

Sustainable Utilization of Pomegranate Peel in the Development of Value Added Products to Enhance Micronutrients and Antioxidant Activity

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Abstract: Pomegranate peel powder has gained increasing attention in recent years due to its rich content of bioactive compounds, including polyphenols and antioxidants. The incorporation of pomegranate peel powder into different food products has been studied for its potential to enhance both nutritional value and health benefits. The present study, examined sensory characteristics, nutrient composition and antioxidant activity of products developed with the incorporation of pomegranate peel powder (PPP). Cookies and crackers were developed by incorporating pomegranate peel powder at different levels (2%, 5%, and 6%) and subjected to acceptability using 9-point hedonic scale. Furthermore, the best accepted variation was analysed for nutrient composition, phenolic content and total antioxidant activity using standard methods. Sensory analysis revealed that cookies and crackers with 5% pomegranate peel powder incorporation were highly accepted compared to the control (wheat based) and other variations. The best accepted products showed higher content of calcium, iron, phenolic content and antioxidant activity. The study concluded that pomegranate peel powder incorporated cookies and crackers can be considered as a healthy alternative to conventional products available in the market. The supplementation of products with pomegranate peel powder offer a nutrient-rich and phytochemical-enriched option that can be enjoyed by individuals of all age groups. Hence, the study supports the potential use of pomegranate peel powder as functional ingredient in the food industry as an innovative and healthy option for the consumers seeking healthier food choices.

Key words: antioxidant activity; sensory; polyphenols; food choices; pomegranate peel powder; phytochemical; supplementation; crackers; innovative

Introduction:

Pomegranate is a berry fruit characterized by leathery rind (husk or peel) that encloses numerous seeds surrounded by juicy arils. The edible part of the pomegranate fruit (50%) comprises of 40% arils and 10% seeds. Pomegranate peel comprises about 50% of the total fruit weight, generally considered as waste (Jalal *et al.*, 2018), an important source of essential minerals like potassium, calcium, phosphorus, magnesium, and sodium. These minerals are pivotal for physiological functioning of the body. It is an abundant source of complex polysaccharides and diverse range of bioactive compounds such as phenolics, flavonoids, proanthocyanidin compounds and ellagitannin (ETs), such as punicalagins and its isomers, as well as lesser amounts of punicalin, gallagic acid, ellagic acid, and ellagic acid glycosides (Gillonet *al.*, 2020). Phenolic compounds exhibit antioxidant activity and thus play an important role in prevention of oxidative stress and acts as anti-aging, anti-inflammatory and anti-atherosclerotic.

Pomegranate peel can be utilized in the value addition of various bakery products to improve their nutritional profile and make them healthier as a large number of population prefer these products for their taste. The presence of antioxidants from PPP can increase the overall antioxidant capacity of the products developed and therefore beneficial for preventing chronic disease and promoting overall health.

The use of pomegranate peel, which would be discarded as waste, also provides environmental sustainability by reducing food waste and promoting eco-friendly practices in the food industry. Hence, a study was carried out to evaluate the effect of PPP incorporation on sensory attributes, nutrition profile and antioxidant capacity of the developed products.

Materials and methodology:

Materials: The peels were collected from fresh pomegranate fruits. Additional ingredients required for the development of value-added products were sourced from the local market. The procured ingredients were thoroughly cleaned to remove any impurities or contaminants. Proper storage measures were implemented to maintain the quality and freshness of the ingredients until they were ready for use. This typically involves storing them in a cool, dry place and in airtight containers to minimize exposure to moisture, light, and air.

Preparation of pomegranate peel powder: Peel of fresh pomegranate fruit was washed to remove any dirt or impurities that may be present. The washed pomegranate peels are then placed in a hot air oven set at 50°C. The peels are dried in the oven for a duration of 48 hours until their moisture content is reduced to 5%. Once the peels have been dried to the desired moisture content, they are pulverized to obtain a fine powder. This can be achieved by grinding or milling the dried peels until they reach the desired particle size. The pulverized pomegranate peel powder is then passed through a sieve to remove any larger particles or coarse material. The prepared fine powder is stored in airtight containers. The resulting pomegranate powder is used for product value addition of products developed.

