (10). According to the 2020 Indonesian Food Composition Table (TKPI), mung beans contain 22.9 g of protein per 100 g (11). The nutritional content of mung bean flour per 100 g is as follows: 286 kcal of energy; 31.50 g of protein; 14.30 g of fat; and 54.50 g of carbohydrates (10). In addition to mung beans, vegetables also play an important role in meeting micronutrient needs such as iron; one source of iron is green spinach. The iron content in green spinach is 3.5 mg/100 g (11). Other nutrients in green spinach include several types of vitamins—namely vitamins A, B, and C—antioxidants (flavonoids, polyphenols, and carotenoids), as well as minerals such as potassium and calcium (12). Allowing it to be processed into flour to facilitate its use in various food products. The iron content in lidah kucing products with the addition of spinach flour was 3.11 mg/100 g, and the iron content in spinach flour was 15.75 mg per 45 g (13). Thus, both of these ingredients can be used in food preparation to support the nutritional needs of pregnant women, particularly for protein and iron from plant-based sources.

One form of food innovation that can help meet the nutritional needs of pregnant women is by providing snacks. Snacks can serve as a supplementary food to meet the nutritional needs of pregnant women by utilizing nutrient-rich ingredients. Snacks commonly given to pregnant women include biscuits or cookies as energy- and protein-dense snacks to support their nutritional intake (6). One type of sweet snack widely enjoyed by the public is brownies. Their not-too-sweet flavor is one reason they are chosen as a snack alternative. Generally, brownies are consumed in a dense and fairly thick form because they are made from wheat flour (14); however, there are modifications to the brownie's form that result in a more appealing shape, a crispy texture, and a longer shelf life (15). In addition, crispy brownies can be enjoyed in combination with various other snacks, so pregnant women won't get bored of eating them. Their portability is another advantage that makes crispy brownies a popular choice as a snack for pregnant women. Crispy brownies are a modified version of traditional brownies that contain a fairly complete range of nutrients (16). Based on this, the author is interested in modifying the food product "Crispy Brownies" (Crispy Brownies) under the title "Development of Crispy Brownies Enriched with Mung Bean Flour and Spinach Flour as an Alternative Snack for Pregnant Women." The development of this product combines the use of local and readily available food resources with an eye toward current snack consumption trends among pregnant women. In addition, this product has the potential to support a variety of processed foods for the Supplementary Feeding Program for Pregnant Women and to increase the value-added potential of mung beans and spinach.

METHODS

This research is an experimental study using a Completely Randomized Design method with three formulations. Formulation F1 has a ratio of mung bean flour to spinach flour of 50% : 30%; F2 is 60% : 20%; and F3 is 70% : 10%. The study was carried out at the Culinary Laboratory, Vocational School IPB University, while organoleptic testing involved pregnant women from Posyandu in Babakan and Tegallega Villages. The panelists were 30 untrained pregnant women who met the inclusion criteria, namely aged 20 – 49 years, in the second or third trimester, healthy, and not allergic to the tested ingredients. Meanwhile, the exclusion criteria were failure to attend the organoleptic test and panelists withdrawing from the study. The method used in this test followed SNI 01-2346-2006, which states that hedonic testing is used to measure product likability using an evaluation form with a minimum of 30 untrained panelists. The main ingredients consisted of mung bean flour, spinach flour, medium-protein wheat flour, sugar, butter margarine, dark chocolate, eggs, cocoa powder, salt, and cheese. The ingredients and formulation of Crispy Brownies in Table 1.

