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FABRICATION AND CHARACTERIZATION OF GRANOLA BAR SUPPLEMENTED WITH FLAXSEED AND BANANA PEEL POWDER FOR COMPOSITIONAL, BIOFUNCTIONAL, AND SENSORIAL ATTRIBUTES

Zainab Atique[*1], Marriam Aftab[2], Ayesha Usman[3], Saba Ahmed[4], Aleena Faryad[5], Murium Sultan[6], Binish Almas[7], Kinza Fatima[8], Muhammad Asif[9]

[*1,2,3,4,5,7]*National Institute of Food Science and Technology, University of Agriculture Faisalabad*
[6]*College of Food Science and Technology, Huazhong Agricultural University, Wuhan, China*
[8]*Graduate School of Chinese Academy of Agriculture Sciences, China*
[9]*Department of Food Science and Technology, UAF-Constituent College, Burewala, Pakistan*

[*1]zainabatique2019@gmail.com

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Corresponding Author: *
Zainab Atique

Abstract

Granola bars are nutrient-dense products, typically based on oats, which provide carbohydrates, dietary fiber, and energy. Granola bars were developed by partially replacing oats with varying levels of flaxseed (0–25%) and banana peel powder (0–20%) to enhance their nutritional and functional properties. The incorporation of these ingredients significantly ($p<0.05$) altered the chemical composition, increasing protein content due to flaxseed and dietary fiber owing to the high fiber content of banana peel powder, while slightly reducing total carbohydrates. Healthy fats from flaxseed, including omega-3 fatty acids, contributed to improved lipid quality, and the mineral content (ash) was enhanced, providing essential nutrients such as potassium, magnesium, and calcium. Furthermore, bioactive compounds were elevated, as total phenolic content increased from 12.40 to 26.20 mg GAE/100 g and antioxidant activity improved from 18.50% to 38.70%, indicating potential health benefits against oxidative stress. Color values (L, a*, b*) changed with supplementation, reflecting darker and more visually appealing bars, while sensory evaluation showed that the T_3 formulation offered the best overall acceptability, balancing taste, texture, and appearance with nutritional enhancement. These findings suggest that granola bars enriched with moderate levels of flaxseed and banana peel powder can serve as a functional snack, providing higher protein, fiber, minerals, and antioxidants, supporting both health and consumer preference.*

INTRODUCTION

A granola bar is a nutritious meal time snack. Granola bars are generally made up of small pieces of different ingredients that are bound together with a sticky binder and pressed into a block, with some bars having an extra coating of the binder (Chompoo *et al.*, 2023). Granola, a snack meal, can be prepared using a number of different ingredients. These ingredients include several food groups, such as cereal grains, millets, pulses, nuts, and seeds. For easy consumption, granola is being transformed into a pressed bar form (Chaudhary *et al.*, 2022).

Oats (*Avena sativa*) are members of the *Poaceae* family, ranked sixth in terms of global cereal production, after sorghum, wheat, maize, rice, and barley (Ahmad *et al.*, 2020). There are several

ways to use oats in meals, such as rolled oats, crushed oatmeal, whole grains, and oat flour. Either whole or rolled, oats are most commonly consumed as a cereal for breakfast. Oats are higher in protein and fats than other cereals, but they have fewer carbohydrates. About 60% of whole grain oat fibers are insoluble, and 40% are soluble. Compared to other cereals, oats contain more soluble fiber. Consumption of oats reduces the blood cholesterol, blood pressure, risk of colon cancer and protects from cardiovascular diseases. It also boosts the immune system's resistance to viruses, germs, fungus, and parasites (Alemayehu *et al.*, 2023).

Flaxseed (*Linum usitatissimmum*), another name is linseed; these terms are interchangeable. Linseed indicates that flax is utilized only for industrial purposes, whereas flaxseed is frequently referred to as flax when consumed by humans. It might be yellow or dark brown in color. With a delightful nutty flavor, flaxseed has a crisp and chewy texture. Flaxseed protein composition ranges from 10.5% to 31%. However, flax has a low carbohydrate content, 41% fat, 7.7% moisture and 3.4% ash. For people who do not eat fish, flaxseed is the finest source of omega-3 fatty acids. Edible flaxseed products include whole seeds, ground meal, and oil or mucilage extracts. These products are designed to be used as nutritious supplements in the production of various foods, including bread, muffins, spaghetti, fiber bars, baked cereal goods, and ready-to-eat cereals (Anurag *et al.*, 2020).

