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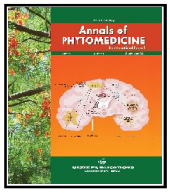

Review Article : Open Access

A review on nutritional, phytochemical, and medicinal properties of underexploited fruit crops

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Abstract

Numerous wild fruit species such as Bael, Chironji, Ber, Karonda, Tamarind, Wood Apple, Jamun, and Amla first appeared on the Indian subcontinent. Although, most of them have adapted to India's climate, they are still considered minor crops. As there are many minor horticultural fruit crops in tropical areas like Amla, Jamun, Ber, Bael, Fig, and Jackfruit, but they lack in utilization due to a lack of awareness of the importance of minor fruit crops. Minor fruit crops have more medicinal and nutritional importance compared to major fruit crops. Numerous chemical compounds, including quinolizidine, alkaloids, stilbenes, tannins, saponins, coumarin, flavonoids, triterpenoids, triterpenes, steroids, taraxerone, taraxerol, glycosides and cryptoxanthin are present in these minor fruits. Multiple biological actions are displayed by these compounds such as anti-inflammatory, antioxidant, analgesic, antidiabetic, antipyretic, hepatoprotective, hypoglycemic, and anticancerous properties. The two most common plant parts used to make medications are fruits and leaves (52% and 22%, respectively). This review paper explains the nutritional and medicinal importance of minor fruit crops.

1. Introduction

Underutilized horticultural crops are those that are not sold widely or cultivated economically on a significant scale. Local people grow, trade and eat these crops (Nanda and Bhardwaj, 2014). India is a tropical country with a wide variety of naturally grown fruits and vegetables. The health and wellness of humans and other living things are promoted by a nutritious diet (Chellammal, 2022). Phytochemicals are chemicals that plants produce to defend against microbial invasions, and they have medicinal use in food and pharmaceutical goods (Pandhi *et al.*, 2022). The unique taste and flavor of fruits such as mango, apple, banana, guava, and citrus have captured the interest of both horticulturists and organic scientists. Unpopular and underused fruits have the potential to offer fresh supplies of substances that promote health (Donno *et al.*, 2018). The most extensively used treatments in use today are new formulations made using plant extracts. One of the most significant of them is the orchid, which is valued for its aesthetic properties. When properly understood and used, underutilized fruit crops may provide inexpensive, wholesome meals. Many polyherbal preparations are used to address a range of chronic sickness issues in conventional medicine. However, there are occasionally different fruits referred to as “underutilized fruits” are incredibly nutritious in terms of vitamin C carotenoids, and antioxidants and should be remembered by fruit fans and the general public. Numerous academic papers have established using medicinal herbs as both preventative and curative medications. An estimated 30000 plant species are known to be significant, and of them, 15000 are known to be used as medications on a global scale (Manoharachary and Nagaraju, 2016). Regardless, they are inexpensive and frequently available Every fruit of every tree in the garden at least once, it is an insult to creation not to experience fully, said the famous British actor Stephen Fry (Vino and Harshitha, 2016). The majority of underutilized fruits are used in various ayurvedic recipe formulations.

Bael (*Aegle marmelos*), Chironji (*Buchanania lanzan*), Ber (*Ziziphus mauritiana*), Karonda (*Carissa carandas*), Tamarind (*Tamarindus indica*), Wood Apple (*Feronia limonia*), Jamun (*Syzygium cumini*), Amla (*Emblica officinalis*) and others are among the most of underutilized fruits that are becoming more and more popular (Ranjit, 2018). Underutilized fruit trees have the advantage of being naturally resistant to diseases and have adapted to flourish in hot, arid climates similar to those found in the equatorial region. These plants are commonly located in arid regions of India such as Gujarat, Rajasthan, and Madhya Pradesh. Some of these species are exclusive to natural and semi-natural arid environments. In these regions, underutilized crops could be taken into consideration for incorporation into the current farming system since they require fewer inputs and can withstand tough climatic conditions. About 20 plant species of the dry zone are recognized for their edible fruits and there are roughly 30 plant species that have been used in cooking. These crops are grown, traded, and eaten in the area. Therefore, using underutilized horticultural crops might be a way to address the socioeconomic issues of food poverty, unemployment and insecurity. By addressing the dietary requirements of vulnerable individuals, the use of underutilized fruit crops can offer sustenance to needy and poor people. Underutilized fruits have been found to be a reliable source of nutrients.

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Additionally, underutilized fruit species serve as a genetic bank for crop enhancement through breeding studies (Cheema *et al.*, 2016). Unused fruits are regarded as nutritional and antioxidant gold mines. They have not gotten the needed attention despite being very nutritious, having medicinal qualities, and being able to thrive in unfavorable soil and climatic circumstances**.** Underutilized fruit trees have unique adaptation characteristics, such as deep tap roots, summer leaf shedding, water-binding mechanisms, wax coating, sunken, covered, and hairiness stomata in leaves, and salt tolerance**.** They possess the nutritional potential to prevent and treat several illnesses, including anemia, night blindness, hidden hunger, hypertension, diabetes, cancer, marasmus, and kwashiorkor (Nandal, 2011). Currently, the utilization of underused fruits in daily life has decreased, mostly because people are unaware of their potential. Resveratrol is abundant in underutilized fruits, and other polyphenols can be used to make beneficial drinks**.** Underutilized fruits can be exploited to enhance value since they have good flavor, color, and juice content. The discovery of drugs to treat cancer and its consequences has made medicinal plants a desirable source. The untapped commercial potential exists for several neglected fruit species. These fruit crops have not gone through any deliberate stages of selection and domestication (Barua *et al*., 2019).

Botanical description of underutilized fruit crops

Common name	Botanical name
Amla	*Phyllanthus emblica*
Bael	*Aegle marmelos*
Jamun	*Syzygium cumini*
Ber	*Ziziphus mauritiana*
Fig	*Ficus carica*
Jackfruit	*Artocarpus heterophyllus*

2. Nutritional and medicinal properties of amla

The Amla fruit is prized for its health-promoting (Figure 1) and therapeutic qualities (Jat *et al.,* 2021). Vitamin C and pectin are abundant in Amla fruit. Amla fruit has 82.2 % water, 0.5 % protein, 0.1 % fat, 14% carbs, and 600 milligrams of vitamin C per 100 g of pulp. Tannins, the polyphenol ascorbic acid, terehebin, linoleic acid, phyllantine, ellagic acid, lupeol, sitosterol, 1,3,6-trigalloylglucose, corilagin. are the primary components of EO. When the Amla fruit's juice is drawn out, the vitamin C content increases even more. The dried fruit of Amla is abundant in vitamin C in significant amounts, ranging from 2428 to 3470 mg per 100 g. Even after drying in the shade and grinding into powder, it retains a significant amount of vitamin C, up to 1780-2660 mg. The fruit includes a molecule called leucoanthocyanins (polyphenol), which prevents vitamin C from oxidizing. Iron, phosphorus, and calcium are also present. Calcium, phosphorus, and iron are also present. Research has extensively studied Amla and has discovered that it contains a wide variety of plant compounds such as sterols, alkaloids, benzenoids, flavonoids, and terpenes. Additionally, moderate amounts of vitamin B (30 mg/ 100 g) and nicotinic acid (0.2 mg/100 g) are also present in this fruit. Amla is sometimes referred to as "Amrit Phal" or "Wonder Drug" because of its extensive medical and dietary applications. In terms of nutritional value, it has a higher concentration of vitamin C than guava or citrus (650-900 mg/100 g) (Sharma *et al.,* 2022). The calorific value of Amla fruit is 59 per 100 g of fruit, which is high. Amla is recognized for its antiscorbutic, diuretic, laxative, alternative, and antibiotic properties.