Table 1. Ingredients and formulations Crispy Brownies

No	Ingredients	Unit	F0	F1 50%:30%	F2 60%:20%	F3 70%:10%
1	Mung bean flour	g	0	25	30	35
2	Spinach flour	g	0	15	10	5
3	Wheat flour	g	50	10	10	10
4	Eggs	g	55	55	55	55
5	Butter margarine	g	40	40	40	40
6	Dark chocolate	g	100	100	100	100
7	White sugar	g	55	30	30	30
8	Cocoa powder	g	5	5	5	5
9	Salt	g	1	1	1	1
10	Cheese	g	20	20	20	20

The production process for Crispy Brownies, requires preparation equipment such as a food scale, spoon, cutting board, and bowl. Processing equipment includes a blender, bowl, oven, pan, ladle, strainer, scraper, baking paper, balloon whisk, knife, and cake pan. Serving equipment includes paper plates and packaging labels.

Sensory evaluation was conducted using a hedonic test assessing color, aroma, flavor, and texture on a 5-point scale. A 5-point hedonic scale was employed to measure consumer preference, ranging from 1 (strongly dislike) to 5 (strongly like). Data were analyzed using Saphiro-Wilk normality testing and Kruskal-Wallis tests. The selected formula was determined using the Weighted Sum Method based on hedonic scores. The crispy brownies products in this study emphasized flavor and texture as key parameters, each weighted at 30%, while the color and appearance parameters were each assigned a weight of 20%. The flavor and texture parameters were prioritized because they are the primary sensory aspects of crispy brownies (19). Nutritional analysis, including protein, fat, carbohydrate, an iron content, was performed at a food testing laboratory.

CODE OF HEALTH ETHICS

This study received ethical clearance from the IPB University Health Research Ethics Committee under number 2367/IT3.KEP-IPB/SK/2026.

RESULTS

Crispy Brownies, or crispy brownies, were developed as a snack alternative for pregnant women—particularly those in their second and third trimesters—providing plant-based protein from mung bean flour and iron from spinach flour, all without any preservatives. With their crispy, light texture and a sweet, slightly bitter chocolate flavor, Crispy Brownies are ideal for pregnant women with a strong appetite as a more nutritious snack option. Three formulations were tested through trial-and-error development to improve sensory quality and product stability. The first formulation produced a soft texture, uneven color, a beany aroma, and a bitter flavor, so modifications were made in roasting time, oven temperature, rotating pan use, and flour refinement. The second trial improved color, aroma, and flavor, but texture stability still needed improvement, leading to further adjustment in the third formulation. The final trial produced a crisp texture, balanced flavor, even color, and attractive shiny crust. The result of Crispy Brownies mung bean flour and spinach flour in Figure 1.



Figure 1. Crispy Brownies

A hedonic test was conducted to determine the panelists' preference levels for Crispy Brownies products based on sensory attributes, including color, aroma, texture, and flavor. This evaluation aimed to assess the effect of varying proportions of mung bean flour and spinach flour on overall consumer acceptance of the final product. A total of 30 untrained panelists—pregnant women in second and third trimester—participated in this evaluation. Each panelist was asked to evaluate three different samples, which were coded with random numerical labels to minimize product identification bias. Although the organoleptic test data did not show any significant differences among the three formulations, a trend in the panelist's preferences for the tested parameters was evident. The results of the organoleptic test indicated that F2 was superior in terms of color, flavor, and texture. The results of the hedonic test are presented in Table 2.

Table 2. The results of hedonic test

Parameter	Mean Value of Sample Hedonic			P-value
	F1	F2	F3	
Color	3.73 ± 0.40	3.97 ± 0.809	3.60 ± 0.770	0.426
Aroma	3.67 ± 0.711	3.63 ± 0.809	3.70 ± 0.837	0.056
Flavor	3.80 ± 0.887	3.83 ± 1.053	3.50 ± 0.900	0.066
Texture	4.07±0.828	4.03 ± 0.09	3.90 ± 0.759	0.088

