



# Phytochemistry of *Punica granatum* Fruit: Its Nutritional and Biological Potential

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## Abstract

The present review provides a comprehensive overview of the phytochemistry, nutritional composition, and therapeutic implications associated with the consumption of pomegranate (*Punica granatum*) fruit, renowned for its dual role as a taste delicacy and a medicinal agent. A detailed exploration of the phytochemical composition is undertaken. Recognized for its myriad health benefits, this fruit has been historically employed as a remedy for diverse disorders, with its leaves, peel, and bark demonstrating efficacy in treating gastrointestinal issues leading to diarrhea. Notably, pomegranate juice has been utilized in treating cholera, while the oil extracted from seeds exhibits notable efficacy in addressing skin and breast cancer. The review underscores the presence of bioactive compounds, including flavonoids, tannins, ellagitannins, catechin, and phenols, across various species of *P. granatum*. In addition to its rich phytochemical profile, pomegranate emerges as a nutritionally rich fruit, boasting significant quantities of vitamins C and D, magnesium, potassium, and dietary fibers. Its nutritional composition aligns with its therapeutic properties, encompassing anti-inflammatory, antioxidant, anticancer, and antimicrobial attributes. Notably, a single cup of pomegranate arils contains 72 calories, 16 g of carbohydrates, and 3 g of dietary fiber. This review serves to deepen our understanding of the multifaceted nature of pomegranate, and addresses emerging and technological advancements in pomegranate phytochemistry.

**Keywords:** phytochemistry, *Punica granatum*, nutrition, bioactivities

## 1. INTRODUCTION

Plants are commonly investigated throughout the world due to their useful phytochemical ingredients [1], nutritional [2] and medicinal [3] values. The pomegranate (*Punica granatum* L.) (Figure 1) is a fruit that has been cultivated since approximately 3,000 to 4,000 BC. It has a long history and is referenced in both the Bible and the Quran [4]. Pomegranate stands as a perennial symbol of health and vitality, renowned for its exquisite taste and rich phytochemical composition. It belongs to *Punicaceae* family and is widely distributed worldwide throughout many semi-tropic nations, particularly in the Mediterranean region. The plant is commonly found/cultivated in Pakistan, Iran, India, Saudi Arabia and in the semitropical regions of South America [5]. Especially due to its tasty fruits, lovely blooms, vibrant color and its

enormous genetic diversity, it is typically referred to as a super fruit. The fruit has a coriaceous skin that is irregularly shaped and colored yellow, green, or red and is made up of 10% seeds, 40% arils, and 50% peel [6]. Figure 2 shows the anatomy of pomegranate fruit.

The inside of the pomegranate fruit is composed of spongy chambers that are filled with arils and thin walls that separate each chamber. These arils contain both soft and hard seeds along with edible juice. The color of the juice might vary from clear to dark crimson, depending on the kind of fruit that was used [6]. A considerable number of oil-containing seeds make up the pomegranate fruit, which accounts for around 18–20% of the fruit's total weight. Pomegranate seed oil, sometimes referred to as PSO, is accountable for somewhere in the range of 12 to 20% of the overall weight of the fruit and contains a variety of nutrients that are good for one's health [8]. Figure 3 displays the percentage amounts of different components e.g., arils 45–52%, peel 49–55%, and oil 12–20% in pomegranate fruit [9].

As we navigate the labyrinth of pomegranate phytochemistry, our objective is to present a comprehensive overview of its medicinal and nutritional attributes. People can use this review to better grasp the advantages of pomegranates for their health.

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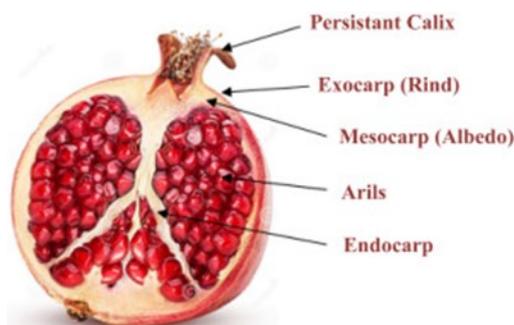
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**Figure 1.** The branches of *P. granatum* bearing leaves, fruit and flowers.



