
DEVELOPMENT OF VALUE -ADDED GRANOLA BARS USING POMEGRANATE PEEL POWDER

Ententa Akshitha^{*(1)}, Ms. Manjari Vaka⁽²⁾

Student⁽¹⁾ Assistant Professor⁽²⁾

Department of Nutrition and Dietetics, Kasturba Gandhi Degree & PG College for Women,
Secunderabad, Telangana, India.

Article Received: 24 May 2026

Article Revised: 13 June 2026

Published on: 02 July 2026

*Corresponding Author: Ententa Akshitha

Student, Department of Nutrition and Dietetics, Kasturba Gandhi Degree & PG
College for Women, Secunderabad, Telangana, India.

DOI: <https://doi-doi.org/101555/ijrpa.8172>

ABSTRACT

The present study was undertaken to develop value-added granola bars using pomegranate peel powder and to evaluate their nutritional composition, antioxidant activity, and sensory acceptability. Pomegranate peel, a major by-product of fruit processing, is rich in dietary fiber, polyphenols, flavonoids, and antioxidant compounds, making it a suitable functional ingredient for food fortification. Granola bars were prepared using foxtail millet, rolled oats, pomegranate peel powder, almonds, cashew nuts, pumpkin seeds, and jaggery. The ingredients were processed, blended, and formulated into granola bars, which were subsequently subjected to sensory evaluation and nutrient analysis. Sensory evaluation was conducted among 50 semi-trained panelists using a hedonic scale to assess appearance, colour, taste, texture, and overall acceptability. The results indicated good consumer acceptance, with an overall acceptability score of 4.04. Statistical analysis revealed that the product was significantly accepted ($p < 0.05$). Nutritional analysis showed that the developed granola bars contained 420 kcal energy, 10.5 g protein, 14.0 g fat, 60.0 g carbohydrate, 8.0 g dietary fiber, and 5.5 g moisture per 100 g. Antioxidant activity determined by the DPPH radical scavenging assay exhibited 68% inhibition, indicating strong antioxidant potential due to the incorporation of pomegranate peel powder. The findings demonstrate that pomegranate peel powder can be effectively utilized as a value-added functional ingredient in granola bars, enhancing their nutritional quality and antioxidant properties while maintaining consumer acceptability. The developed product has potential as a healthy and convenient snack suitable for health-conscious consumers.

KEY WORDS –Granola bars, Pomegranate peel powder, Functional foods, Antioxidant activity, DPPH assay, Anti-inflammatory foods.

INTRODUCTION

The increasing prevalence of lifestyle-related disorders such as obesity, diabetes, cardiovascular diseases, and chronic inflammatory conditions has led to a growing interest in foods that provide health benefits beyond basic nutrition. Consumers are becoming more conscious of their dietary choices and are seeking convenient, nutritious, and functional food products that can support overall health and well-being. Functional foods are defined as foods that offer physiological benefits and help reduce the risk of chronic diseases due to the presence of bioactive compounds [1,2]. The development of functional snack products has emerged as an important area of research in food science and nutrition, as these products provide an effective means of delivering health-promoting ingredients in a convenient form [3].

Food product development is a systematic and multidisciplinary process involving the creation, formulation, testing, and commercialization of innovative food products. The process begins with the identification of consumer needs and market opportunities, followed by product formulation, evaluation, optimization, and commercialization. A successful food product should possess desirable sensory qualities, nutritional value, safety, shelf stability, and consumer acceptability [4]. In recent years, the incorporation of natural bioactive ingredients into food products has gained considerable attention due to increasing consumer demand for healthier alternatives to conventional snacks [5].

Among various functional snack products, granola bars have become increasingly popular because of their convenience, portability, and nutritional benefits. Granola bars are ready-to-eat products typically prepared from cereals, oats, nuts, seeds, dried fruits, and natural sweeteners. These ingredients provide essential macronutrients such as carbohydrates, proteins, fats, and dietary fiber, along with micronutrients and bioactive compounds [6]. Granola bars are considered an excellent vehicle for incorporating functional ingredients due to their versatility and wide consumer acceptance [7]. Furthermore, they offer a healthier alternative to highly processed snack foods that are often rich in refined sugars and unhealthy fats [8].

