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Formulation of granola bar based on soybean and moringa leaf flour as alternative snack for adolescent

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Abstract

Malnutrition in adolescents occur as a result of unhealthy eating behavior. Providing nutritious snacks contribute to prevent malnutrition in adolescents. Some local nutritious food ingredients that can be given to adolescents are soybean and moringa leaves. The aims of this study were to analyze the sensory properties of granola bar formulations based on soybean and moringa leaf flour, and to analyze the nutritional content of the selected formula. This study was experimental research using a completely randomized design with three treatments. The formulations of granola bar in the ratio of soybean flour and moringa leaf flour were F1 (95:5), F2 (90:10), and F3 (85:15). The variables included sensory tests (descriptive and hedonic test) and nutritional contents. The result showed that the formulations (F1, F2, and F3) gave no significantly different in few descriptive parameters (colour, sweetness, soybean taste, crunchy texture, and bitter aftertaste) and hedonic parameters (color, flavor, and texture). However, this formulation gave significantly different in moringa aroma, moringa flavor, and aroma preference ($p<0.05$). The overall sensory test showed that F1 was a selected formula. The nutritional content of F1 in 100 grams was 433 kcal of total energy, 149.4 kcal of energy from fats, 16.6 gram of fats, 16.6 g of protein, and 54.3 g of carbohydrates. F1 meets the requirements for protein sources claims, namely contributing 27.6% of nutritional adequacy per 100 grams. Snack bar based on soybean and moringa leaf flour in F1 had the potential to be an healthy alternative snack for adolescent.

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Keywords

Adolescent, Granola bar, Moringa leaf, Soybean

Introduction

Malnutrition is a major public health problem affecting adolescents worldwide and particularly in developing countries. Malnutrition has various forms including undernutrition (wasting, stunting, underweight), overnutrition (overweight, obesity), and micronutrient deficiencies resulting in diet-related diseases [1]. In Indonesia, the Indonesian Health Survey (SKI) showed that the prevalence of stunting, overweight and

obesity, and thinness in adolescents aged 13-15 is 24.1%, 16.2%, and 7.6%, respectively. These nutritional problems also occurred in the group of adolescents aged 16-18 years, the prevalence of stunting, overweight and obesity, and thinness is 23.7%, 12.1%, and 8.3%, respectively. In addition, the problem of anemia is also quite high, which is 16.2% of the community suffers from anemia and 31.8% of them occur in children and adolescents [2]. The consequences of malnutrition in adolescence are likely to exacerbate health problems in adolescence and later in adulthood. Stunting and thinness in adolescence is associated with morbidity, mortality, poor physical development, lack of learning capacity, and increased risk non-communicable diseases later in life [3]. Overweight and obesity in adolescence has been associated with premature mortality, physical morbidity, increased risk of type 2 diabetes, hypertension, and polycystic ovarian syndrome [4,5].

Malnutrition in adolescents can be caused by many factors, one of which is unhealthy eating habits. Unhealthy eating habits in adolescents generally come from snack consumption. Snacking has become a common habit among adolescents. Previous studies have shown that the main sources of snacks consumed were sweets, fatty and salty snacks, and sugar-sweetened drinks [6,7].These snacks are characterized by high energy, sugar, and salt and low fiber and other nutrients. Unhealthy snacks have been shown to have negative impacts on health, such as blood pressure, obesity and diabetes [8]. Therefore, alternative efforts such as developing healthier and more nutritious food are important, especially for snacks that are popular with adolescents. In addition to providing promising results in terms of reducing malnutrition problems, developing nutritious food products in snacks also has the potential to be effective because adolescents tend to consume snacks every day [8,9].

Many local Indonesian foods have high nutritional value, for example soybean (*Glycine max*). Soybeans are high in protein, more than any other legume produced for human consumption. Soybeans also contain the essential amino acids that must be obtained from the diet. In addition, soybeans contain biologically active compounds, such as isoflavones, saponins, lecithin, phytosterols, and oligosaccharides. Many of these compounds have antioxidant, anti- diabetic, anti-inflammatory, and anti-cancer properties that are beneficial to human health [10]. Previous studies have reported that soybean consumption has beneficial effects in improving skeletal muscle growth, muscle strength, and digestion in adolescents [6,10] In addition, due to its low fat content, soybeans are ideal for children who are on a weight control and obesity prevention [11,12].