**Figure 2.** Pomegranate fruit anatomy [7].

## 2. PHYTOCHEMISTRY OF POMEGRANATE FRUIT

In the regions of Central Asia, the Middle East, and Southeast Asia, a diverse range of *P. granatum* L. varieties have been identified. The fruits of this plant exhibit a spectrum of secondary metabolites, comprising volatile oils, terpenes, sterols, minerals, amino acids, glycosides, and alkaloids [10]. In recent years, scientific inquiry has delved into the intricate world of pomegranate phytochemistry, uncovering a treasure trove of bioactive compounds that contribute to its medicinal and nutritional prowess. Pomegranate seeds are regarded as a fine source of phenolic compounds and good-quality oil (12–24%) [11]. Flavonoids and proanthocyanins such as gallo tannins and ellagitannins, are some of the polyphenols found in pomegranates. Biotic and phenol carboxylic acids, steroid and isoprenoids, triglycerides, fatty acids, and alkaloids are additional phytochemicals found in pomegranates [12].

Pomegranate is rich in a diverse array of compounds including caffeic acid, anthocyanin,

flavonoids, pelletierine alkaloids, luteolin, coumaric acid, chlorogenic acid, sinaphyls, ellagic acid, coniferyl acid, cinnamic acid, genistein, linoleic acid, anthocyanin, gallic acid, catechin, quercetin, rutin, cyaniding, kaempferol, punicalin, delphinidin, and punicalagin [14]. The phenolic compounds that may be obtained from pomegranate aril depend on the solvent system that is used (Table 1) because various phenolic compounds have variable degrees of polarity. Pomegranate aril is an excellent source of these phenolic compounds [15]. Table 2 describes the important phytoconstituents of various parts of pomegranate plants. The chemical structures of important phytoconstituents of pomegranate are given in Figure 4.

## 3. MEDICINAL VALUE OF POMEGRANATE FRUIT

Plant-based medicines have found special importance as they have natural ingredients and minimal side effects [16][17]. In the last ten years, there has been a movement in the direction of an increase in the overall population's understanding of

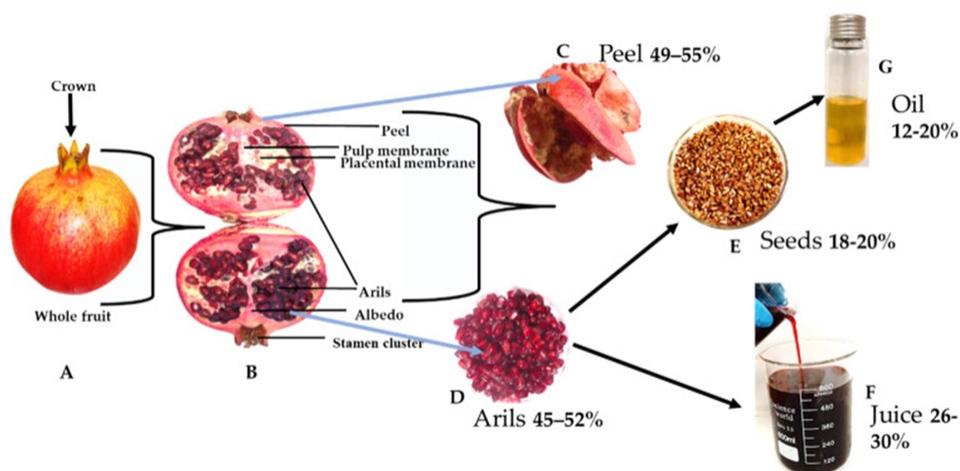
the significant part that food plays in both the prevention of illness and its treatment. As a result, the availability of healthy foods has become increasingly important. Folks are now conscious and are seeking out natural, unprocessed foods that offer health benefits, rather than those that contain artificial ingredients [18]. Three different phytochemicals in *P. granatum* play a vital role in the formation of medicines, which include alkaloids, saponin and triterpenoids [19].

The pomegranate peel (PP) has long been used to cure different ailments e.g. cancer, Alzheimer's disease, ischemia in the brain, erectile dysfunction, ulcers, and microbiological infections [11]. Pomegranate fruit has been recognized as a “healing food” with several health-relieving effects for different ailments. To treat anemia, the Central Council of Research in Ayurveda and Siddha (CCRAS) advises consuming 15 mL of fresh pomegranate juice twice with honey; also pomegranate-based ghee was suggested. *Meenakshi Sundaram* described that almost all pomegranate parts, including the leaves, fruit, sensitive fruit, fruit rind, flower buds, and bark of the root and stem, provide therapeutic benefits against a variety of human ailments. Pomegranates are referred to as a resurrection fruit for this reason. All of the pomegranate components are frequently employed in numerous remedies that are effective against a wide range of illnesses. The Siddha system of medicine considers the healing properties of pomegranates to be a treasure for mankind [23]. Because of its antibacterial, anti-inflammatory, and soothing properties, the pomegranate fruit is

utilized in medicine. Pomegranate fruit extracts from various portions are abundant in nature, both the oil and rind exhibit strong antioxidative action. Ellagic acid, a prominent phenolic compound is found in pomegranate rind extract. The seed oil has an inhibitory effect on skin and breast cancer. In order to produce phytoestrogenic substances, the use of pomegranate seed oil and extracts from various fruit components has been studied. Pomegranate fruit is now taken into consideration for its pharmacological properties in addition to its use as a fruit and for its nutritional worth [24].