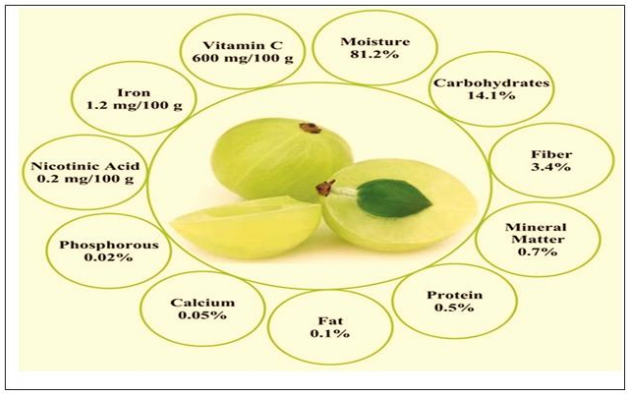
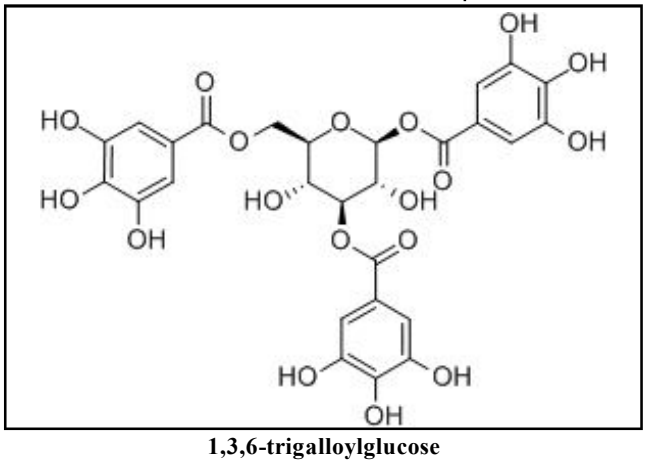


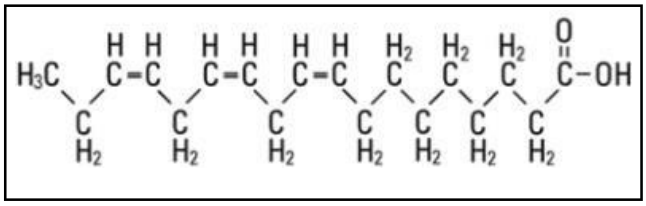
Figure 1: Nutritional properties of amla (% or per 100 g).

Table 1: Physical and chemical characteristics of amla

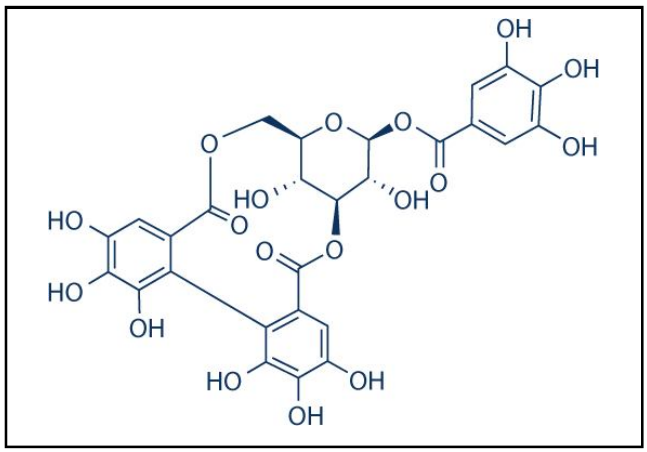
Acid-insoluble ash content (W/W %)	1.90 %
Extractive aoluble in alcohol (W/W %)	15.5 %
Disintegration time	39 min
Test for hardness	6.9 kg/m^2
Drying loss at 110°C (W/W %)	3.4 %
5% aqueous solution pH	3.37
Micro powder	15-20 µ
Total ash (W/W %)	5.33 %
Extractive soluble in water (W/W %)	41.30 %



1,3,6-trigalloylglucose



Linoleic acid

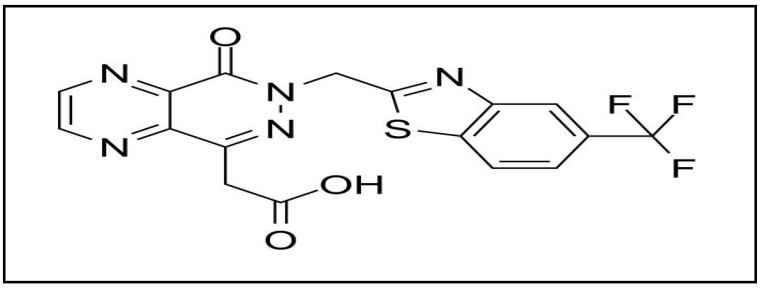


Corilagin

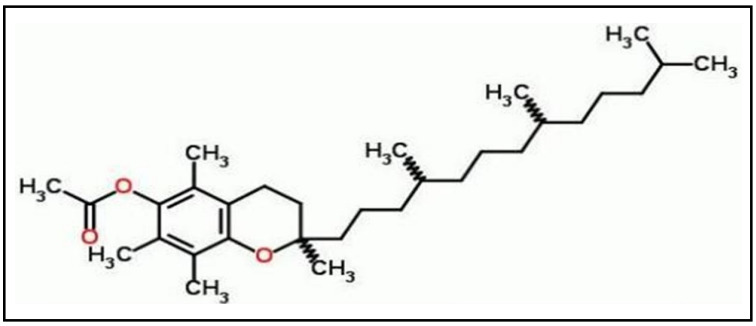
Amla is said to offer a variety of therapeutic properties. One tablespoon of freshly squeezed amla juice blended with honey is a good remedy for treating pulmonary TB, asthma, and bronchitis (Wali *et al.,* 2015). One tablespoon of freshly squeezed amla juice (Kaushik *et al.,*2018). It can also help with conjunctivitis and glaucoma. According to Wali *et al*. (2015). Amla has been found to have a significant effect on intraocular tension and has been shown to stimulate the Islet of langerhans, reducing blood sugar levels in diabetics when taken with fresh bitter gourd juice. Additionally, Amla has been traditionally used to treat rheumatism, scurvy, diarrhea, and dysentery. It has also been recognized as a good therapy for heart problems and a hair tonic that promotes hair growth and pigmentation while having a reviving impact on the body.

The abundance of significant quantities of superoxide dismutase, hepatoprotective, antioxidant, antimutagenic, cytoprotective, anti-tumor, and antibacterial properties have also been found. Amla exhibits antioxidant properties and can scavenge free radicals. For bleeding, diarrhoea, dysentery, anaemia (with iron), jaundice, and dyspepsia, dried fruit is utilized (Jain *et al.,* 2016). In ayurvedic medicine, it is a significant component of Triphala and Chavanprash. The roots 'nor-sesquiterpenoid glycosides demonstrated notable anti-proliferative properties (Zhang *et al.*, 2004). Both young and old rats 'memories were improved in an amla-churning dose-dependent manner. It overcame the amnesia that scopolamine and diazepam caused. Researchers have discovered that the existence of flavonoids in Amla and *Mangifera indica* can lowering cholesterol levels in both the tissues and serum of rats with hyperlipidemia that was induced in the laboratory (Anila *et al.,* 2002). In mice with solid tumors produced by DLA cells, it was shown that *Emblica officinalis* and Chyawanprash (a non-toxic herbal mixture comprising 50% Amla extracts) reduced ascites and tumor growth.

Treatment with *Emblica officinalis* extract and Chyavanaprash resulted in an increase in the lifespan of tumor-bearing mice by 20% and 60.9%, respectively. Pre-treatment of rats with *Phyllanthus emblica* fruit butanol extract at a dose of 100 mg/k g body weight, administered oral for ten days in a row, led to an increase in hexosamine and stomach mucus production (p 0.001) in rats with indomethacin-induced ulceration. Additionally, it prevents lesions on the stomach wall (Mandal *et al.*, 2017). The use of the ethanolic and water extracts (500 mg/kg) in a single oral dose markedly lower blood sugar levels in normal rats as well as in rats induced with alloxan diabetes (120 mg/kg) within 4 h of treatment, when given a dosage of 100 mg/kg body weight. In rats, the development of diabetic cataracts can be delayed with the use of Amla and an enhanced percentage of its tannoids (Suryanarayana *et al.*, 2004). Aldose reductase (AR) contributes to the development of diabetes's secondary consequences, such as cataracts. Amla fruit extracts have antipyretic and analgesic properties. In rats given brewer's yeast-induced hyperthermia 500 mg/kg of the aqueous and ethanolic extracts were given orally as a single dose, significantly reduced the condition (Diwan *et al.,* 2018).