The banana crop is a member of the genus *Musa* and family Musaceae. Bananas are naturally "prepacked", elliptically shaped fruits with firm, creamy flesh encased in a thick skin (Arinzechukwu and Nkama, 2019). Banana peels are frequently thrown into the environment unprocessed. Peels of banana fruit have minimal tannin content and they are rich sources of fiber content that make them suitable for use as organic fertilizer and animal feed in some cases and increasingly, as a nutritious ingredient in the food industry (Zaini *et al.*, 2022). According to studies, Zinc, potassium, copper, calcium, iron, magnesium, and polyunsaturated fatty acids like omega-3 and omega-6 are all abundant in banana peels, as are phenolic substances like tannins, anthocyanins, gallic acid, and catechin (Bhavani *et al.*, 2023).

Nuts are regarded as foods with significant nutritional value and are frequently eaten as fresh, roasted, or salted snacks. Nuts can also be utilized to create high-quality oils, flours, plant-based milk alternatives, spreads, cereal bars, baked goods, and candies. These business-related uses enhance the role of nuts as elements with greater value. Cereal bars are widely consumed and incorporated into many people's diets. The use of nuts in cereal bar formulation has shown good outcomes, increased the nutritional value of diets while lowered sodium and empty calorie intake and improving the profiles of beneficial fatty acids (Polmann *et al.*, 2023). The present study aimed to develop a granola bar supplemented with flaxseed and banana peel powder. Subsequently, investigate the effect of varying concentrations of flaxseed and banana peel powder on the compositional, bionfucntional and sensory analysis of granola bar

Materials and Methods

Procurement of Raw Materials

All raw ingredients, such as oats, flaxseed, jaggery, nuts, and fresh bananas, were procured from the local market of Faisalabad. Chemical and reagents were used of analytical grade (Sigma Aldrich, Germany).

Preparation of raw materials

The banana peels were rinsed with tap water, separated from the pulp, and then cut into little pieces. After being submerged in a 0.5% citric acid solution for 20 minutes to stop browning, banana peels were cleaned and allowed to dry at room temperature for six days. Dried banana peels were ground into a powder in a mixer and sieved through a 0.50 mm mesh screen to obtain uniform powder, packed in an airtight polythene bag, and stored at room temperature for further use (Eshak, 2016).

Similarly, the flaxseed was manually cleaned to remove foreign materials. After that, the flaxseed sample was roasted in a pan at medium flame for 2 to 3 minutes with frequent stirring until there was a warm roasted aroma in the air. Then it was

cooled at room temperature, followed by grinding and sieving, respectively, to obtain a uniform particle size (Subedi and Upadhyaya, 2019).

Development of Granola Bars

Granola bars were developed by using different concentrations of oats, flaxseed, and banana peel powder. Preparation of granola bars consisted of several steps. Firstly, rolled oats were roasted on low flame with continuous stirring. Nuts (peanuts, almonds, and walnuts) were cracked, dehusked and roasted in a pan for 2 minutes cool at room temperature, then ground into fine powder. The jaggery syrup solution was prepared in the ratio of 1:2, calculated Jaggery (g) added in water (ml)) and stirred uniformly in medium flame until the jaggery completely dissolved in water. Then, the jaggery solution was filtered with a sieve to remove the suspended particles present in the jaggery. After that, the filtered jaggery solution was stirred continuously in a pan under medium flame until a thick consistency was reached. All dry ingredients (roasted oats, flaxseed powder, banana peel powder, and nuts powder) were mixed with jaggery syrup in proportions according to Table 1 and mixed properly. Mixed material was placed in a greased tray and kept in the refrigerator for 10 minutes. After setting at a cool temperature material was cut into a bar shape and packed in polythene bags for further study.