Pomegranate (*Punica granatum* L.) is a fruit-bearing plant belonging to the family Lythraceae and has been widely cultivated in tropical and subtropical regions of the world. The fruit has been used for centuries in traditional medicine owing to its therapeutic properties. Various

parts of the pomegranate, including the peel, seeds, juice, and arils, contain numerous bioactive compounds that contribute to its health-promoting effects ^[9]. Pomegranate is particularly rich in polyphenols, flavonoids, tannins, anthocyanins, and other phytochemicals that exhibit strong antioxidant, anti-inflammatory, antimicrobial, and anticancer activities ^[10]. These compounds help neutralize free radicals, reduce oxidative stress, and protect the body against various chronic diseases ^[11].

Pomegranate peel, which constitutes approximately 40–50% of the fruit weight, is considered a valuable by-product of the juice processing industry. Although often discarded as waste, the peel contains higher concentrations of phenolic compounds and antioxidants than many other parts of the fruit ^[12]. Studies have reported that pomegranate peel powder contains substantial amounts of dietary fiber, carbohydrates, minerals, and bioactive compounds ^[13]. The high total phenolic and

flavonoid contents of pomegranate peel contribute significantly to its antioxidant potential ^[14]. The utilization of pomegranate peel powder in food products not only enhances their nutritional and functional properties but also promotes sustainable food processing practices by reducing agricultural waste ^[15].

Oats (*Avena sativa* L.) are another important functional ingredient widely recognized for their nutritional and health benefits. Oats are rich in dietary fiber, particularly β -glucan, which has been associated with cholesterol reduction, improved glycemic control, and enhanced gut health ^[16]. In addition, oats contain proteins, vitamins, minerals, and unique antioxidants known as avenanthramides that exhibit antioxidant activities ^[17]. Regular consumption of oats has been linked to a reduced risk of cardiovascular diseases and improved metabolic health ^[18]. Due to their excellent nutritional profile and functional properties, oats are commonly incorporated into health-oriented food products, including granola bars ^[19].

Jaggery is a traditional natural sweetener produced from concentrated sugarcane juice. Unlike refined sugar, jaggery retains several minerals, vitamins, and phytochemicals that contribute to its nutritional value ^[20]. It is known to contain iron, calcium, potassium, and antioxidant compounds, making it a healthier alternative to refined sweeteners ^[21]. Its natural sweetness and binding properties make it an ideal ingredient for granola bar formulations ^[22].

The combination of pomegranate peel powder, oats, and jaggery offers a unique opportunity to develop a value-added snack product with enhanced nutritional and functional properties. Pomegranate peel powder contributes dietary fiber and antioxidant compounds, oats provide essential nutrients and β -glucan, while jaggery serves as a natural sweetener with additional

nutritional benefits [23]. Together, these ingredients can produce a granola bar that is nutritionally superior and rich in bioactive compounds [24].

Therefore, the present study focuses on the development and nutrient analysis of value-added granola bars formulated using pomegranate peel powder. The study aims to evaluate the nutritional composition, antioxidant activity, sensory acceptability, and overall quality characteristics of the developed granola bars. By utilizing natural and functional ingredients, the research seeks to develop a convenient and health-promoting snack product that meets the growing consumer demand for nutritious foods while contributing to sustainable utilization of fruit processing by-products [25].

MATERIALS AND METHODS

Research Design

The present study was carried out using an experimental research design to develop value-added granola bars incorporating pomegranate peel powder and to evaluate their sensory, nutritional, and antioxidant properties.

Selection of raw materials

The raw materials used for the preparation of granola bars, namely foxtail millet, rolled oats, almonds, cashew nuts, pumpkin seeds, jaggery, and fresh pomegranates, were taken from local markets. All ingredients were selected based on their quality and suitability for product development.