Apart from soybean, another local food ingredient that also known to have many health benefits is moringa leaves (*Moringa oleifera*). Moringa leaves are considered an excellent supplement due to its high protein value and amino acids (lysine, tryptophan, methionine, and cysteine) [13]. It has been reported that moringa leaves are also rich in vitamins and minerals such as vitamin C, E, B (B1, B2, B3, B6, and B12), beta-carotene, calcium, and potassium [14]. Moringa leaves also have bioactive phytochemical

compositions such as flavonoids, glucosinolates, carotenoids, alkaloids, phenolic acids, ascorbic acid, tannins, terpenoids, and lectins [15]. These phytochemicals have many health benefits such as antioxidants, antimicrobial, immunostimulants, and hepatoprotective properties [13,15]. Previous studies have reported the effects of moringa leaves on malnourished adolescent. It was reported that consumption of moringa leaves has the potential to increase body weight and height in malnourished adolescent [16]. It was also reported that consumption of moringa leaves has the potential to improve hemoglobin level in anemic adolescents [17,18].

Research on the development of snack bar products has been widely conducted by several previous studies. Previous studies have shown that the addition of 10% moringa leaf flour to snack bars can increase protein levels by up to 16.9%, calcium levels by up to 285.19 mg/100 g energy bar, and antioxidant activity by up to 75% [19]. Other studies have also shown that snack bars added with 5% moringa leaves have protein content (12.1 g), iron (10.1 g), calcium (345 mg), magnesium (112 mg), zinc (19.4 mg), and energy (447 kcal) [20]. Snack bars fortified with moringa leaf flour have high nutritional value and can be used as an alternative food for malnourished children to provide healthy and high-energy food.

Based on the many beneficial contents of soybean and moringa leaf, the current research aims to make processed foods from these two ingredients in the form of granola bars as a healthy snack for adolescent. This study aims to formulate these two ingredients into granola bars and determine the sensory evaluation and nutritional content.

Methods

Research design

The design of this study was a laboratory experiment with a completely randomized design. The making of granola bars and sensory tests were carried out in the dietetics and product development laboratory of Nutrition Study Program, Universitas Muhammadiyah Cirebon, Cirebon, West Java. Nutritional content analysis was carried out in Saraswanti Indo Genetech (SIG) Laboratory, Bogor, West Java. The nutritional content analysis consisted of ash, moisture, protein, fat, and carbohydrate. This study was conducted from June to July 2024. This research was conducted in two stages. The first stage was the making of granola bars and sensory testing. This stage aimed to obtain the selected formulation from the three formulations that had been made (F1, F2, and F3). The second stage was the nutritional content analysis of selected formulation.

Material and preparation of granola bar

The basic ingredients for making granola bars were oats, powdered milk, puffed rice, chocolate, honey, raisins, brown sugar, egg white, and peanut butter. These basic ingredients were then added with a combination of soybean flour and moringa leaf flour

with different ratios in each formulation, namely F1 (95:5), F2 (90:10), and F3 (85:15). The formulations are presented in Table 1.

Table 1. Formulation of granola bar

Ingredients	Formulation (g)		
	F1	F2	F3
Soybean flour	95	90	85
Moringa leaf flour	5	10	15
Oats	20	20	20
Powdered milk	15	15	15
Puffed rice	18	18	18
Chocolate	33	33	33
Honey	10	10	10
Raisins	33	33	33
Brown sugar	15	15	15
Egg white	33	33	33
Peanut butter	30	30	30

Granola bar was made by combining two main doughs. The first dough contained a mixture of moringa leaf flour, soybean flour, powdered milk, oats, egg whites, peanut butter and raisins. The second dough contained a mixture of puffed rice, honey and melted brown sugar. The first dough then was placed in a baking pan, then the second dough was placed on the top of it. Then the dough was baked in the oven at a temperature of 180°c for 40 minutes. After that, melted chocolate was added to the top of the bars until it hardens.