Table 1. Preparation of Granola Bars Incorporated with Flaxseed and Banana Peel Powder

Treatments	Oats (%)	Flaxseed (%)	Banana Peel Powder (%)
T_0	100	0	0
T_1	85	10	5
T_2	75	15	10
T_3	65	20	15
T_4	55	25	20

Chemical composition

Chemical composition (moisture, crude fiber, crude fat, ash, and crude protein) of granola bars was determined using standard procedures AOAC (2023) as reported in literature (Asif et al., 2023). Moisture contents were calculated after drying of granola bar samples in a hot air oven at 105 ℃ for 24 hours. Fat contents were measured using Soxhlet extraction with n-hexane. Similarly, Kjeldahl apparatus was used for the determination of crude protein after digesting the samples in sulfuric acid. Ash contents were measured using a muffle furnace (MF-1/02, PCSIR, Pakistan), at 600℃ for 5 h.

Biofunctional Characterization Granola Bar

Extract Preparation

In this method, an extract of a granola bar was prepared using 1g sample in 10mL of methanol keep it room temperature for 2 hours and filtered through Whatman Filter No. 2 (Asif et al., 2025a).

Total Phenolic Content

The total phenolic content (TPC) of the granola bar was determined using the protocol described by Chen et al. (2018). In this method, the sample extract and Folin-Ciocalteu reagent (1:1) were added, followed by the addition of distilled water (500 µl), and placed at room temperature. After 3 minutes, 125 µl of saturated solution of sodium carbonate was mixed with the above solution, and the volume upto 10 ml by the addition of distilled water. The absorbance of the sample was observed through a UV-visible spectrophotometer at 760 nm. The total phenolic content was expressed in mg gallic acid equivalent (GAE)/ per gram of extract in dry base.

Antioxidant activity

The antioxidant activity of the granola bar was measured using the DPPH (1,1-diphenyl-2-picrylhydrazyl) method using the prescribed method (Omran's, 2018). Briefly, DPPH solution was prepared with the addition of 0.0215g of DPPH in 500mL of methanol. After that, 2 ml of DPPH solution was added with 20µL of sample

extract. After that, this mixture was incubated in a dark place at room temperature for half an hour. Then, the absorbance of the mixture was measured at 517nm using a spectrophotometer 752D (UV Visible, China). The following equation was used to calculate the scavenging activity.

$$Scavenging\ activity = 1 - \frac{A_f}{A_0} \times 100$$

Where A_o and A_f are the absorbance values of the blank and sample, respectively.

Color analysis

Color analysis was granola bar was performed using suggested methods (Singh et al., 2022; Zahid et al., 2025). The color values in terms of L* (100 = white; 0 = black), a* (positive = red; negative green), and b* (positive - yellow; negative - blue) were determined by using a colorimeter.

Microbiological study

The total plate count was recorded as a colony forming unit by following the method of Akhtara *et al.* (2015). 10g of the bar sample was homogenized in 90 ml of normal saline solution and serially diluted up to 10 dilutions. 0.1 ml sample of each dilution was spread on prepared general media plates under a sterilized environment. After that, the inoculated plates were incubated at 37°C for 24-48 h.

$$TPC(Cfu/g) = \frac{No.of\ colonies \times Dilution\ factor}{volume\ of\ sample\ used}$$

Sensory Evaluation

Sensory properties of the granola i.e., color, appearance, aroma, texture, taste and overall acceptability, were assessed by using a 9-point hedonic scale according to the method given by Allai *et al.* (2022).

Statistical analysis

All the analyses were carried out in triplicates and the results were presented as mean ± standard deviation. The Least Significant Difference (LSD) test, by keeping 5% level of significance, was used to check the extent of difference among treatments (Asif *et al.*, 2025b; Fatima *et al.*, 2025).

Results and Discussion

Chemical composition of granola bar

The chemical composition of granola bar was determined and results are presented in Table 1. Results revealed that incorporation of varying concentration of flaxseed and banana peel powder significantly ($p<0.05$) effect the chemical composition of granola bar. Moisture contents in granola bar significantly decreased as compared to control. It may be due to the fiber present in flaxseed and pectin in banana peel, they bind water, absorb excess moisture, and contribute to less sticky texture in the final product (Sharma, 2018). These results are correlated with findings of Singh *et al.* (2022). Ash and fat contents significantly increased due to the supplementations of flaxseed and banana peel powder. Similarly, protein contents were significantly increased with the addition of flaxseed and banana peel (Mathur *et al.*, 2020). These results are in line with previous reported literature (Sharma *et al.*, 2018). Likewise, fiber contents in granola bar were significantly enhanced. This increase in fiber can be attributed to the inclusion of flaxseed and banana peel powder, both rich in insoluble and soluble fiber. These ingredients are known not only to boost fiber but also to provide additional health benefits such as improved gut health and reduced cholesterol levels (Kokani *et al.*, 2019). These findings are correlated with prior results reported in literature (Silva Carvalho and Conti-Silva, 2018).