Fruits rich in nutrients include pomegranates. Low molecular weight substances that are collectively referred to as phytochemicals are produced by plants and are what give the fruit its medicinal powers. In Sani, the fruits have a curative function and prevent vomiting during fevers. In order to lessen heartburn, the pulp is mashed, pressed in a solvent, and combined with sugar to make sweets. Moreover, it is utilized to stop excessive oral salivation and hiccupping. The mixture is used to stimulate conception and control women's menstrual cycles. The fruit helps to maintain a healthy blood flow when consumed. Due to its high iron content, pomegranate seeds aid in reducing the symptoms of anemia, such as weakness, fatigue, and hair loss [25].

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**Figure 3.** Percentage amounts of different components of pomegranate [10].

**Table 1.** Extraction techniques.

Instrument	Procedure
Liqua fresh juice extractor (JE) (mellerware South Africa)	Works at minimum speed without grinding
Electronic juice blender [13] (AEG Germany)	Operates at a maximum speed ~30 with seeds
Commercial manual juicer CH (Jupiter China)	Without harming the capillary membrane, the

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For a very long time, pomegranate has been utilized both as foodstuff and medicine. It is consumed as a diet during recovery from diarrhea. Pomegranates are seen as an illustration of God's excellent creations and are produced in the gardens of heaven, according to the Muslim holy book, The Quran. It is mentioned twice in the Quran for this reason [26]. When taken in a dose of 65 mg twice a day, the scorched powder combined with the powders of mastiche cardamom and poppy seeds have the ability to stop diarrhea and dysentery. For diarrheal fever, a decoction made with the pomegranate's sensitive fruits is administered. To stop bleeding from the nose, flower juice mixed in a 1:1 ratio with *Cynodon dactylon* juice is administered. The dried flowers are known as "Goolnar" and they are beneficial for hemoptysis and hematuria. In order to make a tooth powder for toothaches, dried pomegranate fruit rind, myrrh powder, and chalk powder are combined. Using *Galleria mellonella* as an *in vivo* model, researchers were able to demonstrate the antibacterial efficacy of pomegranate glycolic extract (PGE) against the periodontal infection *Porphyromonas gingivalis* [27]. The roots and stem bark may be used to make the best natural intestinal wormicide and are used to treat a variety of pediatric illnesses [28]. Fruit juice of pomegranate is created by combining sugar candy, syrup, and other ingredients, and is then used to treat fevers, peripheral neuritis, and other conditions. A good haematenic syrup can be made with its fruit juice as the primary ingredient,

coupled with honey, jaggery, and rosewater [29]. The syrup is used to treat morning sickness during the first trimester of pregnancy as well as burning in the soles of the feet, nausea, and vomiting. When used in conjunction with *Annabedhi chendooram* to treat iron deficient anemia, the syrup increases both medications' therapeutic efficacy [30]. Some important medicinal properties of pomegranates are described below.

Cancer, advanced-level antioxidants called flavonoids are present in pomegranates. These flavonoids are regarded as having potent anticancer properties. Fruit juice consumption reduces the high risk of breast and prostate cancer and helps the body fight any cancer cells already present [31]. Heart Problems, the fruit's regular consumption aids in maintaining the body's healthy blood flow. Also, it lowers the dangers of heart attacks and cardiac arrests [13]. Stomach disorder, the bark, leaves, and peel of pomegranates are used successfully to treat digestive problems that cause diarrhea. Moreover, pomegranate juice is utilized to cure cholera [32]. Osteoarthritis, pomegranate is used as a medicine to treat diseases brought on by a variety of factors, such as atherosclerosis and osteoarthritis, which

occur because artery walls harden and solidify, as well as in joints and cartilage, as well as other conditions [33]. Diabetes, pomegranate juice aids diabetic patients in preventing cardiovascular diseases [34]. Dental care, pomegranate juice has antibacterial and antiviral qualities that can be used to successfully lower dental plaque occurrences [35].