Aldosereductase



Superoxidedismutase

Table 2: Various chemical components in amla

Part	Chemical constituents	References
Bark	Tannins, β-sitosterol, leukodelphinidin and lupeol	Sankaran *et al*. (2003)
Capsule	Ash, calcium, fat, fibre, nitrogen, phosphorus, potassium, selenium, silica, sodium, sulphur, water, zinc, ascorbic acid, beta-carotene, boron, chebulagic acid, chebulic acid, gallic acid, gallic acid ethyl ester, proanthocyanidins, ethyl gallate, emblicanin, and emblicol quercetin, rutin, tannin, trigalloyl glucose, zeatin, zeatin nucleotide, zeatin riboside, cystine, phenylalanine, proline, tryptophan, tyrosine, valine, protein, starch, sucrose, d-fructose, d-glucose, riboflavin, thiamin, chebulic acid, polysaccharide, flavonoids, phyllantidine, phyllantine, phyllemblin, phyllemblinic acid, phyllemblic acid, and phyllantidine, gibberellin-1, gibberellin-3, gibberellin-4, gibberellin-7, gibberellin-9.	Zhang *et al*. (2014)
Leaf	Phyllanthin, gallo-tanin, ellagic acid, gallo-tanin-3-o-glucoside, kaempferol, phyllanthin-3 -o-glucoside, tannin, and rutin.	Perianayagam *et al*. (2004)
Pericarp	Gallic acid, phyllemblic acid, emblicol, elagic acid, and **root**-elagic acid.	Asmawi *et al*. (1993)
Seed	Acids such as linoleic, linolenic, myristic, oleic, palmitic, phosphatides, stearic and -sitosterol, shoot-chebulinic acid, -sitosterol, glucogallin, lupeol, gallic acid and ellagic acid.	Bharthakur and Arnold (1991)

3. Nutritional and medicinal properties of Bael

Several studies conducted on the Bael fruit's (*Aegle marmelos* L.) nutritional profile has shown that it is abundant in many elements that are highly beneficial for human health. These include minerals, fatty acids, vitamins, vital amino acids, and carbs. Bael also contains several different phytochemicals, including phenolic acids, flavonoids, and alkaloids including gallic acid, protocatechuic acid, and ellagic acid (Sharma *et al*., 2022). The Rutaceae family includes the holy plant *Aegle marmelos* (L.) Corrêa (Priyadharshini *et al*., 2019). It is utilized in traditional medical practices in Sri Lanka, China, Burma, and India. Bael is another excellent source of fiber, glucose, and natural sugars. It has potent antioxidant properties that prevent oxidative damage and discoloration because it is loaded with vitamins, which includes the vitamins B, C, and A. phosphorus, calcium, iron, potassium, and among the easily accessible minerals listed are their salts from the fruit's edible portion. The moisture content of Bael leaves (71.26 per cent) is higher than that of the fruit (63.04 per cent) and seed (53.75 per cent). Bael seed has a greater fat content than other seeds (14.94 per cent). The fat content of the fruit pulp and leaves is 0.28 % and 0.07 %, respectively. Fruit also has a higher vitamin C concentration than apples. The mature fruit is delicious, aromatic, and extremely delectable; it is highly respected and consumed with the assistance of all human instructions (Singh *et al.,* 2021). Other studies have discovered that Bael contains beta-sesquiphellandrene (12.85%), alpha-zingiberene (14.41%), 1,7-nonadiene, 4,8-dimethyl-1-nitro, (e)-(2.25%), alpha-curcumin (9.56 percent), citronellylpropionate (4.1 perc ent), mycrene (1.22 per cent), and ethanone, 1,2-cyclopropyl (0.90 per cent).

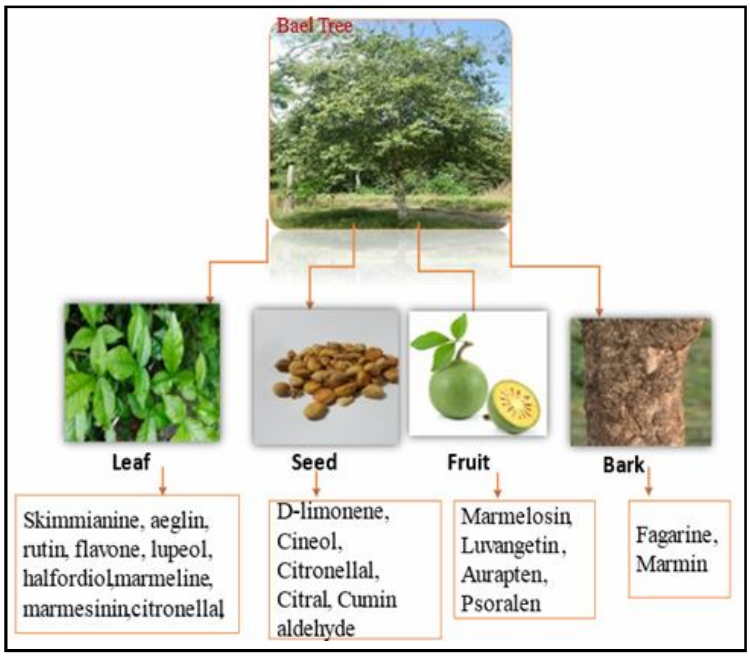
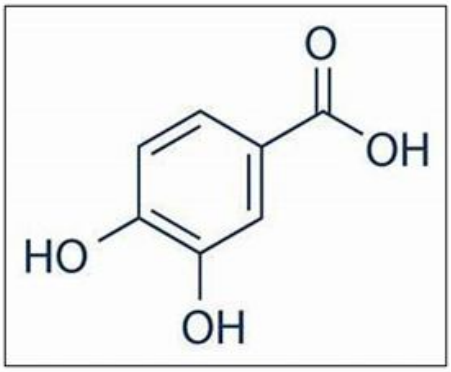
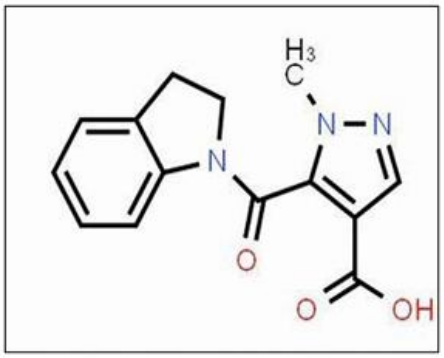


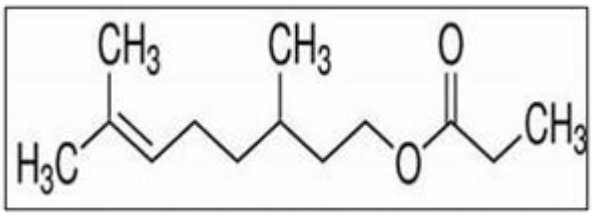
Figure 2: Chemical constituents of Bael.



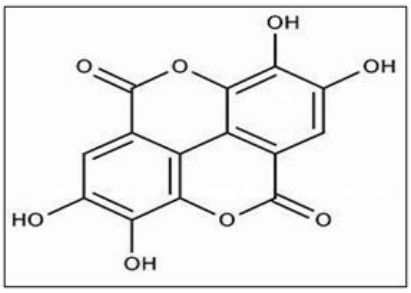
Protocatechuic acid



Alpha-zingiberene



Citronellylpropionate



Ellagicacid

Bael is an essential component of Ayurveda, an ancient Indian medical practice. According to Baliga *et al.* (2011), different tree components, including the leaves, roots, bark, fruits, and seeds, possess therapeutic properties and can be utilized to treat various human ailments and disorders. In particular, ripe fruits are believed to be more effective in preventing sub-acute and chronic diarrhea compared to raw fruits. The fruit pulp stimulates the intestinal mucus barrier and prevents diarrhea. Dyspepsia may be treated with ripe fruit in a simple and effective manner. The unripe fruit pulp is steeped in gingelly oil for a week before being spread all over the body before washing. This oil is believed to help relieve a strange burning feeling in the soles. The tree's bark and roots are utilized to make a decoction that is effective in treating fever, according to Sharma *et al.* (2011). Various illnesses including abdominal pain, urinary issues, fever, heart palpitations, diarrhoea, dyspepsia, stomach soreness, seminal weakness, vomiting, and edoema are also treated using the tree's leaves. The unripe fruits which are bitter, astringent, sour, and acrid, aid in digestion and alleviate stomach inflammation. Furthermore, the half-ripe fruit is also known for its astringent, digestive, and antidiarrheal properties, according to Baliga *et al.* (2011). The leaves are used to make a poultice that is used to cure ophthalmia. Inflammation, asthma, hypoglycemia, febrifuge, hepatitis, and analgesia have all been reported to be treated using the leaves of the plants. Unripe fruit's astringency is the secret to curing chronic diarrhea and dysentery. The fruit's ethanolic extract has been found to effectively inhibit more than 35 types of bacteria, including those that cause diarrhea, such as Shigella sp., *Escherichia coli*, and *Vibrio cholera*. Consuming fruit powder causes the feces to gradually become solidified and the mucus and blood to leave the stool. Fruit juice can reduce clotting, which indirectly improves blood circulation and the state of diabetes. Fruit juice consumption have demonstrated that it has the ability to decrease oxidative stress. in diabetic animals by increasing glutathione, catalase, superoxide dismutase, hydroperoxide, and conjugated diene levels in the blood and liver, respectively.