Table 1. Chemical Composition of Granola Bars supplemented with varying concentrations of flaxseed and banana peel powder

Treatments	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fiber (%)
T_0	9.85±0.10^{d}	1.10±0.03^{e}	5.20±0.10^{e}	7.80±0.12^{d}	3.50±0.08^{d}
T_1	9.70±0.14^{c}	1.35±0.04^{d}	6.45±0.12^{d}	8.50±0.10^{c}	4.20±0.10^{c}
T_2	9.30±0.18^{b}	1.58±0.02^{c}	7.10±0.15^{c}	9.20±0.15^{b}	5.10±0.12^{b}
T_3	8.90±0.15^{a}	1.79±0.03^{b}	7.85±0.14^{b}	9.85±0.14^{a}	5.85±0.09^{a}
T_4	8.85±0.12^{a}	1.95±0.02^{a}	8.30±0.11^{a}	9.95±0.13^{a}	5.80±0.07^{a}

Biofunctional Characterization of Granola bar

Total Phenolic Content

The total phenolic contents in supplemented granola bar were determined and results are shown in Table 2. Results showed that inclusion of varying concentration of flaxseed and banana peel powder significantly ($p<0.05$) effect the TPC in granola bar. The minimum TPC was measured in control sample (12.40±0.25 mg GAE/100g). With increasing the concentration of flaxseed and banana peel powder, TPC was increased significantly across the treatments: T_1 (16.85±0.30mg GAE/100g), T_2 (20.10±0.28mg GAE/100g), T_3 (23.95±0.32mg GAE/100g), and the highest TPC was measured in T_4 (26.20±0.26mg GAE/100g). The increase in phenolic content is attributed to the presence of naturally occurring polyphenols in banana peel, flaxseed, and pumpkin seed, all of which are excellent sources of antioxidants (Umme *et al.*, 2021). These results are correlated with prior reported study (Khouryieh and Aramouni, 2019).

Antioxidant activity

The antioxidant activity of supplemented granola bar was determined and results are presented in Table 2. Results showed that incorporation of various concentrations of flaxseed and banana peel powder significantly ($p<0.05$) effect the antioxidant activity of granola bar. The control sample (T_0) had the lowest antioxidant activity, with a DPPH value of 18.50±0.30 % inhibition. As the levels of functional ingredients increased, the DPPH activity also increased progressively: T_1 (24.90±0.35%), T_3 (35.40±0.38%), and the highest value was recorded in T_4 (38.70±0.40%). This pattern clearly shows that the enrichment of granola bars with natural sources such as flaxseed (polyphenols and lignans, which have antioxidant properties), banana peel (has Phenolic compounds, Flavonoids), and other antioxidant-rich ingredients effectively boosts their radical scavenging capacity (Sharma, 2018). These findings are in line with reported literature (Khouryieh and Aramouni, 2019).

Table 2. Biofunctional characterization of supplemented Granola Bar

Treatments	Total Phenolic Content (mg GAE/100g)	DPPH Assay (%)
T_0	12.40±0.25^e	18.50±0.30^e
T_1	16.85±0.30^d	24.90±0.35^d
T_2	20.10±0.28^c	30.10±0.42^c
T_3	23.95±0.32^b	35.40±0.38^b
T_4	26.20±0.26^a	38.70±0.40^a

Color Analysis

The color analysis of supplemented granola bar was performed and results are presented in Table 3. Results indicated that inclusion of varying concentration of flaxseed and banana peel significantly effect the color (L, a and b values) of granola bar. The control sample (T_0) showed the highest L* value (65.40±0.45), indicating the lightest appearance. With the progressive addition of flaxseed and banana peel powder significant reduction in L* value was observed: T_1 (61.85±0.40), T_2 (58.30±0.38), T_3 (55.10±0.42), and the darkest shade was found in T_4 (52.75±0.35). This darkening effect is primarily due to the higher levels of polyphenols and dietary fibers, which are naturally brownish in color and tend to absorb more light (Mathur *et al.*, 2020).