Sensory test

Sensory tests including descriptive and hedonic tests were conducted on 30 semi-trained panelists using a sensory assessment form with nine-point scale (one as the lowest value and nine as the highest value). The sensory aspects assessed in descriptive test were color, moringa aroma, sweetness, moringa leaf flavor, soybean flavor, crunchy texture and bitter aftertaste. The sensory aspects assessed in hedonic test were color, aroma, flavor, and texture. The nine scales of hedonic test were liked extremely (9), like very much (8), like moderately (7), like slightly (6), neither like nor dislike (5), dislike slightly (4), dislike moderately (3), dislike very much (2), dislike extremely (1).

The selected formulation is the formula that has the highest overall value from the ranking calculation based on percentage contribution of each hedonic parameter test. The percentage contribution of hedonic parameter for the ranking calculation in determining the selected formula is 25% for color, 25% for aroma, 25% for taste, and 25% for texture.

Nutritional content

Nutritional content analysis consisted of ash, moisture, protein, fat, and carbohydrate. Ash content was analyzed using the SNI 01-2891-1992 method, moisture content was analyzed using the SNI 8217-2015 method, protein was analyzed using the Titrimetry method, total fat was analyzed using the Gravimetry method, and carbohydrates (by difference) were analyzed using calculations. Total energy content and energy from fat

were analyzed using the calculation method. Furthermore, the percentage of daily value was calculated by comparing the nutrient content of selected formula with the nutrition label reference for general population by The Indonesian Food and Drug Authority.

Statistical analysis

Data were processed using Microsoft Excel and SPSS Statistics for Windows. Sensory test data were analyzed descriptively by calculating the average value (mean) and standard deviation (SD). In addition, this data was also analyzed using the Kruskal Wallis difference test, then if there was a significant difference (p-value <0.05) it would be continued with the Mann Whitney test. The results of significant differences in each parameter were stated at a 95% confidence level or if the p-value <0.05. Data of product nutritional content was analyzed descriptively by displaying the average value and standard deviation.

Results and Discussion

Sensory evaluation

Sensory evaluation was conducted in a well-ventilated sitting room (booth) with good lighting facilities. During the assessment, drinking water was given to each panelist so that they could neutralize their mouths again to conduct testing on the next product sample. The scale used in the sensory test was a nine-point scale. This sensory evaluation was conducted on 30 semi-trained panelists. The sensory tests carried out include descriptive tests and hedonic tests.

Descriptive test result of granola bars on various parameters is presented in Table 2. Sensory attributes of this test included color, moringa aroma, sweetness, moringa taste, soybean taste, crunchy texture, and bitter aftertaste. Color scale parameters range from one (dark green) to nine (dark brown). Moringa aroma, sweetness, moringa taste, and soybean taste scale ranges from one (weak very much) to nine (strong very much). Crunchy texture scale ranges from one (not crunchy very much) to nine (crunchy very much). Bitter aftertaste scale ranges from one (strong very much) to nine (weak very much).

Table 2. Descriptive test result of granola bars on various parameters

Formulation	Parameter						
	Color	Moringa aroma	Sweet ness	Moringa flavor	Soybean flavor	Crunchy texture	Bitter aftertaste
F1	5.7±1,9^{a}	4.8±1,6^{a}	5.3±1.2^{a}	5.2±1.6^{a}	4.4±1.4^{a}	4.3±1.4^{a}	6.4±1.3^{a}
F2	5.6±1.9^{a}	5.7±1.9^{ab}	5.4±1.3^{a}	5.9±1.4^{b}	4.2±1.6^{a}	4.7±1.7^{a}	6.2±1.3^{a}
F3	6.0±2.3^{a}	6.2±2.1^{b}	5.5±1.6^{a}	6.8±1.8^{c}	4.2±1.7^{a}	4.7±1.7^{a}	5.7±1.6^{a}
p-value	0.671	0.014	0.940	0.010	0.920	0.464	0.338

^{a,b,c}Means within the same column with different superscripts are significantly different (P<0.05). F1 presents treatments: 95:5, F2 presents treatments :90:5, and F3 presents treatments: 85:15 as % of soybean flour and moringa leaf flour.