Preparation of Pomegranate Peel Powder

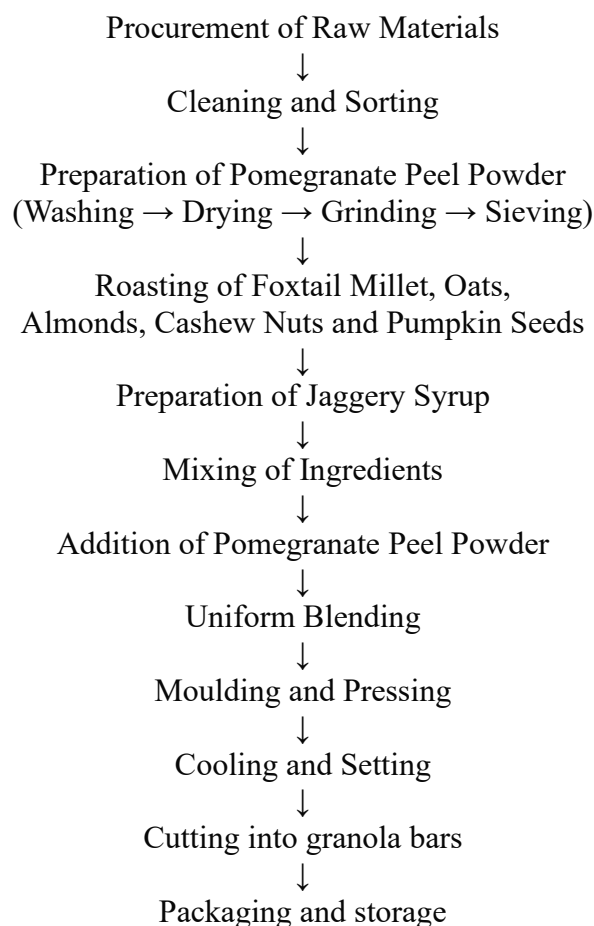
Fresh pomegranates were washed thoroughly under running water to remove dirt and impurities. The peels were separated manually, cut into small pieces, and subjected to sun drying for 5–6 days until a constant weight was obtained. The dried peels were ground using a mixer grinder and sieved to obtain a fine powder. The prepared pomegranate peel powder was stored in airtight containers until further use.

Formulation and Preparation of Value-Added Granola Bars

Foxtail millet, rolled oats, almonds, cashew nuts, and pumpkin seeds were cleaned and roasted separately to enhance flavour and reduce moisture content. Jaggery syrup was prepared by dissolving jaggery in a small quantity of water and heating until a uniform consistency was achieved. The roasted ingredients were mixed thoroughly with pomegranate peel powder, and the jaggery syrup was added as a binding agent. The mixture was blended uniformly and transferred into a greased tray. The mixture was pressed evenly, allowed to

cool and set, and then cut into rectangular bar-shaped pieces. The prepared granola bars were packed in airtight containers for further analysis.

Flow chart of Millet granola bar



Sensory Evaluation

The developed granola bars were subjected to sensory evaluation by 50 semi-trained panelists. The samples were evaluated for appearance, colour, flavour, taste, texture, and overall acceptability using a five-point hedonic rating scale. The sensory scores obtained were statistically analyzed to determine the acceptability of the product.

Nutritional Analysis

The nutritional composition of the developed value-added granola bars was determined using standard analytical procedures. Energy value was calculated and expressed as kcal per 100 g of product. Protein content was determined by the Kjeldahl method. Total fat content was analyzed according to AOAC Method 920.39, while dietary fiber was estimated using AOAC Method 985.29. Moisture content was determined by the oven drying method. Total

carbohydrate content was calculated by difference. All analyses were expressed on a 100 g basis of the developed granola bars.

Determination of Antioxidant Activity

The antioxidant activity of the developed granola bars was assessed using the DPPH (2,2-Diphenyl-1-picrylhydrazyl) radical scavenging assay. The sample extract was mixed with DPPH solution and incubated under dark conditions. The absorbance was measured using a spectrophotometer, and the percentage inhibition of free radicals was calculated to determine antioxidant activity.