Similarly, the control (T_0) exhibited the lowest a* value (4.10±0.10), indicating minimal redness. With increasing addition of functional ingredients, there was a consistent and significant rise in a* values: T_1 (4.85±0.12), T_2 (5.60±0.11), T_3 (6.25±0.09), and the highest redness in T_4 (6.90±0.08). This enhancement in red hue can be attributed to the natural pigmentation of added plant-based components such as seeds, peels, or antioxidant-rich flours, which deepen the product color as their concentration increases (Bansal *et al.*, 2022).

Likewise, b* value of control treatment (T_0) had the highest value (18.90±0.35), suggesting a bright yellow tone typical of traditional cereal-based products. As the level of functional or colored ingredients increased from T_1 to T_4, there was a gradual but significant decrease in b* values, showing a shift away from yellowness: T_1 (17.10±0.30), T_2 (15.50±0.28), T_3 (14.20±0.25), and T_4 (13.30±0.22). This decreasing trend in b* values could be attributed to the inclusion of dark-colored ingredients such as flaxseed, date pulp, banana peel flour, or plant polyphenols, which mask the natural yellow hues of base ingredients. Such ingredients contain phenolic and flavonoid compounds that tend to impart brown, red, or darker tones rather than yellow (Sharma, 2018). These outcomes are correlated with previously reported literature (Allai *et al.*, 2021).

Table 3. Color Analysis of Granola Bars supplemented with varying concentrations of flaxseed and banana peel powder

Treatments	L*	a*	b*
T_0	65.40±0.45^a	4.10±0.10^e	18.90±0.35^a
T_1	61.85±0.40^b	4.85±0.12^d	17.10±0.30^b
T_2	58.30±0.38^c	5.60±0.11^c	15.50±0.28^c
T_3	55.10±0.42^d	6.25±0.09^b	14.20±0.25^d
T_4	52.75±0.35^e	6.90±0.08^a	13.30±0.22^e

Microbial Analysis of Granola Bar

The total plate count in granola bar was determined and results are depicted in Figure 1. Results showed that total plate count in granola bar was significantly decreased with inclusion of varying concentrations of flaxseed and banana peel powder. The highest total plate count was observed in the control sample T_0 (2.05 ± 0.06 log CFU/g), while the microbial load decreased progressively with the addition of functional and potentially antimicrobial ingredients across the treatments. T_1 recorded 1.88±0.05log CFU/g, T_2 1.75±0.04log CFU/g, T_3 1.65±0.05log CFU/g, and the lowest TPC was observed in T_4 1.55±0.03log CFU/g. The reduction in microbial count can be attributed to the natural antimicrobial properties of phytochemicals present in functional ingredients. Many plant-based components contain bioactive compounds like phenolics, flavonoids, and tannins that inhibit the growth of spoilage and pathogenic microorganisms by disrupting bacterial membranes and interfering with enzyme activity (Singh *et al.*, 2018).

Additionally, the reduced moisture content in the improved formulations may have contributed to lower microbial activity. Water activity plays a significant role in microbial growth, and the inclusion of dry fiber-rich or protein-rich components likely reduced water availability, thereby enhancing shelf stability (Ravichandran *et al.*, 2019). These findings are consistent with prior studies that reported a decrease in total plate counts with the use of antioxidant-rich and fiber-enhanced formulations in bars and snack products, reflecting their protective effects against microbial proliferation. The declining trend in total plate count values from T_0 to T_4 demonstrates that the inclusion of functional ingredients not only improves the nutritional profile but also contributes positively to the microbiological safety and shelf life of granola bars.

