Journal of Health and Nutrition Research
Vol. 4, No. 3, 2025, pg. 1184-1193, https://doi.org/10.56303/jhnresearch.v4i3.591
Journal homepage: https://journalmpci.com/index.php/jhnr/index

e-ISSN: **2829-9760**

The Development of Snack Bars from Salak Seed Flour and Red Beans as Potential Supplementary Food for Anemic Adolescent Girls

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ORIGINAL ARTICLES

Submitted: 19 August 2025

Accepted: 17 September 2025

Keywords:
Adolescent Girls, Anemic, Functional Food, Snack Bar

Access this article online

Quick Response Code

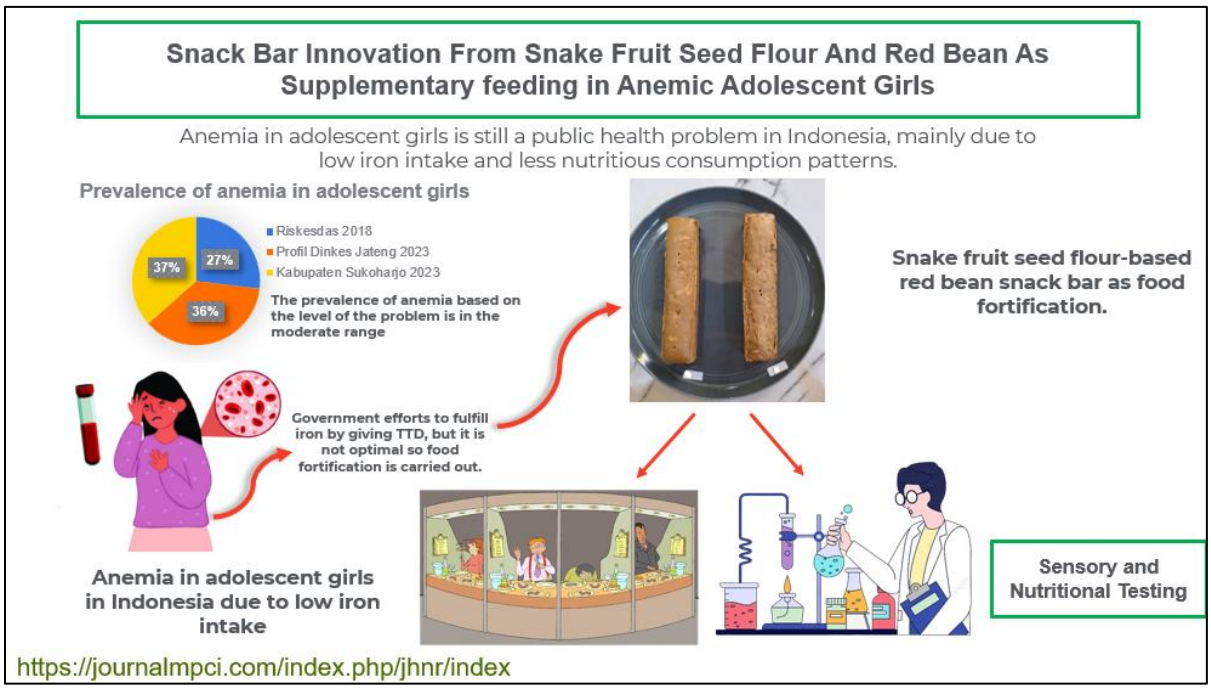
ABSTRACT

Anemia is a condition in which the body experiences a lack of Hb in the blood. One of the causes of anemia is the need for iron and protein that is not fulfilled by the daily intake. Snake fruit seed flour and red beans have high potential to be developed into health-beneficial products such as snacks. The purpose of this study was to develop snack bars as a treatment for anemia in adolescent girls and to analyze hedonic tests, microbiological contamination, and nutritional content. The data analysis used was the Kruskal-Wallis test with Dunn's Post-Hoc test. This study shows that the snack bar formulation of snake fruit seed flour and red bean has a statistically significant effect with a p-value <0.05. Based on the level of liking of high school adolescent girls, the most preferred formulations are formulations P0 and P3. The P0 treatment has nutritional content (carbohydrate 43.33%, protein 14.30%, fat 19.70%, total calories 400 Kcal, iron 3.6 mg, vitamin C 24.5 mg, and zinc 4.8 mg) and the P3 formulation has nutritional content (carbohydrate 49.49%, protein 10.71%, fat 13.53%, total calories 360 Kcal, iron 11.4 mg, vitamin C 28.0 mg, and zinc 5.2 mg), so it has the potential to innovate supplementary feeding for anemic adolescent girls.

Key Messages:

- Red bean snack bar combined with snake fruit seed flour has a high iron content value so that it can be a functional food for anemic adolescent girls.
- This research is the first study to develop a functional snack bar from a combination of red bean and snake fruit seed flour as an additional food for adolescent girls.
- This Snakefruit seed flour-based red bean snack bar has good food safety.

GRAPHICAL ABSTRACT



INTRODUCTION

Anemia remains a major public health and nutrition issue, particularly in developing countries such as Indonesia (1). Anemia is a condition characterized by a deficiency of hemoglobin (Hb) in the (2). Clinical symptoms of anemia can include fatigue, palpitations, headaches, shortness of breath, and paleness of the palms (3). Based on 2018 Basic Health Research data, the prevalence of anemia in Indonesia according to age characteristics at the age of 15-24 years reached 32.0%. In 2023, the prevalence of anemia in Central Java Province is 30.5%, while the anemia rate among adolescent girls in Sukoharjo District is even higher at 36.9%(4).