Bael fruit contains a new substance called marmelin, which has the chemical name 1-hydroxy-5, 7-dimethoxy-2-naphthalene-carboxaldehyde. Studies have shown that marmelin can effectively inhibit the proliferation of certain types of cancerous epithelial cells, such as HEp-2 and HCT-116 colon, without affecting normal cells such as mouse embryo fibroblasts. These findings suggest that marmelin is non-cytotoxic. Mechanistic studies have revealed that marmelin induces apoptosis through the actions of tumor necrosis factor (TNF), the TNF receptor-associated death domain (TRADD), and caspases. The treatment led to the activation of genes for TNF, TNFR1, and TRADD, as well as the arrest of the G1 cell cycle and the induction of apoptosis through activated caspase-3. However, the activation of caspase-3 was inhibited by pretreatment with caspase-3 inhibitor (Subramaniam *et al.*, 2008). According to studies, lupeol administration to athymicnude mice can prevent the growth of certain tumours, including 451Lu and CWR22Rnu1, by changing the expression of markers that control cell proliferation, apoptosis, and cell cycle regulation. Lupeol has been found to cause cell cycle arrest in the G1-S phase and increase p21 protein expression, while decreasing the levels of cyclin D2, cdk2, and cyclin D1 in PC-3 cells. By reducing the molecules involved in deregulation and raising p21, a cyclin-dependent kinase inhibitor that helps control the course of the cell cycle, lupeol appears to induce cell cycle arrest, which is beneficial in preventing the abnormal cell cycle seen in malignant cells.

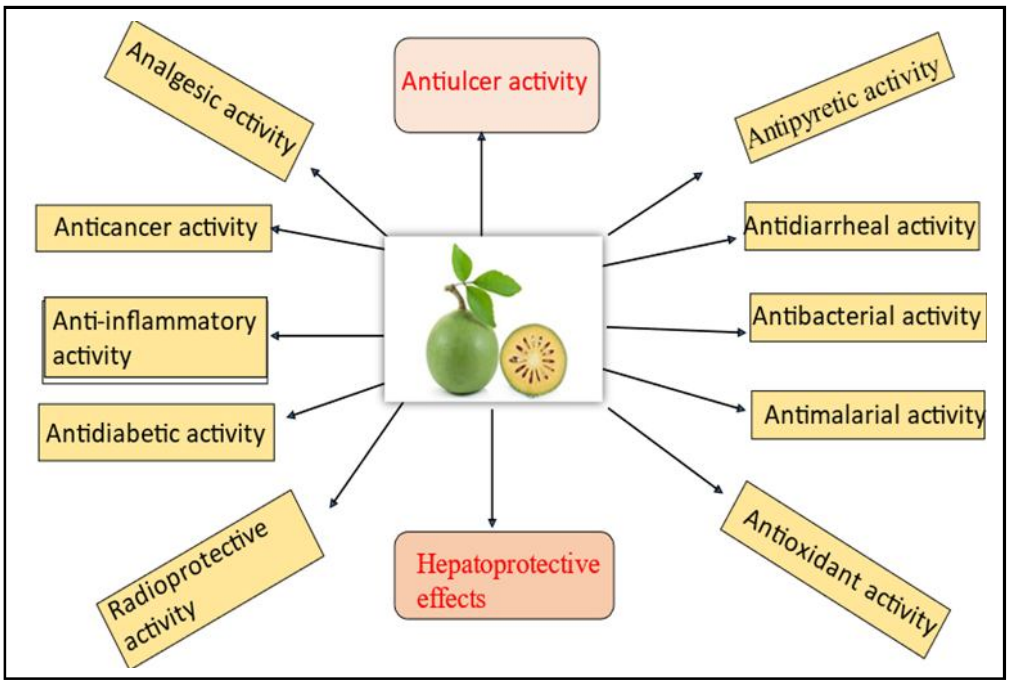
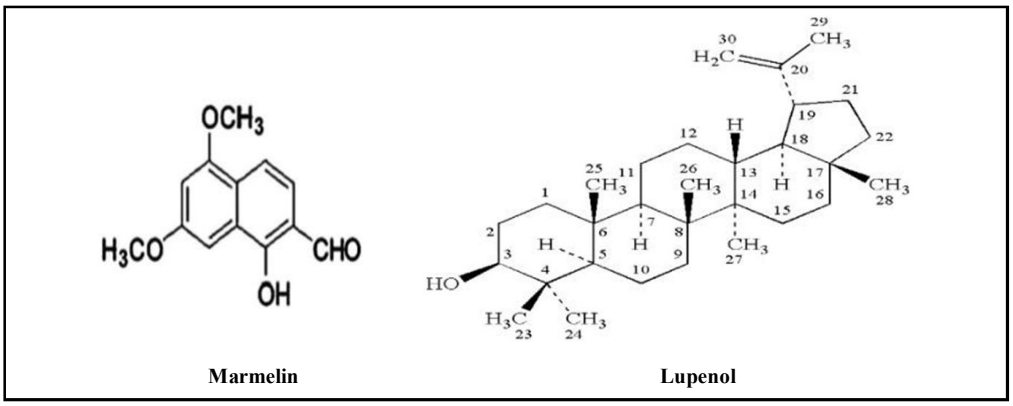


Figure 3: Medicinal properties of Bael.



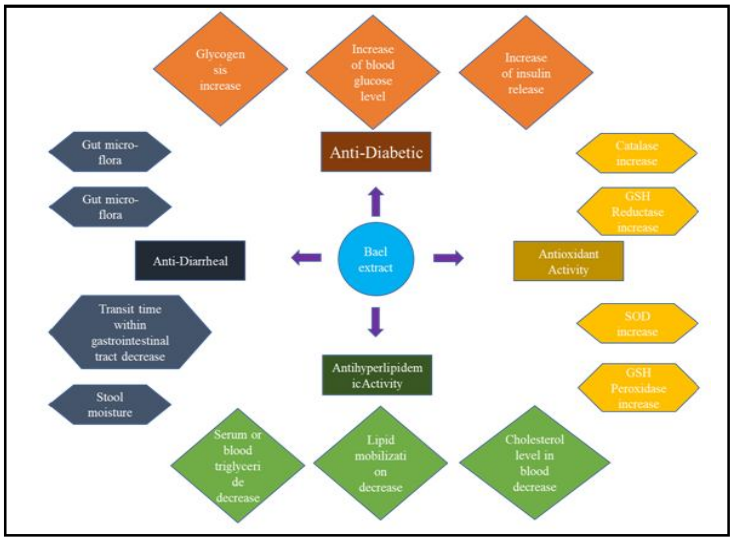


Figure 4: Medicinal importance of Bael.

4. Nutritional and medicinal properties of Jamun

Jamun fruit (*Syzygium cumini*) moderately contains free sugar (mannose, sucrose, glucose), minerals (K, Ca), vitamins (vitamin C, B-complex), and amino acids (aspergine, alanine, arginine, *etc.*). The fruit's purple appearance is a result of the anthocyanin pigment. Delphinidin and petunidin are the two most important anthocyanins. In minor amounts, malvidin, peonidin, and cyanidinareal were found. There have been discovered 29 chemicals, which make up more than 99 per cent of the volatile mixture, the most important of which are trans-ocimene (23.03%) and cis-ocimene (29.95%) (Shrikant *et al.*,2012). Jamun pulp, when completely ripe, includes minerals (Mn, Na, Mg), ascorbic acid, beta-carotene, organic acids, dietary fiber, and free amino acids (Tak *et al.*,2022). The Jamun fruit's distinctive flavor is thought to be caused by three esters: dihydrocarvylacetate, geranyl butyrate, and terpinyl valerate. A phenolic chemical's presence (215 mg/100 g) causes the fruit to be astringent. Jamun possesses a sizable amount of antioxidant activity when compared to fruits lacking in anthocyanins like sapota and papaya.