Product development: In the study, cookies and crackers were prepared using pomegranate peel powder incorporated at three different levels i.e., 2, 5 and 6%. The other ingredients used in the recipes were kept constant throughout the experiment. The experimental products were developed using a combination of millet and oats flour along with the incorporation of pomegranate peel powder at the specified levels. On the other hand, control was prepared using wheat flour without any incorporation of pomegranate peel powder.

Sensory evaluation: In order to assess the acceptability of the developed products (cookies and crackers) compared to the control group, a sensory evaluation was conducted. The evaluation involved a semi-trained panel of members who assessed the products using a 9-point hedonic scale. The scale typically ranges from 1 to 9, with 1 representing "dislike extremely" and 9 representing "like extremely." Panel members assigned a score on this scale based on their subjective assessment of the products' sensory characteristics and overall liking.

Nutrient and phytochemical analysis:

Macro and Micro-nutrient Analysis: The best accepted variation of cookies and crackers, along with the control, were analysed to determine their macro and micro-nutrient composition. The analysis involves identifying and quantifying the essential macronutrients (such as carbohydrates, proteins, fats, crude fibre and ash) and micronutrients (such as calcium and iron) present in the samples.

Phenolic Content Analysis: The phenolic content of pomegranate peel powder, as well as the best accepted products and control, was determined using FolinCiocalteu's method. This method involves a colorimetric assay to measure the total phenolic compounds present in the samples. Phenolic compounds are known for their antioxidant properties and potential health benefits.

Total Antioxidant Activity Analysis: The total antioxidant activity of the samples was evaluated using the Ferric Reducing Antioxidant Power (FRAP) assay. This assay measures the ability of the samples to reduce ferric ions (Fe^{3+}) to ferrous ions (Fe^{2+}) and provides an indication of their overall antioxidant capacity. Antioxidants help neutralize harmful free radicals in the body and protect against oxidative stress.

Results and Discussion:

Sensory evaluation:

Based on Figure 1 and 2, which represents the mean sensory scores obtained for cookies and crackers developed with pomegranate peel powder (PPP) incorporation at different levels (2%, 5%, and 6%), the results indicate that the both crackers and cookies with 5% PPP incorporation were the most preferred among the sensory characteristics evaluated. The control (cookies and crackers without PPP incorporation) was ranked second in terms of acceptability, followed by 2% and 6% PPP incorporation.

A study conducted by Palak, *et al.*, 2020, found similar results where, 5 and 10% pomegranate peel powder incorporated bread and cookies respectively scored best for colour, appearance, texture, taste, flavour and overall acceptability.

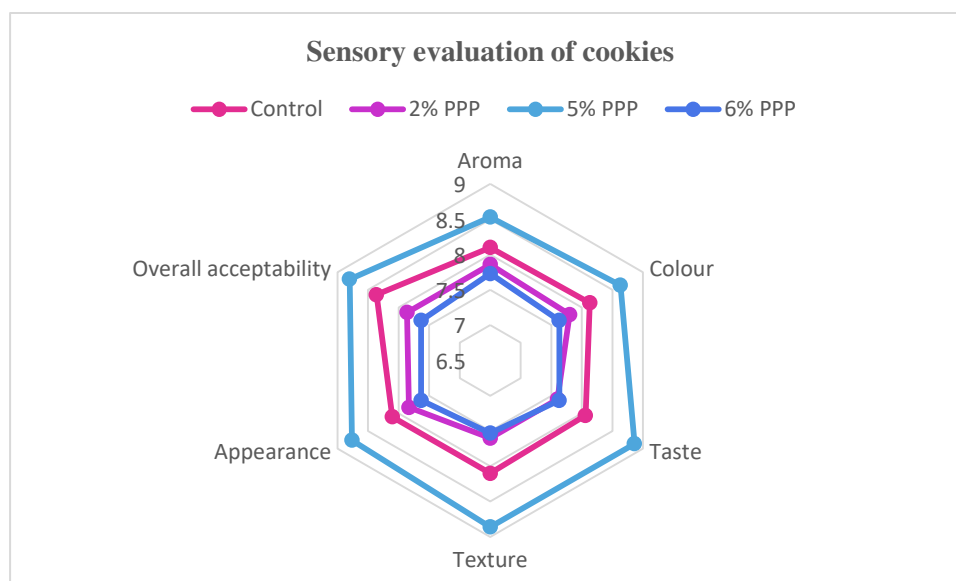


Fig1: Meansensoryscoresofcookies developed with pomegranatepeel powder incorporation

The study concluded that pomegranate peel powder possesses good sensory properties, as evidenced by the positive sensory scores obtained for the bread and cookies with the incorporation of pomegranate peel powder. These findings suggest that pomegranate peel powder can be successfully used as an ingredient in the development of various food products.

