





REVIEW

Nutritional importance and industrial uses of pomegranate peel: A critical review

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Abstract

Pomegranate (*Punica granatum* L.), commonly known as a seeded or granular apple, is a delectable fruit eaten worldwide. Pomegranate is one of the healthiest fruits, with a high concentration of phenolic compounds. Large quantities of byproducts, such as seeds and peels, are produced during the pomegranate juice extraction process, which causes disposal problems and environmental contamination. Pomegranate peel (PoP), which accounts for around 30%–40% of the fruit component, is a byproduct of the fruit juice manufacturing industry. PoP is a rich source of polyphenols including phenolic acids, tannins, and flavonoids, especially anthocyanin. These peels offer several functional and nutraceutical qualities owing to their bioactive ingredients, including lowering blood pressure, reducing oxidative stress, lowering cholesterol levels, and restoring heart health. PoPs have a variety of biological effects, including the ability to resist pathogenic microbes effectively, and used as an additive in various food applications. The current review focuses on the PoP's nutritional and practical attributes, as well as their functions as food additives and functional food preparations.

KEYWORDS

animal feed, antioxidants, bioactive compounds, functional properties, human health, industrial use, nutritional composition, pomegranate peel, punicic acid

1 | INTRODUCTION

Annually, the United States dumps approximately 31% (almost 133 billion pounds) of its food supply (Lins et al., 2021). About 61.2 billion pounds of food waste are in landfills. Not only is this excessive waste harmful to the environment, but it is also a significant

contributor to climate change problems, as food waste accounts for 18% of all methane emissions from landfills in the United States. Even more food waste and methane emissions are 30%–40% from fruit and vegetables in the trash (Bayram et al., 2021). As one of the biggest businesses in the world, the food industry is crucial to numerous economies. In any case, the quick development of the

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world's population and the requests of the food supply chain will lead to a quick increase in nourishment generation within 50 years. Agreeing to a report by the Food and Agriculture Organization of its member countries (FAO, 2011), almost one-third of the food for human utilization is misplaced or squandered around the world (Despoudi et al., 2021).

Food scraps comprise materials proposed for human utilization, which are then taken out, lost, disintegrated, or tainted. The issue of food squandering is getting increasingly dire and influences all spaces of waste administration from assortment to removal. Like retailers and end clients, all members of the food inventory network, agribusiness and industry are engaged in the quest for feasible arrangements (Giroto et al., 2015). Food waste is tormented by environmental factors (along with weather alternatives and air, water, and land pollution) and social factors (which include the aforementioned populace boom and new intake trends) (Garcia-Garcia et al., 2015). The loss and waste of fruits and vegetables are not only related to food waste but also indirectly include the loss of essential resources (such as land, water, fertilizers, chemicals, energy, and labor). They generate most environmental waste (Sagar et al., 2018).

A large amount of fruit and vegetable waste can be recycled in various ways, including immediately discarding it in a landfill, drying to a stable state (humidity 10%) for off-season feed, and processing by biotechnology to produce superficial chemical peels. Vinegar, citrus extract and acidic corrosive are gotten from side-effects of the leafy foods industry. Squander from potato and wheat starch-preparing plants can be matured into ethanol (Khedkar & Singh, 2014). When handling foods grown from the ground, many wastes like skins, seeds, fluids, and molasses are created. These squander are a decent wellspring of sugars, proteins, fibers, nutrients, and minerals. The waste can be used to make natural blossoms through maturation (Kaur et al., 2019). The utilization of leafy food squanders, mainly shrubs, in the improvement of significant worth-added items are harmless to the ecosystem approach to set out new organizations open doors and highlight, and economic courses in organizations that produce valuable waste (Kumar et al., 2020).

Phenolic contents in the strip of lemon, orange and grapefruit are 15% lower than the all-out phenol in the strip. Lemon and lime strip oils are generally used as flavor enhancers in delicate and alcoholic food varieties and fluids (Gorinstein et al., 2001).