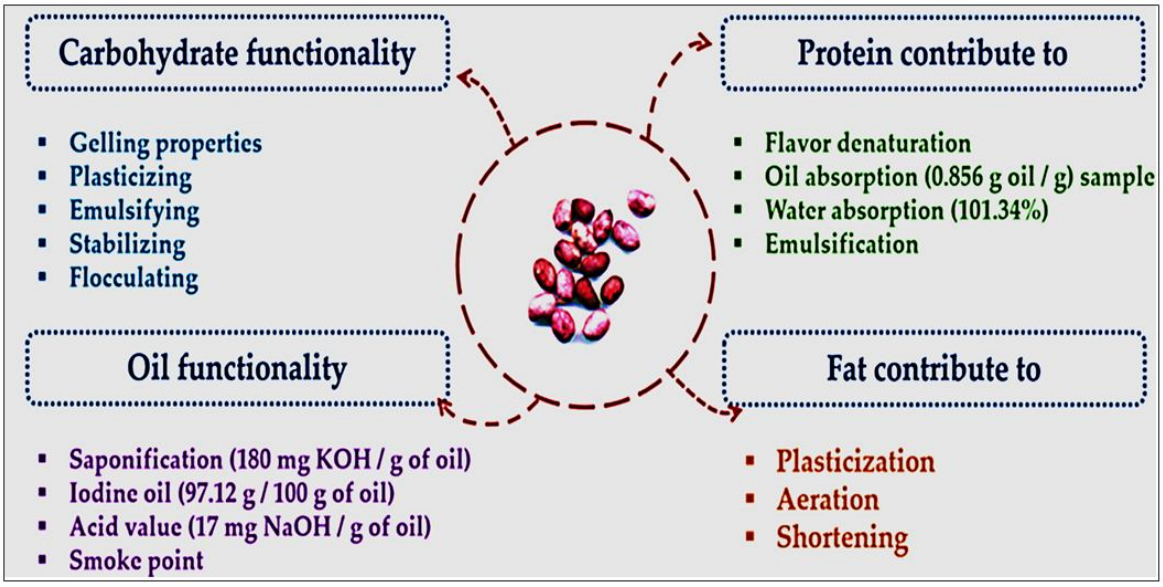


Figure 5: Jamun seed functional food properties.

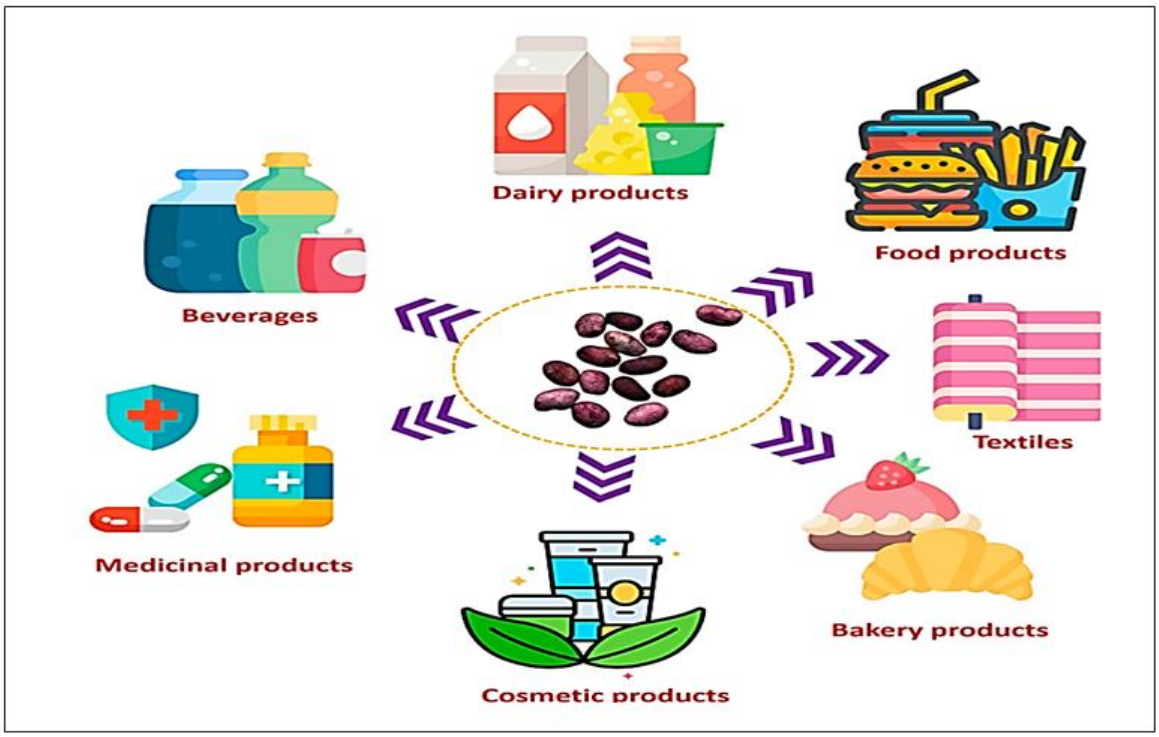
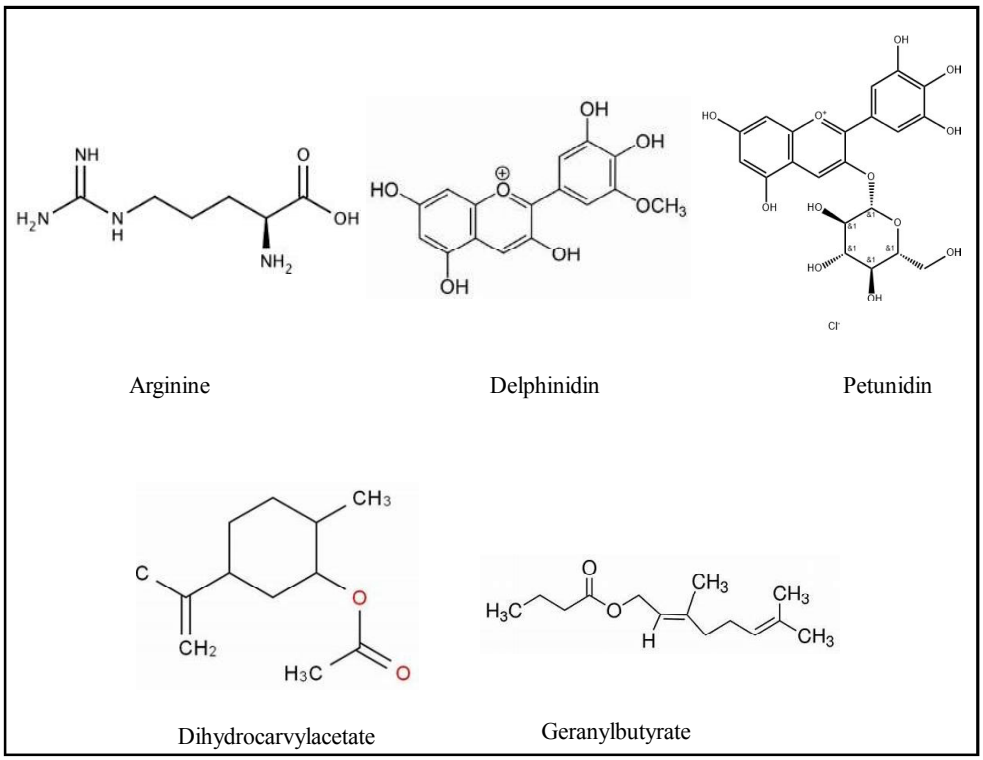


Figure 6: Applications of Jamun seed powder in the various products.