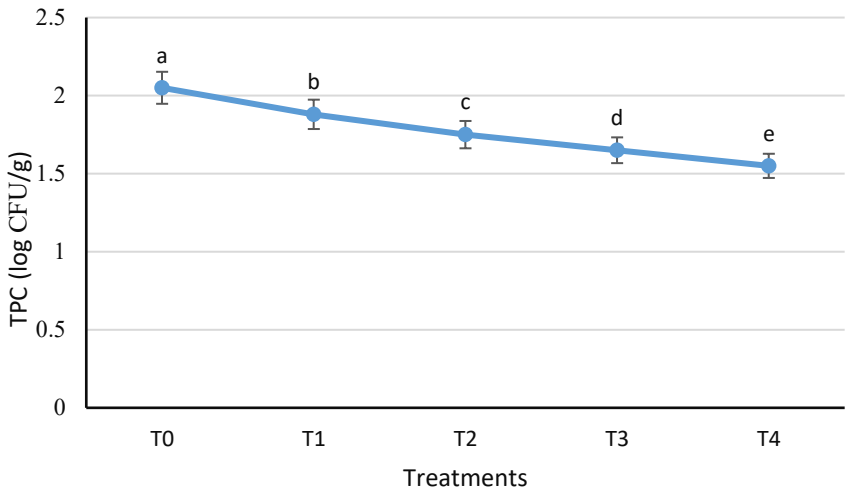

Figure 1. Graphical representation of total plate count in supplemented granola bar

Sensory Analysis of Granola Bar

Sensorial attributes of granola bar supplemented with varying concentrations of flaxseed and banana peel. Results revealed that incorporation of flaxseed and banana peel significantly ($p<0.05$) effect the sensorial attributes of granola bar. Color score was observed in treatments; T_3 (8.2±0.18) followed by T_4 (7.8±0.26) and T_2 (7.2±0.25). T_1 (7.0±0.23) and T_0 (6.1±0.20) received comparatively lower scores. These differences could be attributed to the type and concentration of added ingredients such as natural fibers, seeds, or fruit powders, which may have altered the surface appearance and visual appeal of the product (Raza *et al.*, 2022). Aroma score significantly effects with the incorporation of flaxseed and banana peel powder. It may be attributed to the optimal blend of roasted flaxseed and banana peel powder, which can release pleasant nutty and sweet aroma during roasting (Sharma *et al.*, 2020). Texture score was significantly decreased with increasing supplementation of banana peel powder and flaxseed (Patel *et al.*, 2020). Taste of granola bar was significantly improved. Overall acceptability score showed that T_3 was the best among the treatments and score maximum sensory score.

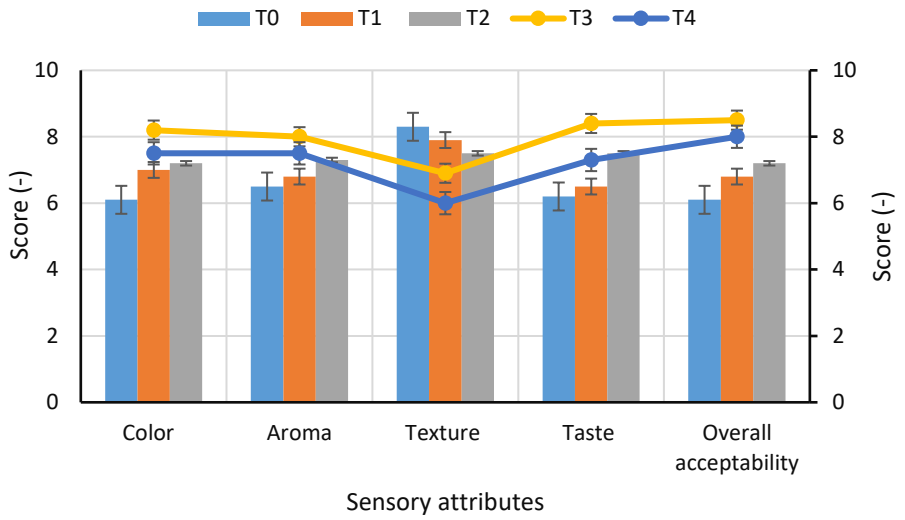

Figure 2. Graphical representations of sensorial attributes of granola bar supplemented with flaxseed and banana peel

Conclusion

The study demonstrated that granola bars enriched with flaxseed and banana peel powder have significantly improved nutritional and functional properties compared to the control. Partial replacement of oats with flaxseed increased protein and healthy fats, while banana peel powder enhanced dietary fiber and mineral content. The incorporation of these ingredients also elevated total phenolic content and antioxidant activity, indicating potential health-promoting benefits. Sensory evaluation revealed that the T3 formulation, containing moderate levels of flaxseed and banana peel powder, provided the best balance of taste, texture, appearance, and overall acceptability. These results suggest that the developed granola bars can serve as a functional snack, offering enhanced nutritional value, bioactive compounds, and consumer appeal, making them a promising option for health-conscious individuals seeking convenient and nutrient-rich foods.