Pomegranate (*Punica granatum*) is a small tree native to the Middle East and is now found in the Mediterranean, China, India, South Africa, and the United States. In the past decade, the prevalence of pomegranate has increased significantly, especially after it has been proven to have antimicrobial and antiviral properties. It has anti-cancer properties, powerful antioxidants and resistance to mutations. The pomegranate fruit consists of three parts: seed, juice, and peel (Figure 1). In particular, peeling is traditionally used as a natural remedy for infectious diseases (Elfalleh et al., 2012; Kharchoufi et al., 2018).

1.1 | Pomegranate peel

Many researchers have affirmed that pomegranate peel (PoP) is a rich wellspring of bioactive mixtures, including ellagitannins, catechins, rutin, and epicatechins (Figure 2). Previously, pomegranate was broadly used in daily medication to destroy parasites and to treat and fix ulcers, wounds, acidosis, loose bowels, microbial contaminations, and respiratory illnesses. PoP has higher cancer prevention agent movement than heart and juice (Mphahlele et al., 2016). Pomegranate skin accounts for 40% of the whole fruits, and its antioxidant activity is higher than that of the edible (Abid et al., 2017).

The peel and seeds of pomegranate account for about 54% of the fruit and the pomegranate were lost after pressing. Pomegranate is composed of 43% of bark, 11% of seeds, and 46% of juice (Ko et al., 2021). In particular, PoP comprises nearly 30%–40% of the fruit. The skin is rich in polyphenols, and because polyphenols are cancer prevention agents, they can show the pharmacological capability of pomegranate (Ijaz et al., 2020). Literature demonstrated that peel contains more bioactive compounds than other parts of the fruit (Akhtar et al., 2015; Rahnemoon et al., 2016; Ullah et al., 2012; Wang et al., 2011).

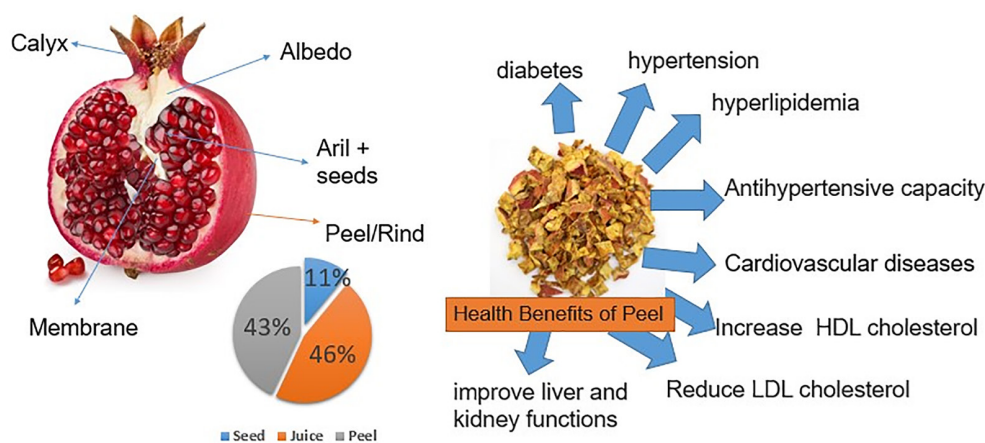


FIGURE 1 Parts of pomegranate fruit and its therapeutic effects.

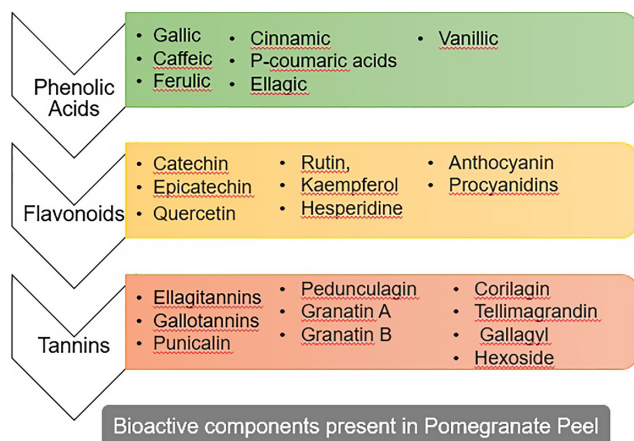


FIGURE 2 Bioactive components present in the pomegranate fruit peel.