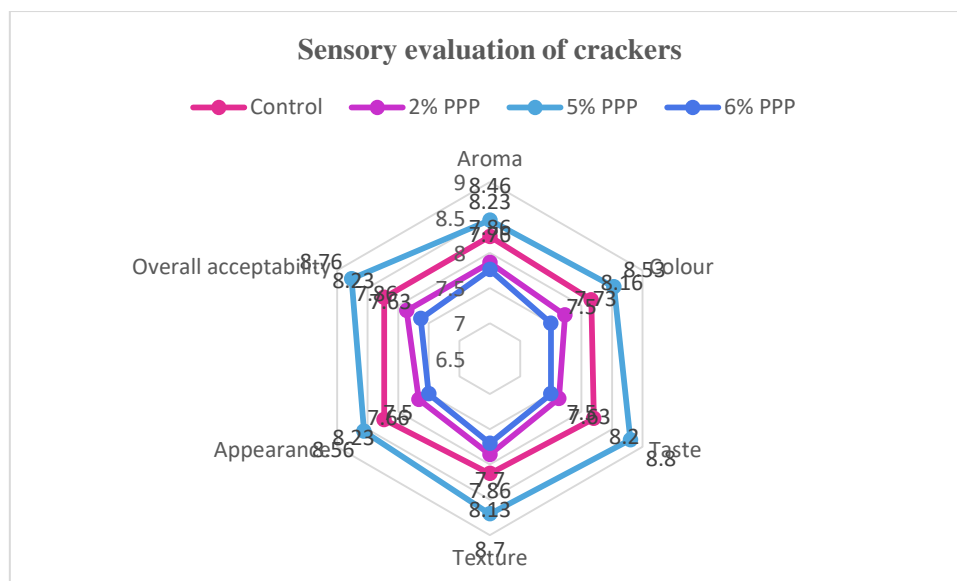


Fig2: Meansensoryscores of crackers developed with pomegranatepeel powder incorporation
Nutrient analysis:

Nutritional composition of cookies and crackers incorporated with pomegranatepeel powder are presented in Table 1. The results obtained from the study revealed an increased nutritional profile for PPP incorporated products, especially for calcium and iron. A reduction in moisture content was observed in the products developed with PPP incorporation when compared to control. This may be due to difference in the ingredients used and moisture holding capacity. A significant increase in the protein, fat, ash, crude fibre, calcium and iron was observed in both cookies and crackers incorporated with PPP. Similar results were obtained by the study conducted on the effect of pomegranate peel powder supplementation on nutritional properties of cookies. Results showed a significant reduction in moisture content, increase in dietary fibre and inorganic residues (Kulkarni, *et al.*, 2018).

A study conducted by Mehder, 2013, reported pomegranate peel powder as a good source of crude fibre and ash, and subsequently contained less amount of protein and carbohydrate. Thus, it was observed that as the level of pomegranate peel powder incorporation increased in pan bread, the fibre and ash content increased while the protein and carbohydrate decreased. Present study, observed an increase in protein content of the products developed with the incorporation of PPP. Incorporation of millets and oats might have contributed to the higher levels of protein compared to products without PPP incorporation.

Pomegranate peel powder was found to contain significant amount of minerals. With the incorporation of PPP, the level of calcium, potassium, zinc and iron was significantly increased in the cookies. By fortifying cookies with PPP, the mineral content of the final product can be enhanced, providing potential health benefits associated with these minerals (Muhammed, *et al.*, 2023).

Results of the study suggest that pomegranate peel powder can be utilized as a functional ingredient in food formulations to provide health benefits and improve the nutritional value of the final products. However, it is important to note that further research and studies are needed to validate these findings and explore the broader applications of pomegranate peel powder in ready-to-serve foods. Further, in order to accurately assess the contribution of pomegranate peel powder (PPP) in the nutritional profile of the experimental products, it is important to keep the ingredients used for both the control and experimental products the same, with the only difference being the incorporation of PPP.