Several factors cause anemia, such as bleeding due to helminthiasis, nutritional deficiencies, iron deficiency, and an increase in iron requirements but are not met by the food consumed (5). Another factor contributing to the occurrence of anemia in adolescent girls is their diet, as their food choices are often based on enjoyment rather than nutritional content (6). In adolescents in Karanganyar senior high school (SMA), the incidence of anemia reached 13.73%, which was caused by fruit (<150g / day) and vegetable (<250g / day) intake so that it could increase the risk of developing anemia, fruits and vegetables are one of the important sources of iron and are easy to find (7). Protein intake in adolescent girls of SMA Batik 1 Surakarta as many as 43.5% of students have a deficient level of intake (8). Based on research by Ratih et al. 2022, 52% of female students have unhealthy eating habits because they prefer to choose based on price, mood, and instant food (9).

The government has made efforts to meet the iron needs of adolescent girls who are future mothers by providing Iron and Folic Acid (IFA) supplements, as outlined in the Circular Letter of the Director General of Health Number HK.03.03/V/0595/2016, targeting adolescents aged 12 to 18 years (10). Currently, Indonesia is in the process of transitioning from the IFA supplementation program to a more comprehensive approach through Multiple Micronutrient Supplements (MMS) (10). However, the provision of TTD is still not effective in adolescent girls due to the side effects of TTD consumption, namely nausea, vomiting, and abdominal pain, so there is a need for alternatives such as food fortification (11). Fortification is the addition of micronutrients to food ingredients aimed at improving the nutritional quality of food, one of which is used to overcome iron deficiency anemia such as salak seed flour (12). Giving 18.52 g of salak seed flour jelly for 60 days to anemic adolescents increased hemoglobin levels by 1.07 g/dL without affecting body weight, indicating a sufficient therapeutic effect (12). a combination of

https://doi.org/10.56303/jhnresearch.v4i3.591

jelly from 14.9 g salak seed flour and 5.7 g moringa leaf flour given for 30 days increased Hb levels by 6.47 g/dL in moderately anemic adolescent girls (13). Salak seed flour biscuits can increase the intake of iron, vitamin C, and zinc in anemic adolescent girls (11). However, jelly and biscuit products still require fresh serving and have a short shelf life, indicating the need for further product development (11). Red beans are a plant protein source rich in iron. In mildly anemic pregnant women, consuming 200 ml of red bean juice daily for a week increased Hb by 0.8 g/dL (14). Giving red beans to adolescent girls can also increase hemoglobin levels by 1.7 g/d (15).