Because it is thought to delay the onset of cataracts, pomegranate seed (of particular fruit strains), is also utilized in eye drops. To treat haemorrhoid flare-ups, pomegranate juice is used topically and in treating sore throat. It clarifies the chest, stomach, esophagus, and oral cavity [36]. Urosolic acids, betulic acid, several alkaloids, including pelletierine and pseudo-pelletierine, and some other basic chemicals are said to be responsible for the observed therapeutic qualities [37]. Health benefits of pomegranates, for instance, their antioxidant content, non-mutagenic characteristics, resistance to depression effects, and ability to minimize liver damage, have led to a substantial growth in their commercial production around the world [38]. Anthocyanins from pomegranates have been shown to have scavenging

**Table 2.** Important phytoconstituents of various parts of pomegranate plants.

Plant part	Constituents
Seed oil	95% puniolic acid, ellagic acid, sterols [20]
Leaves	Apigenin, tannins, luteolin [20] The hydroethanolic extracts contain 0.133–3.000 mg/g granatin B, 0.7–2.4 mg/g (-)-epicatechin and 0.95–1.45 mg/g gallic acid
Roots and bark	Ellagitannins, piperidine alkaloids, punicalagin, punicalin
Pomegranate fruit	50% peel, 10% seeds, 40% arils [20]
Pomegranate aril	10% total sugars (majorly glucose and fructose), 85% water, 1.5% pectin, organic acids (e.g., malic acid, citric acid, ascorbic acid) and bioactive compounds (e.g., flavonoids, phenolics). Each 100 g serving of aril provides 16% of vitamin K and 12% of the daily value for vitamin C [21]
Pomegranate juice	10.6% total sugars, 85.4% water, 1.4% pectin, 0.2 to 1.0% other components including organic acids, amino acids, fatty acids, polyphenols [22], caffeic acid, anthocyanins, glucose, amino acids, quercetin, rutin, ascorbic acid, ellagic acid catechin, gallic acid, minerals [20]
Pomegranate flower	Ursolic acid, gallic acid, isoprenoids including asiatic acid and maslinic acid [20]
Pomegranate pericarp (rind, peel)	Flavonones, phenolic punicalagins, flavones, catechin, anthocyanidins, gallic acid [20]

abilities. Pomegranate polyphenolic components can boost the body's natural antioxidant capacity. Additionally proven to be useful against HIV-I, osteoarthritis, prostate cancer, and other illnesses, the pomegranate fruit's anti-atherosclerotic and anti-inflammatory properties were also reported [39]. Pomegranate juice contains one of the most potent antioxidants known to exist in nature [40]. The antioxidant activity of pomegranate is comparable to that of green tea and a red wine infusion, proving that commercial pomegranate drinks had triple times the antioxidant activity of *Camellia sinensis* [11]. Pomegranate juice also strengthens the kidneys, makes a delightful beverage, supports liver function, and increases heart health and the body's resilience to infections. All of the tree's parts, such as the roots, blossoms, bark, rinds, leaves and seeds have been utilized in pharmacopoeia for years since the tree comprises several chemical compounds [41]. Gastrointestinal disorders are treated using dried and ground buds. *P. granatum* ashes are applied to the skin to prevent skin infections. The powder made from its rind is utilized in the cosmetic and tooth powder industries. *P. granatum* peel extract in aqueous form has wound-healing action. Low-density lipoprotein can also be inhibited by fruit juice [42].

Pomegranate kinds that are sweet are thought to be effective laxatives, at the same time beneficial for heartburn and stomach issues. It was found that pomegranates increase the activity of an enzyme that lowers the risk of cardiovascular disease. Pomegranates may have numerous health advantages, such as those for bacterial, fungal, viral, immunological, vermifuge, stimulant, refrigerant, astringent, stomachic, styptic, laxative, and diuretic illnesses. AIDS, dyspepsia, obesity, and neonatal hypoxic-ischemic encephalopathy are just a few of the ailments that can affect people and, for which pomegranate is frequently prescribed. The pomegranate's natural components can be used to treat obesity [43].