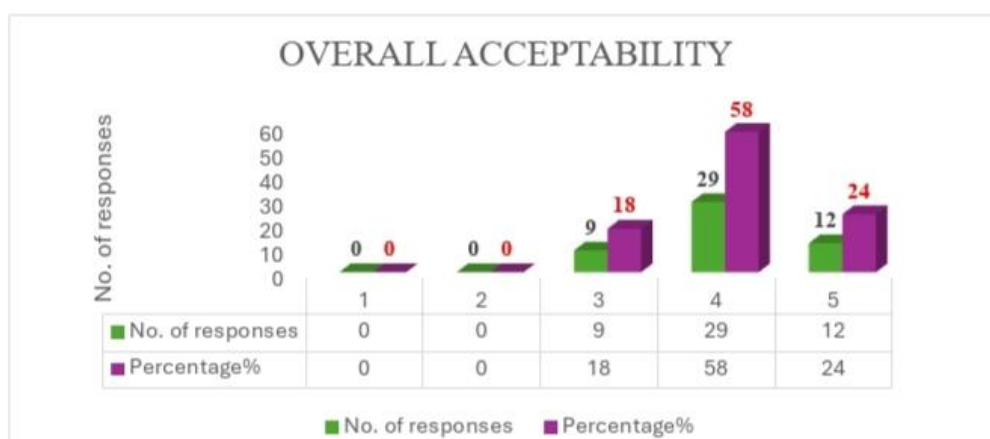
Statistical Analysis

The data obtained from sensory evaluation and analytical studies were compiled and analyzed using appropriate statistical methods. Descriptive statistics such as mean and percentage were calculated, and a one-sample t-test was used to determine the significance of sensory acceptability. A significance level of $p < 0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

Sensory Evaluation of Value-Added Granola Bars

Sensory evaluation was conducted among 50 semi-trained panelists to assess the acceptability of the developed granola bars based on appearance, colour, taste, texture, and overall acceptability using a 5-point hedonic scale. The developed granola bars received favourable sensory scores, indicating good consumer acceptance. The majority of respondents rated the appearance, colour, taste, and texture as "very good" to "excellent". Overall acceptability scores revealed that 58% of the panelists assigned a score of 4, while 24% assigned the highest score of 5, demonstrating a high level of preference for the developed product. The positive sensory scores may be attributed to the balanced combination of oats, foxtail millet, nuts, seeds, jaggery, and pomegranate peel powder, which contributed to desirable flavour, texture, and appearance. The findings indicate that incorporation of pomegranate peel powder did not adversely affect the sensory characteristics of the granola bars and was well accepted by consumers.



Overall acceptability for granola bars

Nutritional Composition of Granola Bars

The nutritional composition of the developed value-added granola bars is presented in Table 1. The product exhibited a balanced nutritional profile with an energy value of 420 kcal/100 g, protein content of 10.5 g/100 g, total fat of 14.0 g/100 g, carbohydrate content of 60.0 g/100 g, dietary fiber of 8.0 g/100 g, and moisture content of 5.5 g/100 g. The relatively high energy content may be attributed to the presence of oats, millet, nuts, seeds, and jaggery, which provide carbohydrates and healthy fats. The protein content reflects the contribution of oats, almonds, cashew nuts, and pumpkin seeds. The dietary fiber content exceeded the recommended minimum level for fiber-enriched snack products, indicating the beneficial contribution of pomegranate peel powder and millet. Furthermore, the low moisture content suggests improved shelf stability and reduced susceptibility to microbial spoilage during storage.

TABLE- 1 Nutritional Composition of Granola Bars from Laboratory Analysis.

S. NO	TEST PARAMETER	UNIT OF MEASUREMENTS	TEST METHOD	TEST RESULTS	LIMITS
1	Energy	Kcal/100g	Calculation	420 kcals/100g	380-450
2	Protein	g/100g	Kjeldahl Method	10.5 g/100g	≥ 8.0
3	Total fat	g/100g	AOAC 920.39	14.0 g/100g	10-20
4	Total carbohydrates	g/100g	By Calculation	60.0 g/100g	—
5	Dietary fiber	g/100g	AOAC 985.29	8.0 g/100g	≥ 5.0
6	Moisture content	g/100g	Oven Drying Method	5.5 g/100g	≤ 8.0
7	Antioxidant activity (DPPH)	%	DPPH Radical Scavenging Assay	68%	≥ 5.0

Antioxidant Activity

The antioxidant activity of the developed granola bars was determined using the DPPH radical scavenging assay. The product exhibited 68% inhibition, indicating strong antioxidant potential. The high antioxidant activity can be attributed primarily to the incorporation of pomegranate peel powder, which is rich in polyphenols, flavonoids, tannins, and other bioactive compounds. These compounds possess the ability to donate hydrogen atoms or electrons to neutralize free radicals, thereby reducing oxidative stress. The results suggest that the developed granola bars can serve as a functional snack product with enhanced antioxidant properties. Similar findings have been reported in previous studies where incorporation of pomegranate peel powder significantly increased the antioxidant capacity of cereal-based snack products.