Alternative snacks are important for adolescents to meet macro and micronutrient needs, one of which is snack bars. Snack bars are made from carbohydrate or protein sources, with added ingredients like sugar, fat, chocolate, dried fruit, or cereals, and shaped into bars (16). Snack bars with 70% peanuts and 30% sweet potato flour have a 173-day shelf life and a hedonic score of 6.09, making them suitable as emergency food alternatives (17). (17). Based on the results of Winiastri's research (2021), 46.6% of high school adolescents liked snack bars with a composition of 60g sorghum flour and 100g pumpkin, to evaluate antioxidant activity (18). Research by Nurhusna et al. (2020), 97% of pregnant women like snack bars with the composition of sorghum and kidney beans in a ratio of 2: 1, the sorghum and cowpea flour snack bar has a protein content of 21.38%, carbohydrates 447 Kcal, fat 3.67 and iron 13.21 mg which has the potential for PMT for pregnant women with severe shortages (19).

Based on the description above, seeing the potential of snake fruit seed flour and red beans, which contain iron and protein, it is interesting to develop an innovative product, such as a snack bar, aimed at anemic adolescent girls. Snack bars will be made with a combination of snake fruit seed flour and red kidney beans. Functional food innovation requires the right formulation to produce a high-quality product. Therefore, it is necessary to test the sensory characteristics and nutritional content to determine the level of liking and nutritional content of the resulting snack bar.

METHODS

Research Design

This study is an experimental laboratory investigation that was initially conducted to determine the optimal snack bar formulation, followed by sensory analysis by panelists who evaluated the color, aroma, taste, texture, and overall acceptability. Then, an exploratory study was conducted to see the nutritional content of the best formulation.

Materials

Making snack bars with snake fruit seed flour obtained from previous research, briefly the process of making snake fruit seed flour is through the process of washing, drying, then baking, and finally grinding (12). The red beans used came from Pasar Gede Surakarta. Additional ingredients used were egg yolk, margarine, sugar, chocolate milk, maize flour, baking powder, SP, and chocolate paste. Making snack bars of snake seed flour and red beans modified from peanut snack bars and sweet potato flour as emergency food (17).

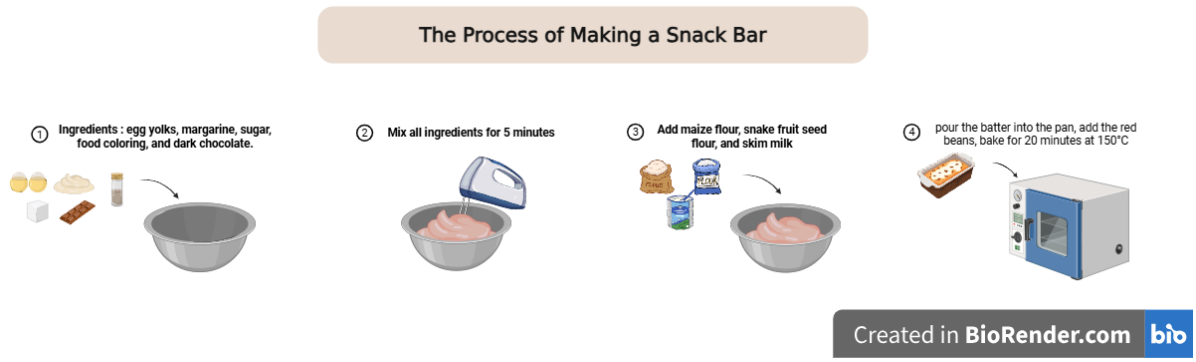


Figure 1. The process of making a snack bar

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Preparation of making snack bar

The making of snacks bar of snake fruit seed flour and red beans refers to previous research conducted by Fitria et al (2022) with modifications (17). The snake fruit seed flour used is a product that has been produced by previous researchers so that it is ready to use(12). The snack bar formulation ratio consists of 4: P0 (0:0) without the addition of salak seed flour, P1 (70:30), P2 (60:40), and P3 (50:50) red bean and snake fruit seed flour. Making snack bars starts with the process of making red beans soaked with water for 24 hours, then drained and boiled for 30 minutes, entered into the process of peeling the skin of red beans and roughly chopped. The process of making snack bars can be seen in Figure 1.