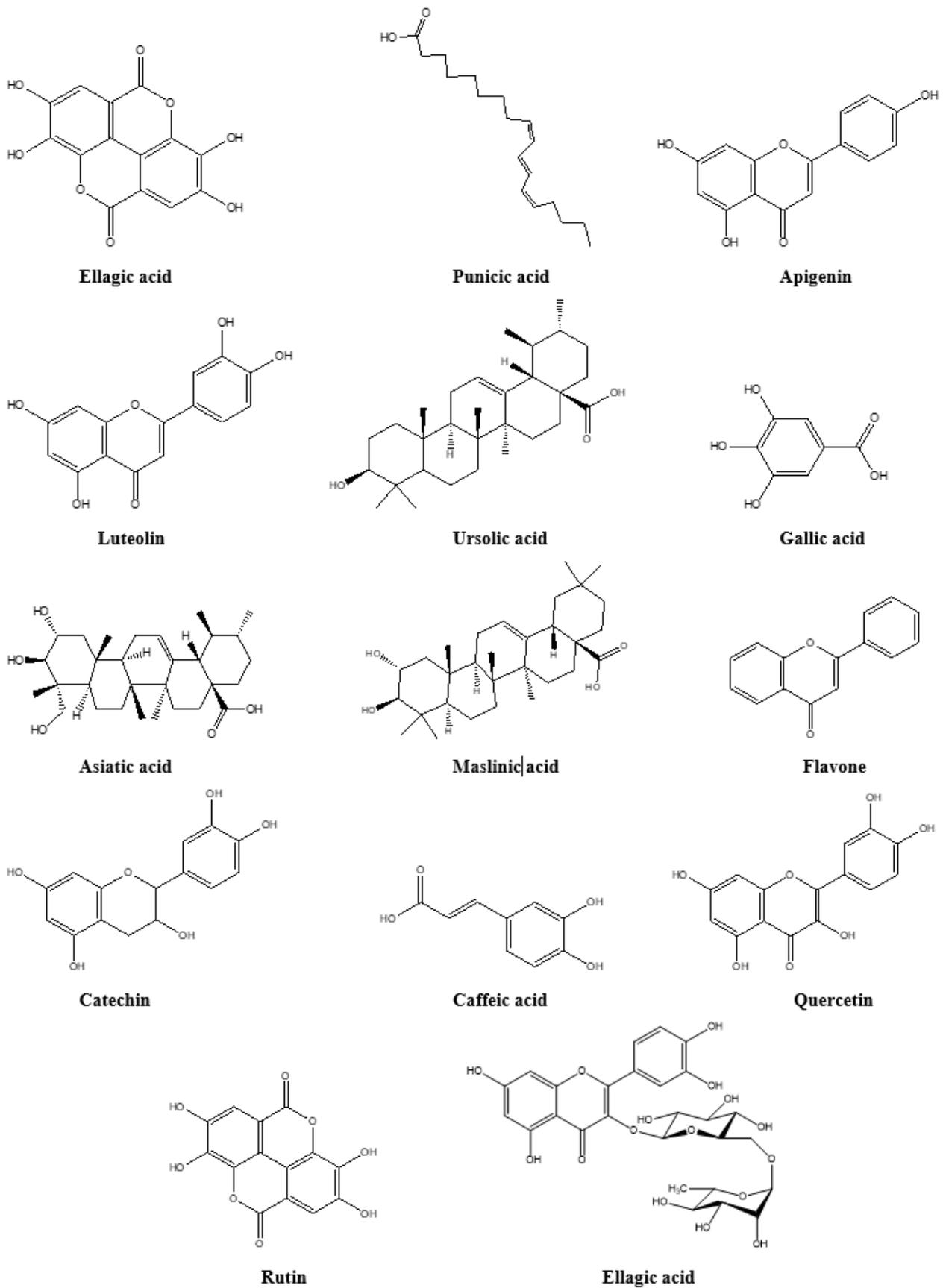
Pomegranate juice can improve the heart's blood flow and also demonstrates strong anti-inflammatory activities [44]. For several different kinds of cancer, pomegranate is used as a cancer preventative. Pomegranate seed extract and peel extract significantly reduce the number of SKOV3 ovarian cells by 89.0 and 78.2%, respectively [45].

The pomegranate was regarded as having its own pharmacy in the traditional Indian medical system, or Ayurveda. It was advised to cure diarrhea and ulcers as well as parasite infections [46]. Pomegranates have been used to cure parasite illnesses since the dawn of time [47].

Since ancient times, pomegranates have gained popularity for their potential in medicine. Even Hippocrates, Pliny, Soranus, and Dioscorides thought of the pomegranate as the most important medicine. Ancient cultures were aware of the pomegranate's health benefits, notably PPE. It was utilized in Egypt to treat infertility, diarrhea, intestinal worms, and inflammation. The generation of inflammatory cytokines can be decreased by PJ. It has been demonstrated that the juice, peel, and seed oil of pomegranates contain anticancer properties that stop angiogenesis, cell division, and proliferation [48].