The results of the statistical analysis showed that there were no significant differences in the descriptive parameters of color, sweetness, soybean taste, crunchy texture, and

bitter aftertaste between the formulations (p>0.05). Based on the results of the panelist description, F1 dan F2 were in the range of creamy green color, normal or neutral sweetness, slightly weak of soybean flavor, slightly not crunchy of texture, and slightly weak of bitter aftertase. Meanwhile, F3 was in the range of brownies green color, normal or neutral sweetness, slightly weak of soybean flavor, slightly not crunchy of texture, and slightly weak of bitter aftertase.

The results also showed that there were significant differences between the formulations in the descriptive parameters of moringa aroma dan moringa flavor (p=0.014 and p=0.010). Further statistical analysis showed that F1 was significantly different compared to F2 and F3. Panelists assessed that F1 had slightly weak of moringa aroma and neutral of moringa flavor. F2 had neutral of moringa aroma and moringa flavor. Meanwhile, F3 had slightly strong of moringa aroma and moringa flavor. These results showed that the higher the percentage of moringa leaf flour, the stronger the aroma and flavor of moringa leaves in granola bar products. The addition of high concentrations of moringa as a functional ingredient result in an increased moringa leaf aroma and flavor in the final product. The same results were also found in other studies which showed that the more moringa leaf powder in the product, the more the aroma and flavor of moringa leaves will be produced, and this can reduce consumer preference for the product [21,22].

Hedonic test result of granola bars on various parameters is presented in Table 3. Sensory attributes of this test included color, aroma, flavor, and texture. The nine-point hedonic scale ranges from one (dislike very much) to nine (like very much). This scale means that the highest scale indicates the most preferred, while the lowest scale indicates the least preferred. The results of the difference test showed that the hedonic values in the aspects of color, flavor, and texture were not significantly different between formulations (p>0.05). However, based on the average value, F1 had a higher value for color (6.2), flavor (6.0), and texture (5.7) compared to the other formulas. F1 was in the neutral range (neither like nor dislike) to like slightly range for color, flavor, and texture parameters. Meanwhile, F2 dan F3 was in the dislike slightly range to neutral range (neither like nor dislike) for color, flavor, and texture parameters. This showed that F1 was preferred in terms of color, flavor, and texture compared to F2 and F3.

Table 3. Hedonic test result of granola bars on various parameters

Formulation	Parameter			
	Color	Aroma	Flavor	Texture
F1	6.2±1,6[a]	5.9±1,7[a]	6.0±1.8[a]	5.7±1.7[a]
F2	5.1±1.8[a]	4.7±1.8[b]	4.9±1.8[a]	4.8±1.9[a]
F3	5.5±1.9[a]	4.6±2.2[b]	4.9±2.4[a]	5.4±2.1[a]
p-value	0.116	0.024	0.089	0,094

[a,b,c]Means within the same column with different superscripts are significantly different (P<0.05). F1 presents treatments: 95:5, F2 presents treatments :90:5, and F3 presents treatments: 85:15 as % of soybean flour and moringa leaf flour.

Apart from that, the aroma parameter of the hedonic test showed that there was significant differences between the three formulations (p=0.024). Further statistic analysis showed that F1 was significantly different compared to F2 and F3, but between F2 and F3 there was no significant difference. F1 had a higher hedonic value for aroma compared to other formulas (5.9). F1 was in the neutral range (neither like nor dislike) for aroma, while F2 dan F3 in the dislike slightly range. This showed that F1 was preferred in terms of aroma compared to F2 and F3.

In this study, the F1 formulation that had a higher amount of soybean flour and lower amount moringa leaves was preferred by panelists compared to other formulas. Similar results were also obtained by Sandhya and Kanniammal which showed that snack bars with lower amounts of moringa leaf flour were consistently preferred by panelists in terms of taste, sweetness, texture, aroma, and appearance.(23) The study showed that snack bar product of Moringa Amla Millet Bar with a 20% incorporation of dried moringa leaf powder showed better overall acceptability, when compared to 40% and 60% incorporation of moringa leaf powder.