Hedonics Analysis

This study was conducted as a hedonic test in September 2024 - February 2025. The panelists in the study consisted of teenage female students at SMA N 1 Nguter, comprising 35 semi-trained participants, and nutrition students, comprising 15 semi-trained participants. Before the sensory test, all panelists received a brief training session on how to use the 5-point hedonic scale and how to evaluate sensory attributes (color, aroma, taste, texture, and overall acceptance). This training included explanation, visual examples, and a short practice test to ensure panelists understood the evaluation criteria.. The sensory test in this study used a hedonic test form instrument with 5 hedonic scales / levels of preference; the assessment used was related to color, aroma, taste, texture, and overall. The panelists consisted of 35 female students, aged 15–17 years, from SMA N 1 Nguter, and 15 nutrition students, aged 18–22 years. Inclusion criteria included: being healthy, non-smokers, not having allergies to the product ingredients, and being willing to participate. Exclusion criteria included: having a cold, sore throat, or other sensory impairments at the time of testing.

Microbiological Contamination, macro and micronutrient levels in the snack bar

All analyses were conducted at the Semarang City Laboratory of the Center for Standardization and Industrial Pollution Prevention Services (BBSPJPPI) on 27 September 2024, using validated instruments and standardized procedures. The nutrient content that would be tested is related to the content of macronutrients (carbohydrates, fat, protein, total calories) and micronutrients (iron, zinc, and vitamin C). Proximate test analysis on protein using the Kjeldahl method, fat using the Soxhlet Extraction method, carbohydrates and calories using By Difference (Calculation) all analysis in accordance with SNI 01-2891-1992 standards. Micronutrient analysis for iron, copper, lead, zinc, and arsenic was conducted using SNI 01-2896-1998 and measured by Atomic Absorption Spectrophotometry (AAS), while vitamin C content was determined by the titrimetric method.

Statistical analysis

The data were analyzed using SPSS version 25. Hedonic test data and nutritional content were analyzed descriptively. Hedonic test data and nutritional content were analyzed using the Kruskal-Wallis ($p < 0.05$) continued with the *Dunn Post-Hoc test.*

RESULT

Hedonics test

Based on the results of the normality analysis test, it is found that the data is not normally distributed, so the Kruskal-Wallis test will be carried out. The Kruskal-Wallis test is a non-parametric statistical analysis used to see if there are significant differences between groups P_0, P_1, P_2, and P_3 in terms of color, aroma, taste, texture, and overall (20). The results of the data analysis can be seen in Table 1 and the snack bar can be seen in Figure 2.

Hedonic test results showed that treatment P3 had the highest level of acceptance from panelists on almost all parameters. The P3 snack bar color obtained the highest score (3.37 ± 1.03) and was significantly different from the P1 and P2 treatments ($P<0.05$). The highest aroma was obtained in P0 (3.88 ± 0.73), although P3 (3.16 ± 0.75) also showed a fairly high score and was significantly different from P1 and P2 ($P<0.05$). The most preferred flavor was found in P3 (3.06 ± 0.96) and P0 (3.92 ± 0.79), which was

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significantly higher than the other treatments (P<0.05). Texture in P0 (3,63 ± 0,87) and P3 (3.16 ± 0.88) also obtained the highest score and was significantly different from P1 and P2 (*P*<0.05). Overall, panelists preferred the P0 formulation with a mean score of (3.76 ± 0.73), P3 (3.33 ± 1.03) compared to the significantly different P1 and P2 formulations. Hus, formulations P0 and P3 showed the best sensory quality and were most preferred by the panelists.