PoP is a rich wellspring of hydrolyzable tannins in ellagitannins. It tends to be closed from past examinations that the pomegranate strip is wealthy in comparative fixings and has cell reinforcement potential. Dyes are made from PoP. An extract or a powder from the peel of pomegranates, this dyestuff is high in tannin and improves the light and wash fastness of any dye with which it is mixed. PoP yields soft yellows to green yellows when used as a dye (Ajmal et al., 2014). The industry price of PoP is very low. It can be used as an added value for various products such as biscuits, pasta and cakes (Saroj et al., 2020), fresh and concentrated fruit juice, herbal tea, and jam. (Karimi et al., 2017).

1.2 | Nutritional and chemical composition

Every day, PoPs are used in various food varieties owing to their great nutritional and chemical composition (Kandylis & Kokkinomagoulos, 2020). PoP contains high levels of carbohydrates (59.60%) followed by moisture content (5.40%–5.95%), protein content (4.90%–8.97%), ash content (3.40%–4.22%), fiber content (16.30%–19.41%), and fat content (0.85%–1.26%) (El-Hamamsy & El-khamissi, 2020; Khan et al., 2017). The chemical and nutritional composition of PoP were presented in Table 1.

1.3 | Punicic acid in pomegranate peel

Punicic acid, a bioactive compound of pomegranate seed oil, has gained wide attention because of its therapeutic potential. Polyunsaturated fatty acid composition, predominantly comprising of punicic acid, is highly present in pomegranate seed oil. Punicic acid is named after its principal source pomegranate. Among all the sources of punicic acid, it is most abundantly present in pomegranate seed oil. The other sources of punicic acid are snake gourd seed oil. Punicic acid has been proven to protect collagen fibers found in the skin, accelerating wound healing, and reducing the appearance

of scars. The anti-inflammatory property of punicic acid has also effectively addressed skincare ailments like eczema and psoriasis (Shabbir et al., 2017). Punicic acid decreases oxidative damage and inflammation by increasing the expression of peroxisome proliferator-activated receptors. Punicic acid is an important nutraceutical compound in the prevention and treatment of neurodegenerative diseases such as Alzheimer's, Parkinson's, and Huntington's disease (Guerra-Vázquez et al., 2022).

DPPH assay is the most adopted procedure to assess the antioxidant capacity of corresponding samples mainly due to its short run time, simplicity, and stability during the whole experimental process. Principally, the antioxidant potential of respective samples is analyzed depending on their potential to reduce DPPH• by donating hydrogen atom that can also be authenticated spectrophotometrically due to the loss of dark violet color of the tested solution. The results help in inferring that PoP antioxidant extracts retard food deterioration which mainly initiates due to the production of free radicals. Punicalagin content in PoP extracts revealed significantly strong antioxidative capacity when evaluated using DPPH assay, validating its therapeutic role (Khalil et al., 2017).

Pomegranate juice was used in human and rat diet against atherogenicity and atherosclerosis, respectively. Findings of the investigation concluded that pomegranate juice has the potential to combat these disorders owing to its antioxidative properties (Aviram et al., 2000).

1.4 | Antioxidant activity of pomegranate peel

Pomegranate has become one of the foods richest in polyphenols. It has a high antioxidant capacity and health benefits, so it is very popular, which is why it is often called "super fruit." Because of the great substance of phenolic acids, flavonoids, and other polyphenol compounds, pomegranate can be used as a successful safeguard of different dynamic oxygen. As such, ordinarily happening phenolic mixtures can restrain food oxidation and increment the timeframe of realistic usability and nature of food. Moreover, the food business desires to supplant synthetic substances with regular mixes to improve food handling (Derakhshan et al., 2018). The presence of mixtures with antioxidant characteristics in PoP is a vital wellspring of more dynamic cell reinforcements (Singh et al., 2002).