References

Ahmad, M., I. Jehangir, R. Rizvan, S.A. Dar, S. Iqbal, S. Wani, U. Mehraj and R. Hassan. 2020. Phylogenetic relationship of oats (*Avena sativa* L.): A guide to conservation and utilisation of genetic resources. International Journal of Current Microbiology and Applied Sciences. 9:831-845.

Akhtara, J., I. Banoa, R. Pandeya, A. Husainb and S. Malika. 2015. Effect of different levels of pectin and starch on quality and storage stability of apple-date fruit bar. Journal of Food. 2:26-31.

Alemayehu, G.F., S.F. Forsido, Y.B. Tola and E. Amare. 2023. Nutritional and phytochemical composition and associated health benefits of oat (*Avena sativa*) grains and oat-based fermented food products. The Scientific World Journal. 2023:2730175.

Allai, F.M., B. Dar, K. Gul, M. Adnan, S.A. Ashraf, M.I. Hassan, V.R. Pasupuleti and Z. Azad. 2022. Development of protein rich pregelatinized whole grain cereal bar enriched with nontraditional ingredient: Nutritional, phytochemical, textural and sensory characterization. Frontiers in Nutrition. 9:870819.

Anurag, A., M. Prakruthi and M. Mahesh. 2020. Flax seeds (*Linum usitatissimmum*): Nutritional composition and health benefits. Innovative Publication Journal of Nutrition, Metabolism and Health Science. 3:35-40.

AOAC (Association of Official Analytical Chemists). 2023. The Official methods of analysis of association of Official Analytical Chemist International. 21st Edition. Arlington, USA.

Arinzechukwu, C. and I. Nkama. 2019. Production and quality evaluation of fruit bars from banana (*Musa sapientum*) and cashew (*Anacardium occidentale*) apple fruit blends. Asian Food Science Journal. 10:1-16.

Asif, M., A.A. Maan, A. Nazir, M.I.M. Khan and M.K.I. Khan. 2025b. Effect of chickpea on the physicochemical, nutritional, antioxidant, and organoleptic characterization of corn extrudates. Journal of the Science of Food and Agriculture. 105:2059-2067.

Asif, M., M. Abbas, K. Fatima, N. Ahmad, S. Ahmed, P. Meghwar, E. Hosseini, A. Nasir and S.A. Hassan. 2025a. Innovative corn extrudates incorporating barley-oat flour blends: Nutritional, functional, and sensory evaluation. Applied Food Research.100812.

Asif, M., M.K.I. Khan, M.I. Khan, A.A. Maan, H. Helmick and J.L. Kokini. 2023. Effects of citrus pomace on mechanical, sensory, phenolic, antioxidant, and gastrointestinal index properties of corn extrudates. Food Bioscience. 55:103012.

Bansal, U., A. Bhardwaj, S.N. Singh, S. Khubber, N. Sharma and V. Bansal. 2022. Effect of incorporating plant-based quercetin on physicochemical properties, consumer acceptability and sensory profiling of nutrition bars. Functional Foods in Health and Disease. 12:116-127

Bhavani, M., S. Morya, D. Saxena and C.G. Awuchi. 2023. Bioactive, antioxidant, industrial, and nutraceutical applications of banana peel. International Journal of Food Properties. 26:1277-1289.

Chaudhary, M., R. Singh and E.S. Chauhan. 2022. Nutritional properties and organoleptic evaluation of formulated granola bar. International Journal of Food and Fermentation Technology. 12:41-45.

Chen, C., L. Wang, W. Ren, X. Luo, Y. Li, J. Li, Y. Li and Z. Chen. 2018. Phenolic contents, cellular antioxidant activity and antiproliferative capacity of different varieties of oats. Food Chemistry. 239:260-267.