Selected formulation

The selected formulation was determined based on the highest value of overall parameters based on the hedonic test. In the hedonic test, each parameter provides the same percentage or contribution (25%). Based on the calculated to determine the selected formula, the highest result was F1, which was 5.9 (Table 4). Therefore, in this study, F1 is the selected formulation.

Table 4. Calculation to determine the selected formulation

Formulation	Hedonic test parameter				Overall (total)	Rank
	Color (25%)	Aroma (25%)	Flavor (25%)	Texture (25%)		
F1	1.5	1.5	1.5	1.4	5.9	1
F2	1.3	1.2	1.2	1.2	4.9	3
F3	1.4	1.2	1.2	1.3	5.1	2

F1 presents treatments 95:5, F2 presents treatments 90:10, and F3 presents treatments 85:15 as % of soybean flour and moringa leaf flour.

F1 with a combination of 95 grams of soybean flour and 5 grams of moringa leaves is the best formula in this study. Similar results were also obtained from other studies which showed that the selected formula for snack bar was the formula that contained the least amount of moringa leaf flour (5%) [23]. A recent research showed that the addition of moringa leaves in food up to 10% was considered acceptable by adults [24]. However, for children and adolescents, it is likely that they prefer products with a smaller percentage of moringa leaves. Another study showed that, in peanut cake products with a 2% addition of moringa leaf flour was found to be more acceptable by children in late childhood [25].

Nutritional content

The nutritional content from laboratory analysis of selected formula (F1) was shown in Table 5. The results of the analysis showed that the granola bar contained 3.3% ash, 9.2%

moisture content, 54.3% total carbohydrates, 16.6% fat content, 16.6% protein content, 433 kcal/100 total energy, and 149 kcal/100 energy from fat. Furthermore, the daily value percentage calculation was calculated by comparing the nutrient content with the nutritional label reference. Adolescents are included in the general population in the nutritional label reference. So, the reference values used are 2150 kcal energy, 67 g fat, 60 g protein, and 325 g carbohydrates. Based on the calculation results, every 100 grams of granola bar in F1 has a daily value percentage of 16.7% carbohydrates, 24.8% fat, 27.6% protein, and 20.1% total energy. The results also show that the granola bar of F1 has a claim as a protein source product because it has a daily value percentage of more than 20% per 100 g.

Table 5. Nutritional content of granola bars

Parameter	Nutritional content of F1			
	Unit	Result	% daily value per 100 g	Nutritional content claim
Ash content	%	3.3±0.1	-	-
Moisture content	%	9.2±0.04	-	-
Carbohydrate total	%	54.3±0.3	16.7	-
Fat content	%	16.6±0.1	24.8	-
Protein content	%	16.6±0.4	27.6	Source
Total energy	Kal/100 g	433.0±0.9	20.1	-
Energy from fat	Kal/100 g	149.4±0.7	-	-

The nutritional content of selected formula (F1) compared to commercial product (Fitbar) per serving size was shown in Table 6. The serving size of the granola bar was 20 g considering the amount of serving size based on commercial product. The calorie content of F1 was 86.6 kcal per 20 g. This value is slightly lower than the commercial snack bar (Fitbar) which has 90 kcal per 20 g serving. Based on the Indonesian dietary recommendation (AKG), the average daily calorie requirement for adolescence aged 13 to 18 years is 2,300 kcal. Generally, the energy requirement for snacking is 10% of the daily calorie requirement, so the calorie requirement for snacking is 230 kcal. This means that the adolescence can consume 2.7 pieces of F1 granola bars to meets their daily calorie needs from snacking. In addition, the results also showed that granola bar F1 has a lower carbohydrate, fat, and energy from fat compared to commercial snack bars. However, the protein content in granola bar F1 is higher than commercial snack bars.