According to reports, pomegranates exhibit tremendous activity at the cellular and enzyme levels, particularly when working on the COX, LOX, PLA2, and CA enzymes as well as the cell cycle, division, and motility. Its clinical effectiveness has recently been noted in cases of baby brain ischaemia, Alzheimer's illness, breast cancer, prostate cancer, arthritis, and male infertility [49]. Both prostate cancer cells and breast cancer cells' ability to spread is reduced by pomegranate juice [50]. The individuals who had been given pomegranate juice had shown a lowering in proliferation and caused apoptosis (cell death) in prostate cancer [50].

Pomegranates have been recommended by Greco-Arabic and Islamic medicine for rheumatism, inflammation, and sore throats. Due to the large concentration of chemicals like ellagic acid and quercetin, pomegranate juice has a potent anti-inflammatory effect. Additionally, pomegranate peels have been used to treat aphthas and diarrhea [51]. The juice and seeds are regarded as a heart and throat tonic. In addition to treating hemorrhoids, it is used to control nose and gum bleeding [52]. This fruit has been suggested as a pharmaceutical and food ingredient in the treatment of sexually transmitted diseases (HIV/AIDS) because of the enrichment of many bioflavonoids and the inhibition of lipoxygenases (the enzymes that convert arachidonic acid to leukotrienes) [53].



**Figure 4.** Chemical structures of important phytoconstituents of pomegranate.

It is known to be an antiparasitic fruit for both people and animals [54]. It can protect against UV-induced skin damage and increase male fertility. It highlights the toxicological properties, cell differentiation stimulation, and inhibition of essential metabolic enzymes [55]. Additionally, it has been proven effective in treating erectile dysfunction [56]. Pomegranate juice has been found effective in treating the symptoms of Alzheimer's disease [57]. Other prospective uses include those for arthritic conditions, obesity, and baby brain ischemia [58]. Pomegranate fruits contain phenolic chemicals, namely ellagitannins, which are frequently employed in the pharmaceutical industry for plastic surgery. Due to their antioxidant activity, they prevent skin flap death. The main polyphenols in the peel, seed, and juice are punicalagin and Punicalin. The polyphenolic contents of pomegranate fruits enable them to decrease inflammatory indicators (tumor necrosis factor- $\alpha$ ) and display antioxidant action [59]. Pomegranate juice lowers blood pressure and stops the action of the serum angiotensin-converting enzyme. After a year, pomegranate juice consumption reduces intima-media thickness by 30% [60].

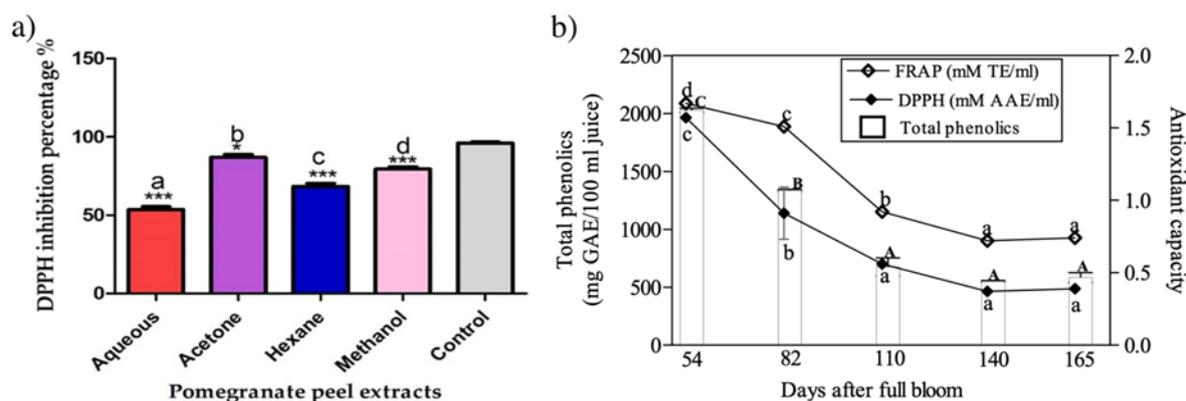
Pomegranate and its derivatives can increase MMP-9 mRNA levels through hemozoin and reduce TNF, which contributes to the prevention of inflammation causing the start of cerebral malaria and ant parasite activity [61]. Pomegranates and their derivatives have the power to lessen the size of wounds while boosting collagen bands, inflammatory cell counts, and fibroblast counts. They are also thought to promote healthy teeth and prevent the onset of gingivitis. Pomegranate hydraulic extract has antiplaque (dental) microbial properties and is efficient as a complementary periodontal therapy [62]. Excellent characteristics for preventing diabetes can be found in the pomegranate and its parts, including the peel and seed arils. The total/HDL and low-density/high-density cholesterol ratios were improved by pomegranate juice concentrate because it reduces increased fecal excretion, and enhanced enzymes [63]. Consuming pomegranate fruit has decreased activity Index (DAS28) in individuals with rheumatoid arthritis, and this benefit may be attributed to pomegranate fruit. Pomegranate intake