Cell reinforcements are compounds added to food varieties, particularly lipids and lipid-containing frameworks. They can broaden the timeframe of realistic usability of food sources by hindering the lipid peroxidation measure instead of simply making substances harm food sources. However, they additionally produce free extremists, for example, peroxy-free revolutionaries and hydroxyl-free revolutionaries, which are believed to be engaged in carcinogenesis, mutagenesis, and maturing (Yasoubi et al., 2007).

A few examinations have shown the antioxidant characteristics of the side effects of pomegranate extract. PoP removal is applied to mackerel to repress the lipid oxidation of fish unsaturated fats. The cell reinforcement impact of the concentrate was analyzed with the

TABLE 1 Chemical and nutritional composition of pomegranate peel.

	Moisture	Total sugar/CHO	Reducing sugar	Protein	Ash	Fiber	Pectin	Fat	Total solids	Reference
Pomegranate peel per 100 g	5.40	17.70	-	4.90	3.40	16.30	-	1.26	94.50	(Khan et al., 2017)
Pomegranate peel (%)	67.26%–73.23%	30.65%–34.83%	-	3.96%–7.13%	3.71%–4.97%	28.10%–4.97%	6.8%–10.1%	-	-	(Ko et al., 2021)
Pomegranate peels (%)	6.95	59.60	-	8.97	4.22	19.41	-	0.85	-	(El-Hamamsy & El-khamissi, 2020)
Pomegranate peel per 100 g	5.40	17.70	4.34	4.90	3.40	16.30	-	1.26	94.50	(Middha et al., 2013)

antioxidant agent impact; butylated hydroxyl toluene, an incredibly engineered cancer prevention agent broadly used in the food business (Andrade et al., 2019).

Natural antioxidants are better than synthetic antioxidants because of their lower activity; the amount of natural antioxidants added is much larger than that of active antioxidants. However, the simple action depends on the particular conditions and food arrangement (Pokorný, 2007).

Contrasted with different concentrates, the methanol removed in the pomegranate strip has the most elevated cell reinforcement action and phenol content (Tehranifar et al., 2011). 2,2-Diphenyl-1-piclyhydrazine (yellow) is a stable free radical that can accept electrons or hydrogen-free radicals from antioxidants. In this study, the inhibitory activity of PoP extracts on DPPH free radicals is very different. It showed the highest antioxidant activity in all extracts, so it was chosen to test its effects on lipid peroxidation, hydroxyl radical scavenging activity and human low-density lipoprotein oxidation (Malviya et al., 2014).

1.5 | Flavonoids in pomegranate peel

Pomegranate is made from different flavonoids, representing 0.2%–1.0% of the organic product. About 30% of all anthocyanins contained in pomegranate are in the peel (Omer et al., 2019). The flavonoid content in PoP is about 12.4 times higher than in juice and seed (Kalaycıoğlu & Erim, 2017).

Flavonoids (mainly anthocyanins) determine the color of pomegranate fruit, but the content of tannins in the whole pomegranate skin is also higher than the total flavonoids (Singh et al., 2018).

PoP may be a potential supply of flavonoids, equivalent to catechins, epicatechins, quercetin, anthocyanins, and procyanidins. The composition of flavonoids varies with the fetus's biological process stage, and the concentration within the PoP varies with the sort of pomegranate. The compound and rutin are thought to be the very best content of flavonoids in contemporary dishes from Granada (Mphahlele et al., 2017). The composition of polyphenols and total phenolic content of PoP extract was shown in Table 2.

2 | ETHNOMEDICINAL USES OF POMEGRANATE PEEL

2.1 | Type II diabetes

Diabetes is possibly the main pandemic-persistent metabolic sickness on the planet (Middha et al., 2014). Diabetes is sometimes characterized by hyperglycemia that ends up in disorders of carbohydrate, lipid, and macromolecule metabolism (Barathikannan et al., 2016). The antioxidant-rich PoPs and seeds have antecedently shown protection against diseases regarding aerophilous stress, together with diabetes (Manna et al., 2019).

TABLE 2 Composition of polyphenol compounds and total phenol of pomegranate peel extract.