Table 1. Hedonic test of snack bars with snake fruit seeds and red bean flour.

Parameter	Mean ± SD				*P Value*
	P0	P1	P2	P3	
Color	3,31 ± 0,76[a]	2,73 ± 1,04[a]	2,39 ± 0,85[a]	3,37 ± 1,03[b]	<0,01*
aroma	3,88 ± 0,73[a]	2,45 ± 0,92[a]	2,57 ± 1,00[a]	3,16 ± 0,75[a]	<0,01*
Flavor	3,92 ± 0,79[a]	2,10 ± 0,78[a]	2,27 ± 0,85[a]	3,06 ± 0,96[b]	<0,01*
texture	3,63 ± 0,87[a]	2,51 ± 0,90[a]	2,43 ± 0,83[a]	3,16 ± 0,88[b]	<0,01*
Overall	3,76 ± 0,73[a]	2,47 ± 0,75[a]	2,57 ± 0,87[a]	3,33 ± 1,03[b]	<0,01*

Description:

[a] : The letter notation a means there is no significant difference at the Dunn test level.

[b] : The letter notation b means there is a significant difference at the Dunn test level.

* : Significantly different in *Kruskal-Wallis Test.*

Figure 2. Snack bar of snake fruit seed flour and red bean

Nutritional content test

Based on the level of liking in the panelists, the most preferred formulations were P_0 and P_3. So that the results of the nutrient content in the P_0 and P_3 formulations are presented in Table 2.

Table 2. Nutritional content of snack bars per 100 grams

Nutritional content	Snack Bar Treatment	
	P-0	P-3
Protein (%)	14.30	10.71
Fat (%)	19.70	13.53
carbohydrates (%)	43.33	49.49
total calories (Kkal/100g)	400	360
Iron (mg)	**3.6**	**11.4**
Vitamin C (mg)	**24.5**	**28.0**
Zinc (mg)	4.8	5.2
Arsenic (mg)	<0.001	<0.001
lead (mg)	0.0437	0.0341
copper (mg)	0.0802	0.3626
Total plate count (TLC)	1.6×10^5	1.4×10^2

https://doi.org/10.56303/jhnresearch.v4i3.591

Based on Table 2. The iron content reaches 11.4 mg per 100 grams, almost three times higher than P0 (3.6 mg), and is reinforced by the higher vitamin C content (28 mg), which can optimally increase the absorption of non-heme iron. Based on the lower protein content of P3 (10.71%) than P0 (14.30%), this value is still adequate for snack products. In addition, the levels of heavy metals such as lead, arsenic, and copper are still below the SNI Max standard, 0.25 mg, and the total number of plates (1.4×10^2) is far below the maximum limit of the SNI Max standard. 1.0 x 10.4 in P_3, indicating that the product is microbiologically safe.

DISCUSSION

Hedonic test of snacks bar made from snakefruit seed flour and red bean.

Color hedonic test

formulation P3 obtained the highest color parameter score with an average of (3.37 ± 1.03), indicating a brown color that was preferred by panelists. the brown color is produced from salak seed flour which goes through a roasting process, giving rise to a natural brown color. This is in line with the research of Nugraheni et al., (2024) which states that snake fruit seed flour jelly has brown color characteristics, this is influenced by the drying and grinding process of snake fruit seeds (21). During the roasting process, the evaporation of water content in salak seeds occurs due to heating so that the water content decreases (22). The increase in brown color is influenced by the maillard reaction that occurs during the oven process due to the presence of reducing sugars and amino groups contained in food (23). The addition of chocolate paste strengthens the color and increases visual appeal, this is in line with research related to chocolate tempeh products which are added with flavors to improve appearance (24).