Jamun leaves, fruits, bark, and seeds have all been employed in Ayurvedic treatment in the past. The bark is historically used as an astringent to treat conditions like diarrhoea since it includes tannins and carbs. The seed of the Jamun fruit contains a glycoside, which is believed to possess anti-diabetic properties. (Shrikant *et al.,* 2012). Additionally, it has been demonstrated that the seeds contain antioxidant and anti-inflammatory properties in diabetic rats. Jamun fruit pulp and seeds have been demonstrated to assist diabetic patients with a number of concerns, including lowering their blood sugar levels and preventing the onset of diabetes-associated complications, such as cataracts and neuropathy, are among the benefits of inhibiting diabetes development. (Ramteke *et al.,* 2015). Antibacterial, astringent, constipating, carminative, digestive, diuretic, stomachic, febrifuge, and sweet are some of the uses for Jamun stembark. The Jamun may be used medicinally in all areas, and it has a long history in alternative medicine. When a fruit water extract was orally administered to mice with benzopyrene-induced gastric cancer, a notable decrease was observed in the number of gastric carcinomas, tumor burden, and tumor incidence. This finding indicates that the fruit water extract could be effective in inhibiting the progression of gastric cancer in mice. Quercetin, gallic acid, and oleanolic acid are phytochemicals with anticancer action (Li *et al.,*2021).

Table 3: Medicinal value of Jamun fruits and seeds

Chemical constituents in Jamun seeds and fruits	Medical importance	References
Alpha-pinene	Gastroprotective and antiulcerogenic effect induced by ethanol and indomethacin in mice	Magalhães *et al*. (2015)
Beta-bisqbolal	Anti-inflammatory, anticancer, antiviral	Kamatou and Alvaro (2010)
Quercetin	Antioxidant and antiviral application	Maalik *et al.* (2014)
Cisocimene	Antimutagenic	Burt *et al*. (2004)
Cynadin	Antitumorigenic	Paluszczak *et al*. (2014)

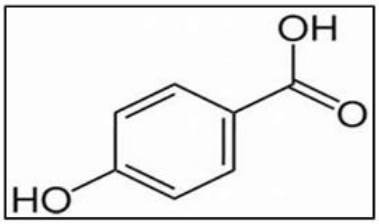
Fruits contain various antioxidant substances such as flavonoids, phenols, carotenoids, and vitamins considered to have beneficial impacts on human health. These substances are known to lowered likelihood of degenerative illnesses, alleviate oxidative stress, and prevent macromolecular oxidation (Shrikant *et al.,* 2012). Studies conducted *in vitro* have revealed that the entire extract of Jamun has cytotoxic effects on SiHa (HPV-18 negative) and HeLa (HPV-18 positive) human cervical cancer cells (HPV-16 positive). The effect of the extract was larger in HeLa cells than in SiHa cells, and it was concentration-dependent in how it promoted cell death. In these two cell lines, the crude extract performed better than the methanolic extract. These results suggest that the fruit pulp extract has selective antibreast cancer activities at supra-dietary levels. It has been determined that the chloroform seed extract inhibit acute carrageenan-induced paw edema in rats as well as reduce protein exudates, dye leakage in leukocyte migration, and peritoneal inflammation. Additionally, this extract has been observed to decrease kaolin-carrageenan-induced paw edema in rats. Similar findings were found

regarding the aqueous seed extract's ability to reduce inflammation in human neutrophils. The ethanol extract of the seed kernel decreased blood urea cholesterol, and glucose levels, increased glutathione (GSH) levels decreased the enzymes glutamate, oxaloacetate, transaminase, and glutamate, pyruvate, and improved glucose tolerance, and in the liver and kidney of rats with diabetes caused by streptozotocin. Additionally, it restored the functions of catalase, superoxide dismutase (SOD), and glutathione (Jagetia *et al.,* 2017). The juice of mature Jamun fruit, the decoction of Jamun fruit, and jambolana vinegar are used in India to treat spleen enlargement, chronic diarrhea, and urinary retention. Diluted Jamun juice is also used as a gargle for sore throats and as a moisturizer for scalp ringworm.

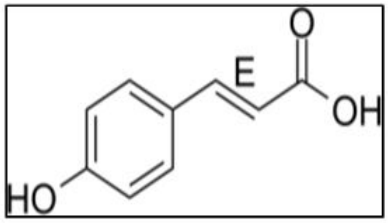
5. Nutritional and medicinal properties of Ber

Ziziphus mauritiana is a fruit tree that has gained popularity for its therapeutic and dietary properties (Butt *et al.,* 2021). Fresh ripe Ber fruits have a pulp content of 81-97 per cent, which is a good source of nutrients. Ber fruits are very nutrient-dense, high in ascorbic acid, and have a respectable number of vitamins (A and B) and minerals (such as iron, calcium, and phosphorus) (Vikalp *et al.,* 2021). Ber fruit contains 0.8% fiber, 17.0% protein, and 0.3% carbohydrates. It has a very low-fat content of 0.02 mg/100 g. The fruit is also rich in essential vitamins and minerals, including vitamin B2 (0.02 mg/100 g), vitamin A (76.0 mg/100 g), vitamin C (4.0 mg/100 g), calcium (9.0 mg/100 g), phosphorus (1.8 mg/100 g), and iron. It has an energy content of 73.9 kcal/g and is characterized by its beautiful yellow color and spherical shape, with an average weight of 20 g. The fruit is a good source of minerals, particularly K, P, Ca, and Mn, while Fe, Na, Zn, and Cu are present in smaller amounts. The ascorbic acid content in Chinese jujube ranged from 192 to 359 mg/100 g across the cultivars examined. There were 0.04-0.08 mg of thiamine and 0.05-0.09 mg of riboflavin per 100 g, respectively. The range of total phenolic levels was 5.18 to 8.53 mg/g. The pulp of the fruit has a TSS of 17 to 19 per cent and an acidity of 0.46 to 0.51 per cent.

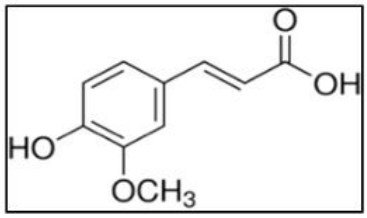
Hexanoic, nonanoic, heptanoic, octanoic, dodecanoic, decanoic, hexadecanoic, pentadecanoic, trihydroxybenzoic and benzoic acids are among the chemicals found in Ber fruit extract. Gluconic acid, galacto-furanoside, D-fructose, and -sitosterolwerealsofound.7-octadecenoic, 9,12-octadecenoic, hexanoic, octanoic, eicosanoic, docosanoic, and 11-eicosenoic acids, together with 7-octadecenoic acid, were discovered to account for about 55% of the total fatty acids in Ber seed oil. Ferulic, P-coumaric, caffeic acids and p-hydroxybenzoic are the predominant phenolic compounds found in Ber fruit. Ber fruits also include certain important sugars such as galactose; fructose, and glucose, which were tested for fatty acid and carotene levels in particular Ber types from Spain. It was discovered to be high in medium-chain fatty acids and triglycerides. The fruit's pulp is a terrific choice for a nutritious supper because it is also rich in phytonutrients (Hussain *et al.,* 2021). The main fatty acids present in the total saponifiable oil of Ber fruit were 18:1n9, 16:0, 12:0, 16:1n7, and 18.2n6, with an average saponifiable oil content of 1.3 g per 100 g of fruit on a dry weight basis. Unlike other fruits, significant amounts of carotenes were also detected in Ber, with concentrations ranging from 4 to 6 mg per 100 g on a dry weight basis. Additionally, the primary organic acids present in ber were identified as malic, malonic, and citric acids.



p-hydroxybenzoicacid



Pcoumaricacids

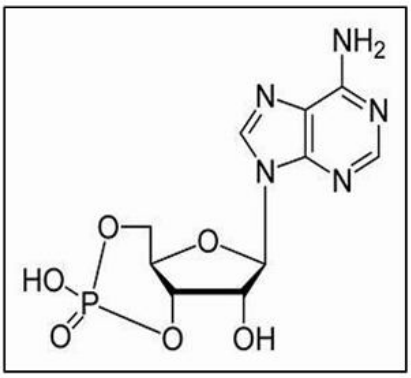


Ferulic acid

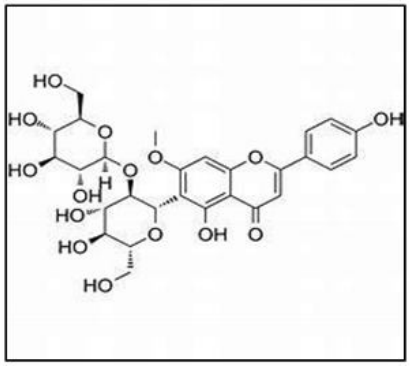
In the Ber fruit found different secondary metabolites, such as phenols, sterols, lignins, saponins, glycosides, and flavonoids have been extracted. These secondary metabolites have a high level of antimicrobial activity against microorganisms. The therapeutic applications of Ber fruit can extend to the treatment of liver diseases and cancer, depending on their specific properties and functions. Ayurvedic and Uunani treatments employ several components of the tree, like flowers, seeds, leaves, bark, and root cure asthma, ulcer, bleeding gums, indigestion, headache, biliousness, cough, and diarrhea. It is also a blood purifier and a tasty appetizer. *In vitro*, research was done on the cytotoxicities of triterpenoid acids extracted from Ber against tumour cell lines. The cytotoxic properties of lupine-type triterpenes were found to be rather strong. Betulinic acid, a triterpenoid compound derived from *Ziziphus jujuba* and *Ziziphus mauri*tiana, exhibited notable toxicity against human melanoma cells cultured *in vitro*, suggesting that it may be utilized to treat cancer. Huang qin Tang's compound prescription, which incorporates the fruit, has a strong anti-inflammatory effect.