Polyphenolic compounds (mg/g)	Source: Ibrahim (2010)	Source: Gullón et al. (2020)
Punicalagin	296	-
Delphinidin	34	-
Cinnamic acid	42	2.5
Punicalin	15	-
Pelargonidin	21	-
Coumaric acid	32	0.91
Ellagic acid	18	12.56
Quercetin	40	-
Ferulic acid	28	-
Gallic acid	71	2.5
Kaempferol	62	-
Sinapic acid	17	-
Cyanidin	26	-
Luteolin	33	-
Caffeic acid	11	-
Chlorogenic acid	-	1.56
Total phenolic compounds	867 mg/g	mg/g

The anti-diabetic impact of the active ingredient of PoP is closely related to the inhibition of α -glucosidase and the increase of aldohexose absorption. The active ingredients in PoP have also been shown to cut back polygenic disorder-related cardiopathy by inhibiting beta-lipoprotein oxidation. The acetate fraction (F5) within the crude alcohol extract of PoP has innovative inhibitor and anti-diabetic activities that are equivalent/better than the quality used. It is used as a nutritional health product for the interference and treatment of kind a pair of diabetes and its connected complications (Arun et al., 2017).

2.2 | Alzheimer's disease

Alzheimer's disease might be a reformist neurodegenerative problem and hence the most overarching assortment of derangements described by a reformist decrease in memory, conduct, and mental component capacities inside the matured populace. It influences people and has become a critical clinical and social weight in non-industrial nations (Subash et al., 2014). It is accepted that Alzheimer's is a complex multifactorial sickness, and there are no successful restorative specialists to moderate or forestall the improvement of the infection (Braidly et al., 2016).

Alzheimer's sickness might be a persistent illness that has not been treated until late. Momentum treatment strategies downsize sickness movement, are costly, rarely cause aspect impacts, and are poorly designed for the patients (Morzelle et al., 2016). In Alzheimer's infection, oxidative pressure is fundamental (Harakeh et al., 2020).

The concentrates from the shell showed more significant levels of phenols related to cell reinforcements, which is why they were picked as likely inhibitors of acetylcholinesterase, which might be a key impetus worried inside the advancement of Alzheimer's disease. The engineered sap compounds in the pomegranate strip show a harsh effect on acetylcholinesterase, which relies on the grouping of phenol (Morzelle et al., 2019).

2.3 | Oral cavities

Get the first profit from PoP (pomegranate) because agricultural waste is tooth glue framed from PoP squander, financial and ecological insurance (Abbas, 2014). PoP is a rich wellspring of polyphenols, including penicillin, punicalagin, and ellagic corrosive, yet it is viewed as rural waste. Reports indicate that pomegranate-determined items have various medical advantages, including antibacterial properties (Smith et al., 2020).

Pomegranate has significant utilization in the field of dental well-being. Clinical reports have affirmed that this current cancer prevention agent is dissolving the underlying driver of tooth rot with its force at the biochemical level (Umar et al., 2016). PoP extract is a promising strategy for the treatment of oral thrush. Because of its viability, oral thrush tends to be used as a characteristic substitute (Bassiri-Jahromi, 2018a, 2018b). Pomegranate can hinder *Streptococcus* mutants because of its tannic corrosive antimicrobial properties so it could be a potential enemy of caries specialists. It can keep different microorganisms from clinging to the oral hole (Menezes et al., 2006; Prasad & Kunnaiah, 2014).

2.4 | Human cancer cells

As indicated by reports, the work of PoP has been hostile to tumor impacts, along with the annihilation of tumor cell expansion, cell cycle, intrusion and angiogenesis. Pomegranate strip separation has appeared to moderate cell expansion in different neoplastic cell lines. Pomegranate strip affects the extension of carcinoma cells of arranged subatomic subtypes (Bassiri-Jahromi, 2018a, 2018b).

The counter-proliferative properties of pomegranate strip extricate are outlined in shifted human malignancy cells (human non-little cell carcinoma A549, human PC-3 glandular disease cells, SKOV3 testicle malignant growth cells and SKOV3 malignant growth cells). Carcinoma (MCF-7) it has been discovered that MCF-7 bosom adenocarcinoma cells are the preminent touchy (Vučić et al., 2019).