The selected Crispy Brownies formula was determined using the Weighted Sum Method (WSM), which involves summing the products of attribute rankings and attribute weights (17). This method was used to select the most optimal formula based on the results of physical property tests and hedonic tests, which included the parameters of color, aroma, texture, and flavor. The weight values can be adjusted according to the characteristics and objectives of the product being tested (17). The rankings are multiplied by the weights for each parameter, and the resulting scores are summed to obtain a total score. The formula with the highest total score receives the lowest ranking, while the formula with the lowest total score receives the highest ranking (18). The results of the summation indicate that the selected Crispy Brownies formulation is Formulation 2 with the proportion of 30 g mung bean flour and 10 g spinach flour. Formulation 2 received the lowest score of 1 compared to the other two formulations, meaning it ranked highest and was selected as the winning formulation. The result of alternative component score using WSM are presented in Table 3.

Table 3. The result of alternative component scores

Parameters	Percent ange	Alternative Component Scores					
		F1 (25 g mung bean flour : 15 g spinach flour)		F2 (30 g mung bean four : 10 g spinach flour)		F3 (35 g mung bean flour : 5 g spinach flour)	
		Rank	Score	Rank	Score	Rank	Score
Color	20%	2	0.4	1	0.2	3	0.6
Aroma	20%	3	0.6	2	0.4	1	0.2
Flavor	30%	2	0.6	1	0.3	3	0.9
Texture	30%	1	0.3	2	0.6	3	0.9
Score Total	100%	-	1.9	-	1.5	-	2.6
Ranking		2		1		3	

The nutritional analysis of F2 with addition 30 g mung bean flour and 10 g spinach flour used proximate analysis was conducted at PT Saraswanti Indo Genetech (SIG), which covers the main components in food evaluation: ash content, moisture content, energy from fat, total energy, total fat content, protein content, and carbohydrates. Micronutrient testing was also conducted, specifically an iron (Fe) test to determine the iron content in the Crispy Brownies product. The result of proximate analysis of crispy brownies are presented in Table 4.

Table 4. The results of proximate analysis of Crispy Brownies

Indicator	Unit	Per 100 g	SNI
Ash content	%	2.59	Maks 1.5*
Energy from fat	kcal/100g	276.3	-
Total fat	%	30.7	Min 9.5*
Water content	%	1.92	Maks 5**
Total energy	kcal/100g	535	Min 400*
Carbohydrates	%	56.1	Maks 70*
Protein content	%	8.68	Min 4.5**
Iron	mg/100g	8.16	-

*) SNI 01-2973-1992 about biscuit

**) SNI 2973-2022 about biscuit

The serving size for Crispy Brownies is determined in accordance with BPOM Regulation No. 26 of 2021 regarding biscuit serving sizes, which ranges from 15 to 50 g. Calculation of the nutritional contribution of Crispy Brownies with added mung bean flour and spinach flour toward the average RDAs for pregnant women in the second and third trimesters aged 19–49 years, based on Ministry of Health Regulation No. 28 of 2019 on the Recommended Dietary Allowances (RDAs). Energy and nutrient intake for pregnant women are presented in Table 5.

Table 5. Energy and nutrient intake for pregnant women

Nutrients	AKG pregnant women*	Total per servings size		% Contribution	
		100 g	40 g	100 g	40 g
Energy (kcal)	2550	535	214	21%	8%
Protein (g)	80	8.68	3.47	12%	4%
Fat (g)	67.3	30.7	12.28	46%	18%
Carbohydrate (g)	400	56.1	22.44	14%	6%
Iron (mg)	27	8.16	3.26	30%	12%

*) Ministry of Health Regulation No. 28 of 2019 on the Recommended Dietary Allowances (RDAs).

According to BPOM Regulation No. 1 of 2022, a processed food product may include a claim on its label if it meets the requirements that a single serving contains no more than 18 g of total fat, 6 g of saturated fat, 60 g of cholesterol, and 300 mg of sodium. Snacks should ideally contribute 10–15% of total daily nutrient requirements, with consumption 2 to 3 times a day. Once the nutritional content of the selected crispy brownies formula had been determined, the contribution of the selected crispy brownies formula to the general Nutrition Labelling Reference (NLR) was calculated. The calculation of the contribution to the general NLR are presented in Table 6.