as a dietary supplement could be a helpful additional tactic for rheumatoid arthritis sufferers to lessen their clinical symptoms [64]. Pomegranate extracts were employed by Hippocrates (400 BCE) as a treatment for a range of illnesses, including the treatment of eye and skin inflammation and as a digestive aid [65]. In Mexico, the floral contents are utilized in mouthwash to treat mouth and throat irritation [66].

#### 4. ANTIOXIDANT ACTIVITY

The antioxidant potential of plants is well recognized especially due to the presence of phenolics [17] and flavonoids [67]. Changes occur in the pomegranate arils' total phenol content and antioxidant capacity (FRAP and DPPH) as they mature. The peel extract of pomegranate demonstrated a dose-dependent FIC and FRAP activity (Figure 5); statistical significance is shown by a difference in letter(s) on the bars and lines ( $P < 0.5$ ). The ethanolic extraction of *P. granatum* peel was subjected to phytochemical analysis. The presence of numerous phytochemicals, including alkaloids, flavonoids, steroids, saponins, and cardiac glycosides, was determined using phytochemical screening [68]. The peel of pomegranate had the highest level of antioxidants as compared to other parts, i.e., seeds and leaves [69]. The polyphenolic compounds of this fruit proved a pivotal role in health remedies in past as these include the radical scavenging activities and in-vitro metal chelating effects [70].

Furthermore, the methanol and acetic fractions successfully neutralized the DPPH radical, with scavenging percentages of 86.9% and 79.4%, respectively. The acetic fraction of pomegranate peels demonstrated the highest resistance to proliferation against MCF7 cancer cells after 48 h of incubation, recording an  $IC_{50}$  of 8.15 g/mL, whereas the selectivity of methanol is higher against transformed cancer cells as compared to normal cell lines, recording a selectivity index of 5.93. The pomegranate peel has shown the presence of tannin, alkaloids, phenols, steroids, terpenes and cardiac glycosides. According to the GC-MS results, 5-hydroxymethylfurfural was the predominant active component in both the methanolic and the acetic extracts of



**Figure 5.** Antioxidant activity of pomegranate peel extract a) DPPH radical; b) different maturity stage [71] [72].

pomegranate peels. Its relative percentages ranged from 28.44 to 37.55%, depending on which extract was used [71]. The important phenolic contents in various pomegranate cultivars include 83.54% Arakta, 83.34% ruby, 83.56% Ganesh, 50% ellagic acid and 179.3 mg/g Molla de Elche [73]. The yield is positively affected by increased concentration of maltodextrin which is a bioactive molecule used to identify morphological and storage conditions [74].

## 5. NUTRITIONAL VALUE

The nutritional value of plants is well recognized [75]. The fruit, known as *P. granatum* or pomegranate, is considered a highly functional food that offers numerous health benefits. Its use as a medicinal plant by ancient populations further highlights its potential therapeutic value [76]. The Holy Prophet Muhammad (S.A.W) instructed, “Eat the pomegranate, for it purges the system of envy and hatred” [77]. The Qur'an claims that heavenly fruits like olives, figs, dates, grapes and pomegranates are gifts from God [78]. Due to their appealing color, perfume, and flavor, pomegranate derivatives like aril and peel are employed in the processing industry [79]. Adding fresh peels to the diet resulted in significant enhancements in the intake of feed and the  $\alpha$ -tocopherol level in the plasma of bull calves, with a positive trend towards increased weight gain. Taken together, the nutritional quality and antioxidant capability of pomegranate peel make it a beneficial component of the feedlot beef cattle diet that promotes good health [80].

The peels of fruits are abundant in essential nutrients such as vitamins and minerals, and can be used for various purposes after proper processing, including as food, feed, and dietary supplements. Several studies have demonstrated that fruit peels have significant biological properties, such as antioxidant, antimicrobial, and anticancer activities [73]. Incorporating pomegranate peel powder into wheat flour led to considerable enhancements in the calcium and potassium levels in cookies that were supplemented with pomegranate peel. At a replacement rate of 7.5%, the calcium content increased by 46.90–175.41 mg/kg, while the potassium content increased by 327.26–598.61 mg/kg. Previous research on pomegranate peel has demonstrated its potential as a nutrient-rich fortification agent in various industries, as evidenced by a number of studies [8].