Table 1: Marco and micro-nutrient composition of cookies and crackers incorporated with pomegranate peel powder

Samples	Cookies		Crackers	
	Control	5% PPP	Control	5% PPP
Moisture (g)	13.06±0.03	9.94±0.02	6.12±0.02	5.14±0.02
Protein (g)	5.08±0.02	6.14±0.02	3.00 ±0.01	7.86±0.03
Fat (g)	19.00±1.0	27.5±1.0	14.1±0.04	15.12±0.03
Ash (g)	2.06±0.01	2.55±0.08	3.16±0.02	3.56±0.02
Crude Fibre (g)	1.08±1.0	1.30±0.30	1.08±1.0	2.00±1.0
CHO (g)	52.00±0.85	53.5±0.88	59.3±0.03	68.72±0.02
Energy (kcal)	467±4.11	485±5.13	427±2.01	442±2.0
Calcium (mg)	28.5±1.01	330±30.0	36±1.01	490±2.0
Iron (mg)	1.00±0.01	6.00±2.0	3.3±0.02	6.00±1.0

Note: 5% PPP- 5% PomegranatePeel Powder incorporation; Control- Wheat based

Total phenol and antioxidant activity:

Table 3 represents the total phenolic content of PPP and products developed with the incorporation of PPP. The phenolic content of the pomegranate peel was observed 730±129.47 mg GAE/100g. Products incorporated with PPP also showed increased phenolic content compared to control product without PPP incorporation. According to a study conducted by Urganci, *et al.*, 2021, PPP was found to have the phenolic content of 438.3 ± 14.15 mg GAE/100g and highest among different parts of the pomegranate. Similarly, El Batawy, *et al.*, 2014 reported that the pomegranate peel powder incorporated cookies exhibited a phenolic content of 53.75 mg GAE/100g, while the control cookies had a phenolic content of 6.59 mg GAE/100g indicating that the pomegranate peel powder is a good source of phenolic content.

Phenolic compounds are known for their antioxidant properties and have been associated with various health benefits. The phenolic content of PPP may vary depending on factors such as the variety of pomegranate, processing methods, and storage conditions. Overall, the results of the present study highlight the potential of pomegranate peel powder as a valuable ingredient for enhancing the phenolic content and antioxidant properties of cookies and other food products. And also incorporation of phenolic containing compounds help in extending the shelf life of the products.

Table 2: Antioxidant capacity of pomegranate peel powder and products developed

Sample	Phenolic content (mg GAE/100g)	Antioxidant activity (mg vitamin C equivalent/g)
PPP	730±29.47	62.36±0.75
Control cookies	6.59±1.72	1.36±0.07
5% PPP cookies	53.75±7.32	47.83±1.58
Control crackers	3.26±5.64	2.33±0.32
5% PPP crackers	38.25±1.17	38.13±3.09

Note: PPP- PomegranatePeel Powder; 5% PPP- 5% PomegranatePeel Powder incorporation; Control- Wheat crackers; GAE- Gallic acid equivalent

Antioxidant activity of the PPP and products developed with the incorporation of PPP are presented in Table 3. The results showed an increased antioxidant activity of PPP (62.36±0.75) and the products developed with PPP incorporation compared to control. It is well-known that pomegranate peel

contains a significant amount of antioxidants, particularly phenolic compounds. Therefore, when pomegranate peel powder is incorporated into the crackers, it is expected that the antioxidant activity of the products would increase compared to the control group. Our results are in agreement with Paul and Bhattacharyya (2015), who reported that the total antioxidant activity of cookies fortified with PPP as 72.07 mg vit C equivalent/100g.

The high antioxidant activity of pomegranate peel is attributed to its rich content of phenolic compounds, such as flavonoids and tannins. These compounds possess strong antioxidant properties and can help neutralize harmful free radicals in the body, reducing oxidative stress and potentially providing health benefits. Hence incorporating pomegranate peel powder into bakery products can be a promising way to enhance their antioxidant properties.

Conclusion:

Pomegranate peel, a great source of important nutrients, including vitamins, minerals, and dietary fibre, and antioxidant components, generally discarded as industrial waste. The present study carried out on the utilization of pomegranate peel powder in the development of various products has shown promising results in terms of sensory evaluation, nutrient content, and antioxidant activity. Hence, inclusion of pomegranate peel powder as a functional ingredient can be an effective strategy in enhancing the overall nutritional profile and antioxidant potential of various food products and provide health benefits to consumers.

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Conflict of Interest

The author(s) declares no conflict of interest.

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