Chompoo, M., C. Somjai, S. Sriwattana, N. Utamaang, T. Loakuldilok and S. Osiriphun. 2023. A healthy cereal granola bar formulation from a mixture of Thai local rice flour, job's tears flour, and black sesame seeds. Biology and Life Sciences Forum. 26:15074-15083.

Eshak, N.S. 2016. Sensory evaluation and nutritional value of balady flat bread supplemented with banana peels as a natural source of dietary fiber. Annals of agricultural science. 61:229-235.

Fatima, K., M. Asif, S.A. Hassan, M. Naveed, T. Alvi and M. Abbas. 2025. Fabrication and Characterization of Protein Fortified Corn Extrudates for Nutritional, Bio-functional, Structural and Organoleptic Properties. Food Biophysics. 20:1-12.

Khouryieh, H. and Aramouni, F. 2019. Effect of flaxseed flour incorporation on the physical properties and consumer acceptability of cereal bars. Food Science and Technology International. 19:549-556.

Kokani, R.C., P.R. Virkar and A.S. Shinde. 2019. Studies on formulation and preparation of banana peel powder bar incorporated with psyllium husk. International Journal of Food Science and Nutrition. 4:129-133.

Mathur, M., A. Kumari, R.B. Grewal, A. Panghal, M. Rani and R. Kargwal. 2020. Development and optimization of ingredients for multigrain fibre and protein enriched composite bars using sensory evaluation. Journal of Pharmaceutical Innovation. 9:143-149.

Omran, A.A. 2018. Enhancing the nutritional value of oat bars. American Journal of Food Science and Technology. 6:151-60.

Patel, M., T. Desai and N. Shah. 2020. Development of fiber-rich functional granola bars using fruit peel powder. International Journal of Food Studies. 9:255-262.

Polmann, G., V. Badia, R. Danielski, S.R.S. Ferreira and J.M. Block. 2023. Nuts and nut-based products: A meta-analysis from intake health benefits and functional characteristics from recovered constituents. Food Reviews International. 39:5021-5047.

Ravichandran, K., N.M.M.T. Saw, A.A.A. Mohdaly, A.M.M. Gabr, A. Kastell, H. Riedel and Z. Cai. 2019. Impact of processing of fruit and vegetable products on phenolic compounds. Advances in Food and Nutrition Research. 87:89-131.

Raza, A., M. Bashir and S. Rehman. 2022. Influence of functional ingredients on sensory and visual attributes of cereal-based snack bars. International Journal of Food Science and Nutrition. 7:22-29.

Sharma, R., R. Singh and M. Kaur. 2020. Effect of flaxseed flour incorporation on the sensory and nutritional properties of baked energy bars. Journal of Food Science and Technology. 57:2130-2137.

Sharma, V. 2018. Development and quality evaluation of flaxseed-based energy bar. Ph.D. dissertation, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, India.

Silva Carvalho, V. and A.C. Conti-Silva. 2018. Storage study of cereal bars formulated with banana peel flour: Bioactive compounds and texture properties. Nutrition and Food Science. 48:386-396.

Singh, A., A. Kumari and A.K. Chauhan. 2022. Formulation and evaluation of novel functional snack bar with amaranth, rolled oat and unripened banana peel powder. Journal of Food Science and Technology. 59:3511-3521.

Subedi, B. and N. Upadhyaya. 2019. Preparation and quality evaluation of flaxseed incorporated cereal (oat) bar. Journal of Food Science and Technology Nepal. 11:65-68.

Umme, H., R.M. Ashadujjaman, H.M. Mehedi, T.M. Afroz, A. Delara and M.M.A. Rahman. 2021. Nutritional, textural and sensory quality of bars enriched with banana flour and pumpkin seed flour. Foods and Raw materials. 9:282-289.

Zahid, T., S. Nooreen, M. Asif, S. Maqsood, A. Saddiqa, M. Nazar, T. Alvi and M. Rafiq. 2025. Development and characterization of protein-rich cookies fortified with red kidney beans: A nutritional approach to combat malnutrition. Journal of Pure Applied and Agriculture. 10.21-29.

Zaini, H.M., J. Roslan, S. Saallah, E. Munsu, N.S. Sulaiman and W. Pindi. 2022. Banana peels as a bioactive ingredient and its potential application in the food industry. Journal of Functional Foods. 92:105054.