Overall Product Evaluation

The overall findings of the study demonstrate that the developed value-added granola bars possess desirable sensory characteristics, balanced nutritional composition, and significant antioxidant activity. The incorporation of pomegranate peel powder enhanced the functional quality of the product by increasing dietary fiber and antioxidant potential without compromising consumer acceptability. In addition, the utilization of pomegranate peel contributes to sustainable food processing practices through the value addition of fruit-processing by-products. Therefore, the developed granola bars may be considered a nutritious and convenient snack suitable for health-conscious consumers seeking functional food alternatives.

CONCLUSION

It is concluded that the value-added granola bars developed using pomegranate peel powder were highly acceptable in terms of appearance, colour, taste, texture, and overall acceptability. The developed product exhibited good nutritional quality with appreciable amounts of energy, protein, dietary fiber, and healthy fats, along with significant antioxidant activity. The incorporation of pomegranate peel powder enhanced the functional and nutritional properties of the granola bars without adversely affecting sensory characteristics. Therefore, pomegranate peel powder can be effectively utilized as a value-added functional ingredient in granola bar formulations, providing a nutritious and convenient snack while promoting the sustainable utilization of fruit processing by-products.

ACKNOWLEDGMENTS

The authors express their sincere gratitude to the Department of Nutrition and Dietetics, Kasturba Gandhi Degree and PG College for Women, Secunderabad, for providing the facilities, guidance, and support necessary to carry out this research work successfully. The authors also thank all the participants who took part in the sensory evaluation of the developed product.

REFERENCES

1. Vučić, V., Grabež, M., Trchounian, A., & Arsić, A. (2019). Composition and potential health benefits of pomegranate: A review. *Current Pharmaceutical Design*, 25(16), 1817–1827. <https://doi.org/10.2174/1381612825666190708183941>
2. Ain, H. B. U., Tufail, T., Bashir, S., Ijaz, N., Hussain, M., Ikram, A., et al. (2023). Nutritional importance and industrial uses of pomegranate peel: A critical review. *Food Science & Nutrition*, 11(6), 2589–2598. <https://doi.org/10.1002/fsn3.3320>
3. Cao, S. Y., Feng, Y., Huang, Y., Li, X., Deng, Y., Zhang, Y., et al. (2023). Bioactive compounds and health benefits of pomegranate: An updated narrative review. *Food Bioscience*, 53, 102629. <https://doi.org/10.1016/j.fbio.2023.102629>
4. Azmat, F., Safdar, M., Ahmad, H., Khan, M. R. J., Abid, J., Naseer, M. S., et al. (2024). Phytochemical profile and nutritional composition of pomegranate peel and peel extract as a potential source of nutraceuticals: A comprehensive review. *Food Science & Nutrition*, 12(2), 661–674. <https://doi.org/10.1002/fsn3.3851>
5. Giri, N. A., Gaikwad, N. N., Raigond, P., Damale, R., & Marathe, R. A. (2023). Exploring the potential of pomegranate peel extract as a natural food additive: A review. *Current Nutrition Reports*, 12(2), 270–289. <https://doi.org/10.1007/s13668-023-00469-8>
6. Sweidan, N., Abu Rayyan, W., Mahmoud, I., & Ali, L. (2023). Phytochemical analysis, antioxidant and antimicrobial activities of pomegranate peels. *PLoS ONE*, 18(11), e0295129.
7. Kafeel, S., Inam-ur-Raheem, M., Khan, M. R., & Faisal, M. N. (2023). Phytochemical characterisation and antioxidant capacities of pomegranate peel. *International Journal of Food Science & Technology*, 58(9), 4543–4550. <https://doi.org/10.1111/ijfs.16544>
8. Asbaghi, O., Kolbadi, K. S. H., Naderian, M., & Hosseini, A. (2023). The effects of pomegranate consumption on inflammatory and oxidative stress biomarkers in adults: A systematic review and meta-analysis. *Inflammopharmacology*, 31(5), 2283–2301. <https://doi.org/10.1007/s10787-023-01235-7>