The counter-estrogen movement of polyphenols and flavonoids in pomegranate strips can meddle with aromatase action by disturbing estrogen blend, which may be found in cells with six chemical receptors (e.g., MCF-7 and SKOV3). Its capacities as a development factor. Although SKOV3 female inside regenerative organ malignancy is not estrogen-reliant, as opposed to elective steroid-and androgen-touchy disease cells, these cells are less delicate to the antiproliferative movement of pomegranate strip removal. Furthermore, the

counter proliferative effect of pomegranate strip separate seems, by all accounts, to be tumor-explicit because chemical ward malignancy cells are horrendously touchy to the counter-tumor impacts of those concentrates (Modaeinama et al., 2015).

3 | INDUSTRIAL USES OF POMEGRANATE PEEL

It is possible to take advantage of pomegranate byproducts, as they are a rich source of bioactive compounds such as flavonoids, antioxidants, phenols, polyphenols, and anthocyanins. The peels are packed with powerful antioxidants that help fight against dangerous and life-threatening heart diseases. PoP lowers cholesterol levels, reduces oxidative stress, restores heart health, and lowers blood pressure. It is facial scrub and exfoliates while also containing sun-blocking agents that offer protection from the sun's harmful UV rays. Therefore, there is a need to highlight all the wastes related to the food and food industry so that awareness can be created among the public and their utilization can be improved.

3.1 | Animal feed

PoP is an abundant source of ellagitannins (antioxidants); therefore, it is used to prevent and reduce farm animal diseases and improve meat products, creating it a pretty part of animal feed (Figure 3). Recent studies have additionally shown that increasing the antioxidant content of the beef diet will facilitate the cleaning of the pomegranate. Industrial waste potable can be recycled using tannins; therefore, the remaining byproducts (such as solid waste on the skin) can be produced as feed additives at a low-cost price. These additives are rich in helpful nutrients (Kushwaha et al., 2013).

Pomegranate byproducts have a high worth as feed. For recent skin, this study clearly shows that consumption positively influences the expansion of calves and the accumulation of R-tocopherol within the plasma. Nutrients are directly concerned with the inhibitor system. However, this does not mean that adding them to the diet will improve animal health. However, whenever used legally, the bioavailability of minerals, nutrients and polyphenols in new and kept PoP could have a supportive preventive impact (Shabtay et al., 2008).

PoP affects the daily nutrient intake throughout the Karadi Lamb digestion test. Compared with alternative treatments, the typical biological process worth of lambs fed with 1% PoP was increased to the lower phenol content in lambs fed with 1% PoP (Sadq et al., 2016).

3.2 | Active packaging

Fish gelatin could be a sensible supply of biopolymers for packaging films due to its perishable and good film-forming properties because of its high content of myofibril. The expansion of PoP powder improves the lastingness of the film, however, because of the insoluble particles. It additionally causes a rise in the water vapor porousness of the film. PoP powder is added to fish gelatin film-forming solution to develop an active packaging film with potent inhibitor and medication properties (Hanani et al., 2019). Polyethylene terephthalate with active pomegranate skin film can extend the pork period higher than polypropene with pomegranate skin film and may exceed the shelf life of pork (Hu et al., 2017).

The extract of PoP is supplementary to zein to create a vigorous package, thereby raising the valuable properties of the film. Once packaging Kalari cheese, the film will significantly curtail the oxidation reaction and microorganism deterioration throughout storage. It is used as a food safety antimicrobial and inhibitor packaging