Table 6. Nutritional content of selected formulation per serving size

Parameter	Nutritional content per serving size (20 g)	
	Formula 1 (F1)	Commercial products (Fitbar) [1]
Carbohydrate total (g)	10.9	15.0
Fat content (g)	3.3	3.5
Protein content (g)	3.3	2.0
Total energy (kcal)	86.6	90.0
Energy from fat	29.9	30.0

[1]Nutritional value of "Fitbar Coco Delight" on the package

The high protein content in F1 is due to the addition of soybean flour and moringa leaf flour. Both soybean and moringa flour are good sources of protein [10,13] Soybeans have been reported to have high protein quality, making them and their processed food

products an excellent source of plant protein. Soybeans contain about 35% to 40% protein [26]. Moringa leaves are known as an excellent food source that is easily digestible and rich in protein. The protein content in fresh moringa leaves is 6.7% while in dried leaves it is 29.4% [27]. However, further research is needed both laboratory and clinical studies to further study the nutritional content and other bioactive components as well as the clinical benefits of this snack bar.

Conclusions

Granola bar formulation made from soybean and moringa flour (F1, F2, and F3) gave no significantly different in few descriptive parameters (color, sweetness, soybean taste, crunchy texture, and bitter aftertaste) and hedonic parameters (color, flavor, and texture). However, this formulation gave significantly different in moringa aroma, moringa flavor, and aroma preference. Based on overall result, F1 is the best formulation (selected formula). F1 contained 3.3% ash, 9.2% moisture content, 54.3% total carbohydrates, 16.6% fat content, 16.6% protein content, 433 kcal/100 total energy, and 149 kcal/100 energy from fat. F1 has a claim as a protein source. Adolescence can consume this granola bars as an alternative healthy snack to meets their daily nutrient needs from snacking.

References

[1]. Wells JC, Sawaya AL, Wibaek R, Mwangome M, Poullas MS, Yajnik CS, et al. The double burden of malnutrition: aetiological pathways and consequences for health. Vol. 395, The Lancet. Lancet Publishing Group; 2020. p. 75–88.
[2]. Kementerian Kesehatan Republik Indonesia. Survei Kesehatan Indonesia. Jakarta; 2023.
[3]. Soliman A, De Sanctis V, Alaaraj N, Ahmed S, Alyafei F, Hamed N, et al. Early and long-term consequences of nutritional stunting: From childhood to adulthood. Acta Biomedica. 2021 Mar 5;92(1).
[4]. Reilly JJ, Kelly J. Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: Systematic review. Vol. 35, International Journal of Obesity. 2011. p. 891–8.
[5]. Cheng HL, Medlow S, Steinbeck K. The Health Consequences of Obesity in Young Adulthood. Vol. 5, Current obesity reports. 2016. p. 30–7.
[6]. Lopes TDS, Mello AV de, Nogueira LR, Leme ACB, Fisberg RM. Energy, nutrients and food sources in snacks for adolescents and young adults. Rev Paul Pediatr. 2021;40:e2020148.
[7]. Calvert S, Dempsey RC, Povey R. Normative misperceptions of unhealthy snacking amongst 11- to 12-year-old secondary school students. Appetite. 2021 Nov 1;166.
[8]. 8. Almoraie NM, Saqaan R, Alharthi R, Alamoudi A, Badh L, Shatwan IM. Snacking patterns throughout the life span: potential implications on health. Vol. 91, Nutrition Research. Elsevier Inc.; 2021. p. 81–94.
[9]. 9. Khoiriyah N, Fadillah Heryanda M. Pengaruh media edukasi food model dua dimensi terhadap pemahaman label gizi dan pemilihan makanan sehat pada remaja. Jurnal SAGO Gizi dan Kesehatan [Internet]. 2024;5(3):605–15. Available from: http://dx.doi.org/10.30867/sago.v5i3.1707
[10]. 10. Dukariya G, Shah S, Singh G, Kumar A. Soybean and Its Products: Nutritional and Health Benefits. Journal of Nutritional Science and Healthy Diet [Internet]. 2020;1(2):22–9. Available from: https://journalofnutrition.org
[11]. 11. Wang X, He T, Xu S, Li H, Wu M, Lin Z, et al. Soy Food Intake Associated with Obesity and Hypertension in Children and Adolescents in Guangzhou, Southern China. Nutrients. 2022 Feb 1;14(3).
[12]. 12. Ruscica M, Pavanello C, Gandini S, Gomaraschi M, Vitali C, Macchi C, et al. Effect of soy on metabolic syndrome and cardiovascular risk factors: a randomized controlled trial. Eur J Nutr. 2018