In Chinese medicine, the fruit's microelements, polysaccharides, vitamins, organic acids, flavonoids, and amino acids are used to treat spleen disorders and replenish the blood (Shen *et al.,* 2009). The anti-allergic activity of Ber plant extracts was investigated *in vitro* by measuring their ability to inhibit the activation of hyaluronidase. The results indicate that these extracts exhibit potent antiallergic effects (Pandey *et al.,* 2018). Cyclic adenosine monophosphate (cAMP), which is present in jujube fruits, has beneficial effects on anti-platelet aggregation, diastolic blood vessels, antiarrhythmia, myocardium, and on heart's muscle (Beavo *et al.,* 2002). According to reports, the kernels have a sedative effect and are advised as soporific. They are used to treat pregnancy-related stomach discomfort and to halt nausea and vomiting. A sapogenin called zizogenin has been discovered in the stems of Ber. The peptide and cyclopeptide alkaloids from this fruit were shown to have sedative effects. Spinosyn and Swertish, two sedative flavonoids found in the fruit and seeds of *Z. jujube*, were discovered. 3-O-pcoumaroylalphitolic acids were shown to have superior cytotoxic properties than non-coumarictrit erpenoids. These findings simply

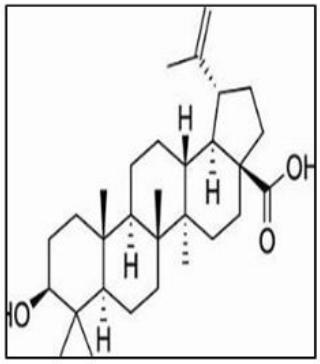
that the coumaroyl moiety of the lupane-type triterpene at the C-3 position may be crucial in boosting cyto-toxicaction (Lee *et al.,* 2003). Human neutrophils 'chemotactic, phagocytic, and intracellular killing potential was found to be stimulated by *Z. jujube* leaf extract (Tripathi *et al.,* 2014).



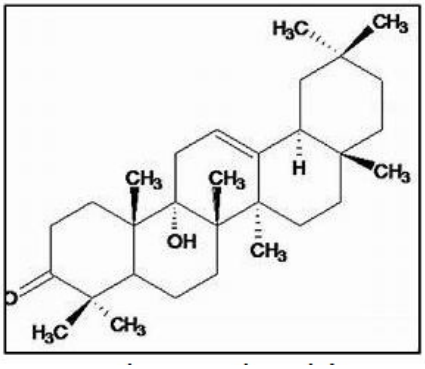
Cyclic adenosine monophosphate



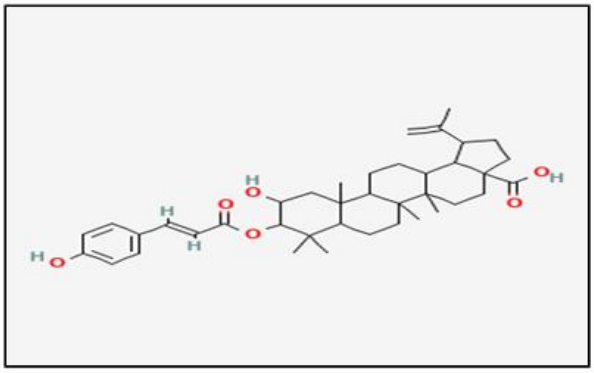
Spinosin



Betulinicacid



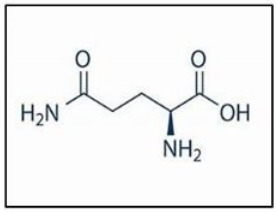
Triterponicacid



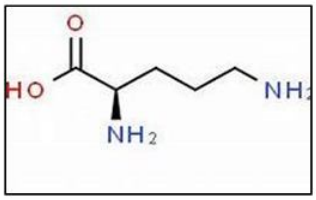
3-O-pcoumaroylalphitolicacid

6. Nutritional and medicinal properties of fig

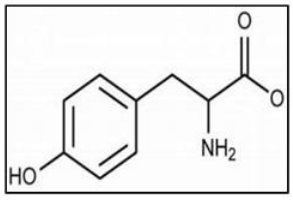
Figs (*Ficus carica*) have a long history as human food and are considered very safe to consume as a fruit. The leaves, latex, and fruits of *F. carica* have been used to address hunger and improve various health issues. Dried figs are particularly nutrient-dense among dried fruits and provide a plentiful supply of vitamins and minerals. The seeds of whole figs, which are surrounded by a jelly-like flesh and a white inner ring, contribute to their nutritional and health benefits (Nakilcioglu *et al*., 2019). Potassium sorbate is commonly used to prevent yeast fermentation and mold formation in dried figs. The moisture content of dried figs can be raised from 14 per cent to as much as 30 per cent, and like other plant-based foods, figs are free of fats, sodium, and cholesterol. Both the fig fruit and the bark of *F.carica* were used to separate fifteen anthocyanin pigments. The majority of them include pelargonidin derivatives as well as cyaniding asanaglycone (Slatnar *et al.,* 2011). Figs serve as a crucial source of calcium for numerous animals and birds and are considered a "keystone" plant. Additionally, the skins of the fruit are the primary source of phenolic compounds in many cases, hence eating entire ripe fruits is suggested. Both the skin (mostly anthocyanins) and the pulp contain high levels of phenolic chemicals (mainly proanthocyanidins). Six organic acids make up the fig leaf's organic acid profile: citric, oxalic, quinic, shikimic, malic, and fumaric acids. Using a combination of high-performance liquid chromatography and ultraviolet-visible spectroscopy (HPLC/UV-vis), the amino acid content of *F. carica* latex was identified. According to Hssaini *et al*. (2019), dark figs showed the best antioxidant capacity and high amounts of total phenolics and anthocyanins. It included 13 compounds, including eight non-essential amino acids (serine, alanine, glutamine, ornithine, cysteine, asparagine, glycine, and tyrosine) and five essential amino acids (leucine, histidine, lysine, phenylalanine, and tryptophan).