Including the vitamins and minerals found in pomegranate peel in one's diet as a means of value addition could be a lucrative approach for utilizing the discarded peel. Half of the pomegranate fruit is edible, with 40% of it being arils and 10% being seeds. According to the findings of a study, fresh juice has a composition that consists of 85% H<sub>2</sub>O, 10% sugars, 1.5% pectin, as well as flavonoids and ascorbic acid [81].

According to the findings of certain studies on the characteristics of pomegranate, the ascorbic acid content of the arils may range from 52.8 to 72.0 mg/100 g fW, depending on the specific variety. According to the findings of many research, when compared to the amounts of ascorbic acid found in the peels, arils have substantially lower levels of the

substance; the difference may be anywhere from 24.4% to 97.0%, depending on the type [82].

Pomegranate is excellent in the regulation of high blood pressure because it has low amounts of sodium while yet providing an abundant availability of several minerals. Pomegranate contains little sodium while magnesium, phosphorus, zinc, and selenium are found in tiny levels, the quantity of iron that is present is rather low. The quantity of ascorbic acid (vitamin C) varies based on the type of pomegranate. Peels contain much greater quantities of ascorbic acid than arils do, with variances ranging from 24.4% all the way up to 97.0% depending on the type. According to quality studies, Arils contain between 52.8 and 72.0 mg/100 g of fw, whereas peels contain between 76.8 and 118.4mg of ascorbic acid /100 g of fw. Peels have significantly higher levels of ascorbic acid than arils [82].

Pomegranate seed oil is a nutritious substance with many functional properties, particularly due to its high levels of conjugated linolenic acid. However, its abundance of unsaturated fatty acid makes it vulnerable to oxidative degradation. On the other hand, pomegranate juice (PJ) is a highly beneficial beverage containing natural antioxidants that can be utilized in the production of wall material. This can help enhance the oxidative stability of spray-dried products [83]. Incorporating pomegranate peel into muffin cakes is an efficient strategy to increase the nutritional and functional qualities of the cakes. Furthermore, it also functions as a useful ingredient in other food items as well [84]. It was reported that adding pomegranate seed powder to bread significantly increased the bread's antioxidant activity [85].

Research has shown that ethanol obtained from pomegranate seed is vital in functional food components for human prostate and breast cancer cells, to use the antihormone-dependent antioxidant and antiproliferative properties of pomegranate seed ethanol extract. This would allow the extract to be used against both types of cancer. These investigations indicate that the leftover materials from pomegranate fruit could be employed as natural antioxidants [86]. A rise in the consumption of pomegranate in different forms, including fresh fruit, juices, jams, and nutritional supplements is attributed to many curative benefits that are

connected with pomegranate, as indicated in references [87]. The arils and peels of the pomegranate act as source material for creating various products such as oil, jams, dye, and ink [88].

## 6. CONCLUSION

In summary, this study illuminates the relative importance of a spectrum of phytochemicals found in *P. granatum*, encompassing crucial minerals such as Calcium (Ca), zinc (Zn), magnesium (Mg), mercury (Hg), potassium (K) and iodine (I) in juice along with polyphenols including punicalin, sugars, and steroids in the peel extract, each present in varying proportions. The intricate composition of these phytochemicals underscores the multifaceted nature of pomegranate's nutritional profile. Moreover, the investigation highlights the pivotal role played by antioxidants and various biochemical compounds in fostering health remedies. These compounds not only contribute to the formulation of dietary supplements but also exhibit therapeutic potential in the treatment of fetal diseases, thereby expanding the scope of pomegranate-derived interventions in healthcare. Beyond its therapeutic applications, pomegranates emerge as a promising avenue for antiaging benefits. This is attributed to the presence of polyphenolic chemicals within the fruit, including phenolic acids, flavonoids, and other bioactive substances, all of which demonstrate robust antioxidant capabilities. The cumulative effect of these compounds positions pomegranates as a natural resource with the potential to mitigate oxidative stress and promote overall well-being, thereby adding a valuable dimension to their significance in preventive health measures. As research continues to unravel the intricacies of *P. granatum*'s phytochemical composition, the comprehensive understanding gained from this study underscores its potential applications in both nutrition and medicine, paving the way for further exploration of this remarkable fruit's health-promoting properties.

## AUTHOR INFORMATION

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## Conflicts of Interest

The authors declare no conflict of interest.

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