Mar 1;57(2):499–511.
[13]. 13. Abdel-Latif HMR, Abdel-Daim MM, Shukry M, Nowosad J, Kucharczyk D. Benefits and applications of Moringa oleifera as a plant protein source in Aquafeed: A review. Vol. 547, Aquaculture. Elsevier B.V.; 2022.
[14]. 14. Islam Z, Islam SMR, Hossen F, Mahtab-Ul-Islam K, Hasan MR, Karim R. Moringa oleifera is a Prominent Source of Nutrients with Potential Health Benefits. Vol. 2021, International Journal of Food Science. Hindawi Limited; 2021.
[15]. 15. Chhikara N, Kaur A, Mann S, Garg MK, Sofi SA, Panghal A. Bioactive compounds, associated health benefits and safety considerations of Moringa oleifera L.: an updated review. Vol. 51, Nutrition and Food Science. Emerald Group Holdings Ltd.; 2021. p. 255–77.
[16]. 16. Barichella M, Pezzoli G, Faierman SA, Raspini B, Rimoldi M, Cassani E, et al. Nutritional characterisation of Zambian Moringa oleifera: acceptability and safety of short-term daily supplementation in a group of malnourished girls. Int J Food Sci Nutr. 2019 Jan 2;70(1):107–15.
[17]. 17. Haque M, Jahan I, Khanam M, Org M. Effects of Moringa oleifera leaves on hemoglobin and serum retinol levels and underweight status among adolescent girls in rural Bangladesh. Frontiers in Nutrition. 2022;9.
[18]. 18. Ariendha DSR, Handayani S, Pratiwi YS. The Effect of Moringa Leaf Cilok Supply on Hemoglobin Levels of Female Adolescents with Anemia. Global Medical & Health Communication (GMHC). 2022 Apr 30;10(1).
[19]. 19. Eid WAM, Azab DESH, Negm SH. Characterization of a novel date energy bar fortified with Moringa oleifera leaves powder. Journal of Future Foods. 2025 May 1;5(3):266–75.
[20]. 20. Ismawati R, Wahini M, Fatkhur Romadhoni I, Aina Q. Sensory Preference, Nutrient Content, and Shelf Life of Moringa Oliefera Leaf Crackers. 2019;9(2).
[21]. Giuberti G, Bresciani A, Cervini M, Frustace A, Marti A. Moringa oleifera L. leaf powder as ingredient in gluten-free biscuits: nutritional and physicochemical characteristics. European Food Research and Technology. 2021 Mar 1;247(3):687–94.
[22]. Sandhya JJ, Kanniammal C. Development and sensory evaluation of Moringa oleifera–enriched snack bar for micronutrients deficiency in adolescents. Int J Nutr Pharmacol Neurol Dis. 2024 Oct 1;14(4):425–31.
[23]. Peñalver R, Martínez-zamora L, Lorenzo JM, Ros G, Nieto G. Nutritional and Antioxidant Properties of Moringa oleifera Leaves in Functional Foods. Foods. 2022 Apr 1;11(8).
[24]. Ademosun OT, Ajanaku CO, Oloyede MO, Owolabi AO, Ajayi SO, Jonathan HO, et al. Proximate and sensory evaluation of peanut cakes fortified with moringa oleifera leaf powder. In: IOP Conference Series: Earth and Environmental Science. IOP Publishing Ltd; 2021.
[25]. Qin P, Wang T, Luo Y. A review on plant-based proteins from soybean: Health benefits and soy product development. J Agric Food Res. 2022 Mar 1;7.
[26]. Islam Z, Islam SMR, Hossen F, Mahtab-Ul-Islam K, Hasan MR, Karim R. Moringa oleifera is a Prominent Source of Nutrients with Potential Health Benefits. Vol. 2021, International Journal of Food Science. Hindawi Limited; 2021.