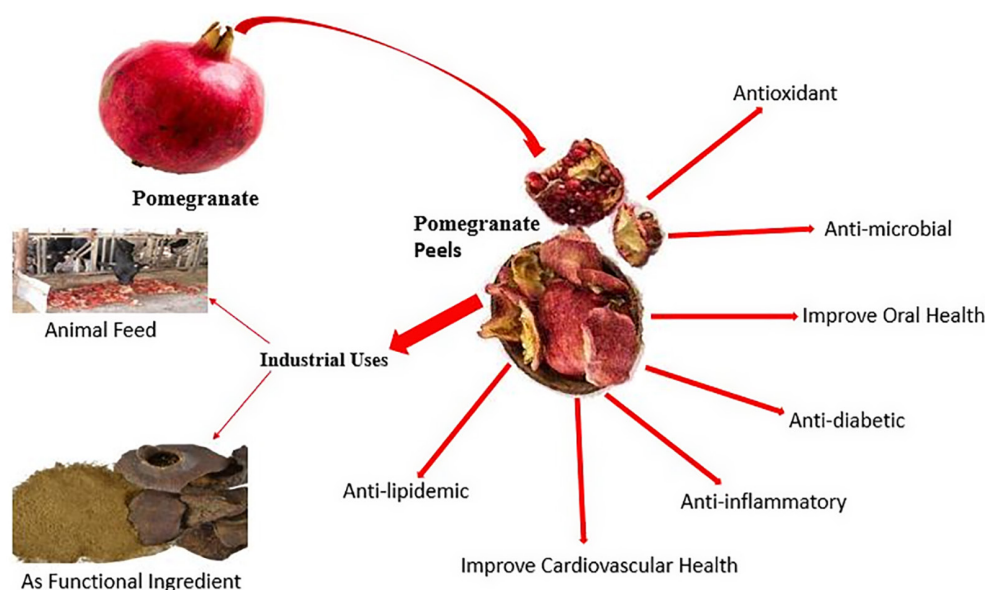


FIGURE 3 Nutritional and functional properties of pomegranate peels.

material within the cheese industry. In addition, the film does not affect the beneficial bacterium of the cheese, thereby increasing its popularity (Mushtaq et al., 2018). Microbiological perceptions demonstrate the probability of mistreating pomegranate polyphenols in zein dynamic layers as common additives. Moreover, cold atmospheric plasma treatment improved the stretching at break and strength of the zein-based nanocomposite film to change the layer surface. Mistreatment of pomegranate strips may likewise settle the garbage removal disadvantage (Cui et al., 2020).

Mung bean protein-based food film has been built up with various groupings of pomegranate strips. The convergence of the pomegranate strip will build the thickness, contact point and fume porousness of the mung bean layer, decreasing its water and dissolvability. As an economic side effect of the food business, it has the valuable capability of being brought into the mung bean protein film to upgrade its deliberate organic properties (Moghadam et al., 2020).

Moreover, Kumar et al. (2021a, 2021b) used PoP extract (0.2 g/mL) as an active antioxidant agent for the preparation of chitosan-pullulan (50:50) composite edible coating and probed its effect on the shelf life of mango fruit during 18 days of storage period at 23°C and 4°C. This has resulted in the improvement of mango fruit shelf life.

3.3 | Yogurt

Pomegranate is considered a good source of antioxidants and antibacterial drug activity. Some researchers used PoPs in hard milk; however, tannins restrained the expansion of bacteria. Adding 0.5% PoP to organic stirred yogurt will improve overall tolerance, consistency, and texture. Because of the rise of protein, dry matter, and cellulose in PoP and addition of pomegranate to organic cooked yogurt exceeds the period of organic fried yogurt. It improves the 21-day survival rate of probiotic culture (Ibrahim et al., 2020). Expanding the extent of PoP extricate brought about a very diminishing viciousness of the blended yogurt. The thickness of the examples containing 20% and 25% PoP removal was almost similar (El-Said et al., 2014).

In a study, Kennas et al. (2020) elaborated that yogurt with PoP and nectar is prepared and freeze-dried. The outcomes show that freeze-dried dairy item has good physical and compound properties, especially low wetness content, which may broaden its timeframe of realistic usability. Once PoP and nectar are added to yogurt, the phenol substance and inhibitor movement are impressively expanded. In this manner, adding PoP can fulfill the interest in deliberate food varieties.