Aroma hedonic test

The aroma of P0 and P3 was rated quite high (3.88 ± 0.73) (3.16 ± 0.75) and significantly higher than P1 and P2. Salak seed flour has a strong distinctive aroma, but the addition of chocolate and milk chocolate powder successfully masked the tart aroma. This is in line with the results of Wijayanti et al. (2021) which showed that the distinctive aroma of snake fruit seeds in jelly can be minimized with the addition of sweeteners and chocolate (13). Based on research on efforts to increase the selling value of local food products, namely tempe chocolate by adding several flavors that can increase the level of panelists' liking for tempe chocolate products which produce a fragrant aroma (24). This is in line with the research of Mudasirah et al., (2024), baruasa cakes added with carrot flour and chocolate paste can improve flavors such as sweet and savory, and increase aroma (25).

The roasting process greatly influences the formation of aroma in food product (26). The aroma produced during this process comes from the reaction between fatty compounds, amino acids and sugars through the Maillard reaction. In this study, the addition of red bean and milk powder as amino acids, fat-source margarine, chocolate paste, and sugar contributed to masking the strong aroma of snake fruit seed flour and increasing the final aroma that was favored by the panelists. This is in line with Rahardjo's (2019) research, which showed that snack bars with a combination of soybeans and cowpeas had the highest level of liking in formulation F2, where margarine as a source of fat, as well as soybeans and cowpeas as a source of amino acids, were able to minimize the languid aroma and produce a distinctive aroma after the roasting process, especially with the addition of honey as a natural sweetener (26).

Taste hedonic test

The results of the hedonic test showed that there was a difference in the flavor parameter which had the highest mean, namely the P_0 and P_3 treatments (Table 1). In the P_0 treatment, snake seed flour and red beans were not added, while P_3 was given snake seed flour and red beans. The addition of snake seed flour to snack bars that have a slightly bitter taste can be covered by adding milk powder and chocolate paste. This is in line with research on snake seed flour jelly, snake seed flour jelly added with cocoa powder, milk powder, and creamer can cover the natural taste of snake seed flour and increase the level of liking (27). Snake fruit seed flour, which has a slightly bitter taste and languorous odor, can be balanced by milk powder and chocolate paste, and the red beans, which have a natural sweetness, further enhance the taste.

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Based on research on mocaf flour and red bean snack bars, the highest average results were obtained with a snack bar formulation of 50% mocaf flour and 50% red bean flour on both taste and color parameters, the resulting snack bar had an acceptable sweet taste (28).

Texture hedonic test

The results of the hedonic test showed that the texture parameters P0 (3.63 ± 0.87) and P3 (3.16 ± 0.88) were higher compared to P1 and P2 (Table 1). Assessment of the texture of the snack bar, most panelists thought that the snack bar had a soft texture but some panelists thought it was a little hard. This is in line with research on mocaf flour and red bean flour snack bars which have a slightly hard texture, this is due to several influencing factors such as the characteristics of mocaf flour and red beans which have low gluten so that the dough is difficult to embrace (28). Based on the research of Fitria et al. (2022), peanut and purple sweet potato flour snack bars have a similar texture due to the addition of more purple sweet potato flour, resulting in a texture that is too dense (17). The higher sugar content can also affect the texture to harden (29). In this case, the addition of margarine and egg yolk can improve the texture of the snack bar. The fat content contained in margarine and egg yolk can provide softness and balance the solid texture of the product (28).

Overall hedonic test

Overall hedonic test related to overall is an assessment carried out as a whole sensory starting from color, taste, aroma, and texture (30). Overall assessment of the most preferred level of liking of the entire formula is formulation P_0 and P_3, because in terms of color, taste, aroma, and texture P_0 and P_3 have the highest scale value. The hedonic test results show that the P_0 and P_3 formulations are the best formulas compared to the P_1 and P_2 formulations. Based on these results, this study used snack bar formulation P_0 as a group that did not add snake fruit seed flour and red beans, and formulation P_3 which added 25g snake fruit seed flour and 10g red beans. overall related to the taste parameter, taste is one of the important parameters in the hedonic test so that panelists mostly choose the level of preference based on taste parameters, the sweetness produced in snack bars comes from milk powder and sugar.