Table 6. Contribution of nutritional content to General NLR

Nutrients	Nutrient content		*NLR	% NLR per serving size (40 g)	% NLR 100 g	**Nutrient claim
	40 g	100 g				
Energi (kcal)	214	535	2150	10%	25%	-
Protein (g)	3.47	8.68	60	6%	14%	-
Lemak (g)	12.28	30.7	67	18%	46%	-
Karbohidrat (g)	22.44	56.1	325	7%	17%	-
Zat Besi (mg)	3.26	8.16	22	15%	37%	High

*) BPOM Regulation No. 9 of 2016

**) BPOM Regulation No. 1 of 2022

Based on laboratory analysis, Crispy Brownies contribute the following nutrients per serving toward the General Recommended Dietary Allowances (ALG): 10% of energy, 6% of protein, 18% of total fat, 7% of carbohydrates, and 15% of iron. The iron content in Crispy Brownies qualifies for a “high iron” claim, with 8.16 mg of iron per 100 g of product. This complies with BPOM Regulation No. 1 of 2022, which requires a “source” claim if a product contains 15% of the RDA per 100 g in solid form, and a “high” claim if the value is double that of the “source” level. This aligns with the research (9) on sorghum-spinach cookies as a high-iron dietary

supplement for anemic pregnant women, which showed that incorporating 10–20% spinach increased iron content by 2.5–4 mg/100 g of product.

DISCUSSION

Color

The results of the hedonic quality test using the Kruskal-Wallis test showed no significant difference ($p > 0.05$) in the color parameter. This is consistent with the study (19) which found that the color of crispy brownies tends to be uniform, namely brown. The results of the hedonic test of color parameters showed that panelists preference for the color “browcrips” ranged from an average of 3.60 to 3.97, which descriptively falls into the “like” category and corresponds to the color specification brown. The brown color in Crispy Brownies is caused by the Maillard reaction, which occurs when amino acid groups from proteins interact with reducing sugars when heated to a certain temperature (20). The use of dark chocolate and cocoa powder contributes to the deep brown color of Crispy Brownies. The use of dark chocolate imparts a brown hue to the cookies (21).

Aroma

The results of the Kruskal-Wallis test for aroma parameters showed no significant difference ($p > 0.05$), with average values ranging from 3.63 to 3.70, which descriptively falls into the “like” category. The highest average score was for F3, at 3.70, which falls into the “like” category and has the highest proportion of mung bean flour. The fragrant aroma of the Crispy Brownies was influenced by the strong, characteristic nutty aroma of F3, which had the highest proportion of mung bean flour. This enhanced aroma resulted from increased protein content, which affects the release of volatile compounds (22).

Flavor

The results of the Kruskal-Wallis test for flavor parameters showed no significant difference ($p > 0.05$), with mean values ranging from 3.50 to 3.83 in the bitter-sweet category. The bitter flavor in Crispy Brownies may be influenced by the use of spinach flour and cocoa powder. Saponins in spinach flour can impart a bitter flavor to processed products made from it (23). The bitter flavor may also stem from the use of dark chocolate, which contains polyphenols and theobromine and has a lower sugar content compared to other types of chocolate (20). The use of mung bean flour enhances the nutty flavor as the proportion used increases.

Texture

The results of the Kruskal-Wallis test for texture parameters showed no significant difference ($p > 0.05$), with average values ranging from 3.90 to 4.07 in the “somewhat hard to crisp” category. The texture of Crispy Brownies is influenced by the protein and fiber in mung bean flour, which contribute to a harder texture (20). The amylose content in wheat flour forms hydrogen bonds with water, which can enhance the crispness of Crispy Brownies. Additionally, a low moisture content in the product tends to result in a harder and more brittle texture (20).