3.4 | Meat industry

Owing to the antimicrobial and antifungal properties of PoP can be used as an effective and natural option for synthetic preservative agents to preserve the quality of food during storage (Kandyliis &

Kokkinomagoulos, 2020; Ullah et al., 2012; Khan & Hanees, 2011; Ibrahim, 2010). As poultry items are prone to lipid and protein oxidation and are perishable, the industry is in constant search of synthetic-free additives that help in retarding the oxidation process, leading to the development of healthier and shelf-stable products. PoP extract is a superb variety of artificial antioxidants (Das et al., 2021). PoP extract inhibits the lipid chemical reaction and also the decomposition of meat pigments, serving to prevent rancidity and stabilize the flesh color of meat and meat product and their shelf life (Smaoui et al., 2019) and improve the quality and functional characteristics (Gullón et al., 2020).

PoP extract is a good antioxidant that will enhance the alpha-tocopherol content of broilers because adding 200 and 300 mg/kg of PoP extract to the diet can increase the antioxidant potential and assess the breast muscle quality of broilers (Saleh et al., 2017).

3.5 | Cookies

Adding PoP to biscuits will improve the organic process worth of the product. It has been found that adding PoP to flour can extend the period of cookies to realize high inhibitor potential. Similarly, in cookies with additives, the content of calcium, potassium, iron, and atomic number 30 also magnified significantly (Ismail et al., 2014).

In this exploration, a fresh out of the plastic new fixing material made of extra organic product squash was created to typify pomegranate strip removal. Furthermore, the unrefined concentrate showed the best expansion in shading boundaries all through capacity, while the inhibitor movement inside the braced treats was kept at a significant level. All through the entire stockpiling time, the degree of the executives' treatment has been extensively improved. Different treats are frightfully steady regarding oil oxidation (Kaderides et al., 2020).

As a food additive, PoP extract can improve the quality and taste of food and the sensory properties of cookies (Ismail et al., 2016).

3.6 | Bakery products

The utilization of dried PoP powder improves the dietary and medical advantages of biscuits because the substance of β -carotene, fiber, and polyphenols in dried PoP powder is higher, which changes the surface, rheology, and tangible properties of the biscuits (Srivastava et al., 2014).

PoP powder is a decent wellspring of naturally dynamic food fixings, yet its monetary worth is little, and it has been used to make biscuits. The expansion of PoP powder brought about a critical expansion in the aggregate and insoluble fiber, Mg, Ca, K, total phenols, and all-out cancer prevention agent action in the biscuits. The tactile view of biscuits can make PoPs effectively used in utilitarian business cakes, and the mechanical utilization of PoPs can help decrease contamination (Topkaya & Isik, 2019).

4 | CONCLUSION

Lately, the food business's interest in natural antioxidant agents has consistently expanded, particularly since the amount of adverse toxicological reports of the many artificial compounds has increased. PoPs showed higher antioxidant properties and pose higher in applications for food products. Bioactive substances in PoPs play key roles in anti-inflammatory, antibacterial, improvement of cardiovascular diseases, anti-infection, and healing, playing a modulating and interventional role. They can be applied to animal feed to improve feed efficiency. The application of PoP has a promising result as an antioxidant in the food industry. PoP prevents diabetes, especially breast cancer, Alzheimer's disease, and cardiovascular diseases. Punicalagin and ellagic acid in PoP have chemopreventive effects against prostate cancer, breast cancer, and colon cancer, partly associated with the ellagic acid-derived metabolite urolithin. The bioactive substances in PoPs can be used as natural food ingredients to prepare innovative food products. In the case of industry, PoP has shown great results by enhancing food products' nutritional properties, taste, texture, flavor, and shelf life. PoP also has a prebiotic effect. Conclusively, reusing pomegranate byproducts in the fresh food industry could be a sustainable way to reduce environmental impact and costs associated with byproducts disposal, with significant advantages to the product quality and its shelf life followed by improvement in human health.

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CONFLICT OF INTEREST STATEMENT

The authors have declared no conflicts of interest for this article.

DATA AVAILABILITY STATEMENT

The authors confirm that the data supporting the findings of this study are available within the article.

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