Nutritional content test of snack bars

Analysis of the nutritional content of the snack bar formulation showed that the combination of snake fruit seed flour and red beans in the P3 formulation had a high nutritional content, especially in iron and vitamin C content. The iron content in P3 formulation reached 11.4 mg/100 g, almost three times higher than the control formulation P0 which only contained 3.6 mg/100 g. Based on research on moringa and soybean-based cereals as prevention of anemia in adolescent girls, the highest iron content is in the MS0 formulation 0.0756 mg/g. Surely the iron content of red bean snack bars based on snake fruit seed flour in this study is higher than that of moringa and soy-based cereals (31). This is in line with the research of Budiyanti et al. (2024), which showed that consumption of snake fruit seed flour-based biscuits was able to increase iron, vitamin C, and zinc intake in anemic adolescent girls (11). In addition, the vitamin C content in P3 formulation of 28.0 mg/100 g can increase the bioavailability of non-heme iron. According to Williams et al. (2023), adequate vitamin C intake in a food product can significantly increase iron absorption in individuals with iron deficiency (2). The high vitamin C content in this study is expected to help increase the absorption of non-heme iron through the reduction process of converting ferric ions to ferrous and can inhibit phytate and tannin compounds (32).

In terms of energy and macronutrients, the P3 formulation contained 360 Kcal/100 g of energy, slightly lower than P0 (400 Kcal/100 g), but still within a good energy range for supplementary food (PMT). The carbohydrate content of P3 was also higher (49.49%) than P0 (43.33%), reflecting the contribution of complex carbohydrates from red kidney beans. Meanwhile, the protein content of P3 (10.71%) was lower than that of P0 (14.30%). The decrease in protein content is likely due to the increase in water and fiber content of the additional ingredients, which resulted in a dilution effect on the protein mass. This is in line with the research of Normilawati et al. (2019), which states that food products with higher water content

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tend to experience a decrease in protein content per 100 grams (33). Nevertheless, the protein value of P3 formulation is still adequate for the supplementary food category and contributes to daily protein needs.

In terms of food safety, the P3 formulation also showed good results. The levels of heavy metals such as arsenic (<0.001 mg) and lead (0.0341 mg) were below the safe threshold, and the Total Plate Number (ALT) value of 1.4×10^2 indicated that the product was microbiologically safe for consumption based on SNI standards (34). Therefore, the P3 snack bar formulation not only has a favorable sensory profile, but is also superior in terms of nutrition and safety, and has the potential to be developed as an alternative functional food in the treatment of anemia in adolescent girls.

CONCLUSIONS

The best snack bar formulation is P_0 without snake fruit and red bean flour and P_3 (50:50) red beans and snake fruit flour. Formulation P0 has a protein content of 14.30% which is higher than P3 but not too significant. P0 also contains as much as 3.6 mg/100g of iron and contains 24.5mg/100g of vitamin C, which can help the absorption of iron in the body. P3 formulation has a protein content of 10.71%/100g, iron 11.4 mg/100g, and vitamin C 28.0 mg/100g. Based on the high content of macro- and micronutrients, the combination of red bean and snake fruit seed flour has potential as an additional food provision (PMT) for anemic adolescent girls. However, this product cannot be said to be a treatment for anemia, as clinical trials have not been conducted to assess its effectiveness in increasing hemoglobin levels. Therefore, further research is needed to investigate the effectiveness of PMT snack bars in increasing hemoglobin levels among anemic adolescent girls, as well as their impact on food quality and long-term consumption.

FUNDING

This research received funding from the Research Group Grant Number 371/UN27.22/PT.01.03/2025.

ACKNOWLEDGMENT

The authors would like to thank the Master of Nutrition Science Study Program, Department of Nutrition Science, Postgraduate Faculty, Sebelas Maret University, Central Java, for providing us with a Research Group Grant, Number 371/UN27.22/PT.01.03/2025.

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