The selected formula in this study was determined using the Weighted Sum Method (WSM), based on the overall average of the parameters that achieved the highest ranking. Using this method, Formula F2 was identified as the selected formula, and further nutritional analysis was carried out in the form of a proximate analysis to determine the macronutrient content and an analysis to determine the iron content.

Nutrients Content

Based on laboratory test results, the average ash content was 2.59%, which is higher than the standard set in SNI 01-2973-1992 regarding biscuits (maximum 1.5%). The high ash content in these Crispy Brownies stems from the mung beans and spinach. According to a study (24), the ash content in mung bean flour is 3.79%. The high ash content in mung bean flour indicates that the mineral content in mung bean flour is quite high. Meanwhile, the mineral content in spinach includes calcium, potassium, and iron (12). This aligns with the research (25), which found that the ash content of spinach flour is 14.67%.

Moisture content can serve as an indicator of the freshness and shelf life of food products (12). Based on laboratory test results, the Crispy Brownies product had an average moisture content of 1.92%, which is still considered safe when compared to the standard set by SNI 2973-2022 regarding biscuits (maximum 5%). The

addition of mung bean flour to food product formulations can reduce moisture content due to the amylose content in mung bean flour, which readily absorbs and releases water (19).

The energy content of the selected formula per 100 grams of product is 535 kcal, derived from the raw materials used. The protein content of the selected formula per 100 grams of product is 8.68%, which is relatively higher than that of similar crispy brownies products on the market—which contain only about 3–6 grams of protein per 100 grams of product. The protein content in this product comes partly from eggs, mung bean flour, margarine, cheese, and chocolate. The fat content of the selected formula is 30.7% per 100 grams of product, which contributes to its sensory characteristics. This fat content can be adjusted according to the portion size per serving. The carbohydrate content of the selected formula is 56.1% per 100 grams, influenced by the use of granulated sugar, margarine, eggs, and cocoa powder. Carbohydrates in granulated sugar (94%) and cocoa powder (48.9%) contribute significantly to the product's total carbohydrate content (24). Carbohydrates play a crucial role in enhancing the flavor of food product. The iron content in these crispy brownies primarily comes from the use of spinach flour and eggs, which are present in significant amounts (13), as raw materials. The iron content in these crispy brownies serves as a unique added value for the product.

Based on laboratory test results, it was found that F2, as the selected formula, meets the claim of being a high-iron product with an iron content of 37% or 8.16 mg per 100 g. Crispy brownies fall into the snack category; therefore, when comparing the energy contribution per 40-gram serving to the recommended 10–20% of total daily energy intake for snacks between meals for pregnant women, this is still insufficient. Therefore, given the limitations of this study, crispy brownies should be combined with other foods to ensure that energy needs during snacking are met and to provide a source of vitamin C to help maximize iron absorption.

CONCLUSION

The optimal formulation was achieved with Formula 2 (F2), consisting of 30 g of mung bean flour and 10 g of spinach flour, which exhibited the highest level of sensory acceptance and texture characteristics most similar to those of comparable products. Furthermore, the nutritional content of the selected Crispy Brownies formula with the addition of mung bean flour and spinach flour per 100 g is as follows: 535 kcal of energy; 8.68 g of protein; 30.7 g of fat; 56.1 g of carbohydrates; and 8.16 mg of iron. The contribution of one serving of Crispy Brownies toward the energy and nutrient requirements of pregnant women in the second and third trimesters is 8% for energy, 4% for protein, 18% for fat, 6% for carbohydrates, and 12% for iron. The ash content of the Crispy Brownies product does not meet SNI requirements. These results indicate that Crispy Brownies made with added mung bean flour and spinach flour can serve as a nutritious snack alternative rich in plant-based protein and iron. Therefore, it is hoped that future research will involve adjustments to the recipe or processing techniques to produce a product with more optimal results that comply with SNI standards.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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