9. Akaberi, M., Boghrati, Z., Sahebkar, A., & Emami, S. A. (2021). Therapeutic potential of pomegranate in metabolic disorders. In *Advances in Experimental Medicine and Biology* (Vol. 1328, pp. 421–440). Springer. https://doi.org/10.1007/978-3-030-73234-9_22
10. Dawra, M., Kaur, J., Kumar, V., & Rasane, P. (2026). Millets as nutri-cereals: Nutritional composition and health benefits. In *Nutraceutical Potential of Millet-Based Food Products*. CRC Press. <https://doi.org/10.1201/9781003574154-4>
11. Jetawat, R. P., Singh, I. P., Mohapatra, R., Swetha, S., Jatav, A. K., Mishra, A. R. K., et al. (2025). Nutritional composition and health advantages of millets in contemporary dietary practices. *European Journal of Nutrition & Food Safety*, 17(6), 287–300. <https://doi.org/10.9734/EJNFS/2025/v17i61684>
12. Chaudhary, M., Singh, R., & Chauhan, E. S. (2022). Nutritional properties and organoleptic evaluation of formulated granola bar. *International Journal of Food Fermentation Technology*, 12(1), 41–45.
13. Barakat, H. A., Sabri, D. M., & Khalil, S. R. (2023). Evaluation of granola bars quality fortified with sweet sorghum jaggery. *Food Technology Research Journal*, 2(1), 26–39.
14. Hossain, S., Momee, M. F., Trisa, A. H., Rahman, A., & Mazumder, M. A. R. (2025). Physico-chemical, textural and sensory properties of bars enriched with oats and flaxseed flour. *Food Humanity*, 100766. <https://doi.org/10.1016/j.foohum.2025.100766>
15. Abbas, R., Aamir, M., Saeed, F., Shankar, A., Kaur, J., Nadeem, R., et al. (2025). Development and nutritional evaluation of pomegranate peel enriched bars. *PLoS ONE*, 20(1), e0315830. <https://doi.org/10.1371/journal.pone.0315830>
16. Muhammad, A., Dayisoğlu, K. S., Pei, J., Khan, M. R., Salman, M., Ahmad, R., et al. (2023). Compositional analysis of natural pomegranate peel powder dried by different methods and nutritional and sensory evaluation of cookies fortified with pomegranate peel powder. *Frontiers in Nutrition*, 10, 1118156. <https://doi.org/10.3389/fnut.2023.1118156>
17. Ayoubi, A., Balvardi, M., Akhavan, H. R., & Hajimohammadi-Farimani, R. (2022). Fortified cake with pomegranate seed powder as a functional product. *Journal of Food Science and Technology*, 59(1), 308–316. <https://doi.org/10.1007/s13197-021-05069-6>
18. Giri, N. A., Gaikwad, P., Gaikwad, N. N., Manjunatha, N., Krishnakumar, T., Kad, V., et al. (2024). Development of fibre-enriched muffins using pomegranate peel powder and its effect on physico-chemical properties and shelf life. *Journal of the Science of Food and Agriculture*, 104(4), 2346–2358. <https://doi.org/10.1002/jsfa.13085>

19. Ruiz-Hernández, A. A., Rouzaud-Sáñez, O., Valenzuela-González, M., Domínguez-Avila, J. A., González-Aguilar, G. A., & Robles-Sánchez, M. (2025). Antioxidant/anti-inflammatory potential and sensory acceptance of granola bars. *Foods*, 14(10), 1787. <https://doi.org/10.3390/foods14101787>
20. Das, A. K., Nanda, P. K., Chowdhury, N. R., Dandapat, P., Gagaoua, M., Chauhan, P., et al. (2021). Application of pomegranate by-products in muscle foods: Oxidative indices, colour stability, shelf life and health benefits. *Molecules*, 26(2), 467. <https://doi.org/10.3390/molecules26020467>
21. Noor, U., Soni, S., Devi, S., Gupta, S., & Gupta, B. (2021). Potential application of *Punica granatum* peel in the food industry. In *Emerging Trends in Science and Technology*. <https://doi.org/10.1002/9781119757397.ch10>
22. Shrestha, L., & Kalpana, C. A. (2020). Quality assessment, phytochemical profile and antioxidant activity of pomegranate peel powders (Thesis).
23. Sreya, K. P. (2021). Development and popularisation of value-added food products using pomegranate peel powder (Master's thesis).
24. Singh, K. (2020). Nutritional and antioxidant potential of pomegranate (*Punica granatum* L.) by-products (Doctoral dissertation).
25. AOAC International. (2019). Official methods of analysis of AOAC International (21st ed.). AOAC International.