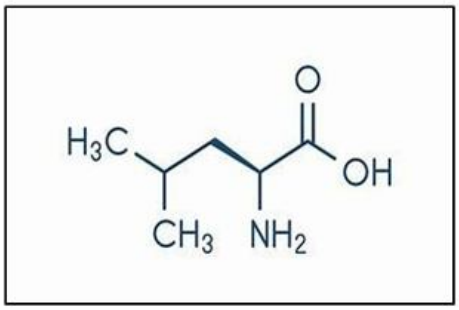
Glutamine



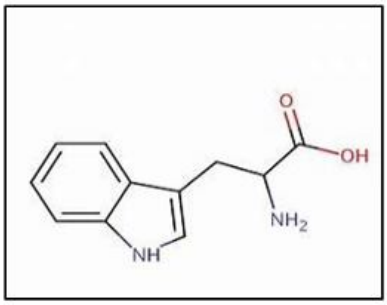
Ornithine



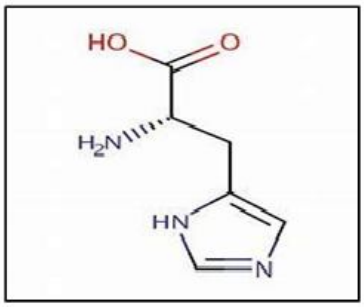
Tyrosine



Leucine



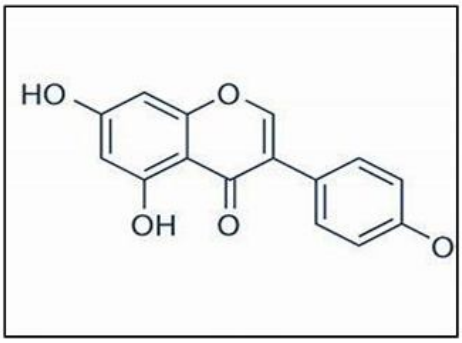
Tryptophan



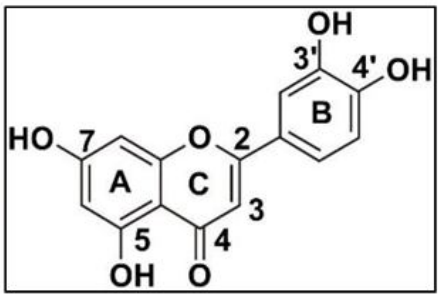
Histidine

The Mediterranean diet has long included the fig fruit, which is rich in anthocyanins flavonoids, and polyphenols. It is produced for its delicious figs, which are widely consumed and used as medicine across the world. When the fruits were harvested, latex was released that was used to cure warts and skin cancer. Studies conducted *in vitro* have revealed that some human cancer cells can not grow when exposed to the extract from fig latex (resin). Meanwhile, *in vivo*, experiments have demonstrated that the same extract from fig latex (resin) has reduced the development of transplanted and spontaneous tumors in mice. *F. carica* has been utilized for metabolic, circulatory, pulmonary, antispasmodic, and anti-inflammatory reasons in conventional medicine (Wang *et al,* 2008). *F. carica* is usually known as "Fig" and its roots, fruits, and leaves used in traditional medicine to treat a range of conditions of inflammatory, cardiovascular, pulmonary, and gastrointestinal conditions (Figure 7). They are also used to alleviate sore throats, coughs, and bronchial issues. A study has identified an array of 6-O-acyl-d-glucosyl-sitosterols as a potent cytotoxic drug obtained from fig latex that inhibited the growth of numerous *in vitro* cancer cell lines (Khadabadi *et al*., 2007). Additionally, *F. carica* fruit juice combined with honey is used to treat hemorrhage (Mawa *et al*., 2013). Fruit is renowned for their mild laxative, diuretic, and expectorant properties in Indian medicine and have been used to treat liver and spleen disorders. The dried fruit of *F. carica*, or fig, is used as a supplement for diabetes management. Studies have mainly focused on the plant's secondary metabolites, such as organic and amino acids, fatty acids, phytosterols, anthocyanins, hydrocarbons, phenolic and volatile compounds, and aliphatic alcohols (Baygeldi *et al*., 2021). Animal studies indicate that fig's ethanol extract reduces normal body temperature in a dose-dependent manner, while yeast causes an increase in temperature. Luteolin ($C_{15}H_{10}O_6$), a compound found in figs, is known for its strong anti-inflammatory effects and has been linked to several potential health benefits (Baygeldi *et al.*, 2021).

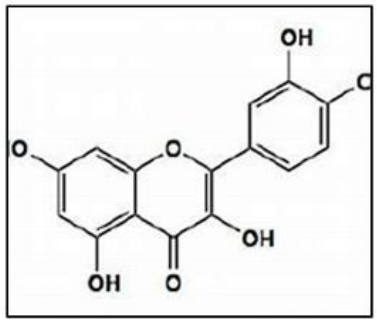
The flavonoid quercetin is commonly used therapeutically to treat allergic diseases such as hay fever, asthma, eczema, and hives. It has been demonstrated that phytoestrogen biochanin-A has a function in cancer chemoprevention. This function may be achieved by modulating the signaling pathways responsible for cell death can potentially halt the proliferation of tumor cells (Badgujar *et al.,* 2014). When compared to the usual antipyretic medication, paracetamol, the impact lasted up to 5 h, following drug delivery. An 80 per cent methanol extract from *F. carica* leaves was screened using a colorimetric microplate-based test for the presence of *Mycobacterium tuberculosis* H37Rv. The results indicated anti-tuberculosis activity, with a minimum inhibitory concentration (MIC) of 1600 g/ml. The ripe dried fruit of *F. carica* was found to mediate the potassium ion ATP channel activation and exhibit antiplatelet activity, providing a strong pharmacological basis for its use in treating gastrointestinal motility and inflammatory diseases. The plant extract also shown a decrease in the mutagenicity of N-metal-N2 -nitro-N-nitrosoguanidine (MNNG)-induced mutations in *Vicia faba* cells, chlorophyll mutations in *Arabidopsis thaliana*, and NAF-induced mutations in rat marrow cells. The capacity of the extract to lessen genotoxicity of environmental mutagens was confirmed. *F. carica* has demonstrated many intriguing biological activities that warrant further investigation for potential therapeutic applications in the future.



Biochanin-A



Quercetin



Luteolin

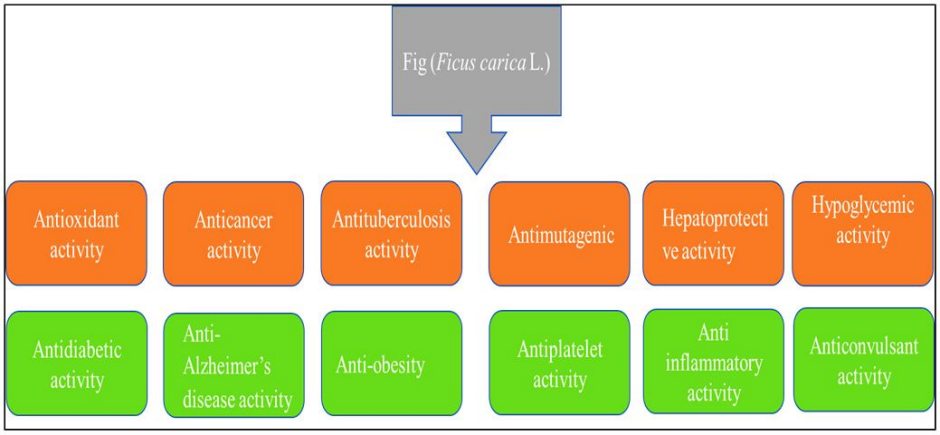
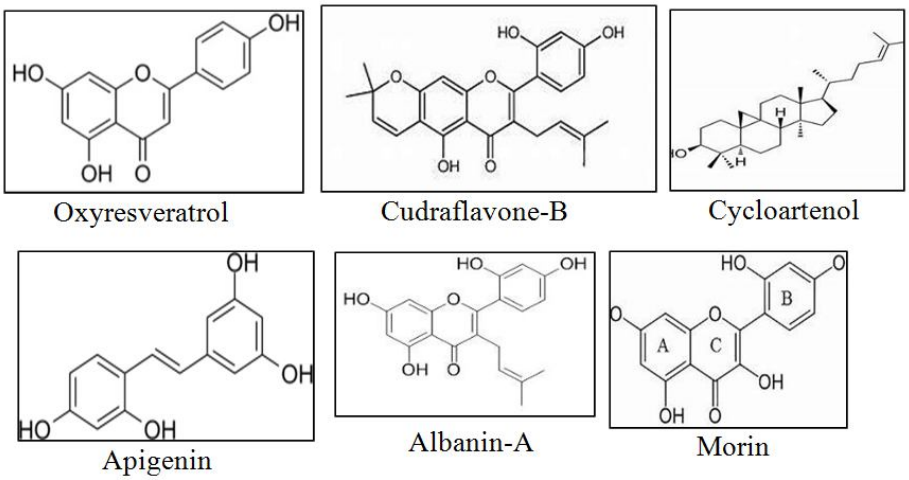


Figure 7: Medicinal properties of Fig.

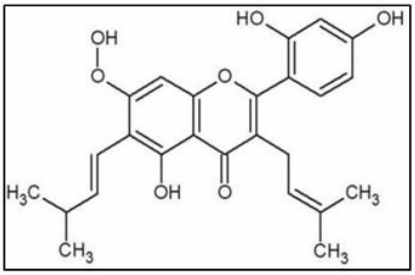
7. Nutritional and medicinal properties of Jack fruit

Jackfruit's (*Artocarpus heterophyllus*) chemical composition varies according to its kind. When compared to other tropical fruits, the seeds and flesh of the Jackfruit have higher concentrations of protein, calcium, thiamine, and iron. In several minerals and vitamins, ripe Jackfruit outperforms apples, apricots, avocados, and bananas. Jackfruit has a low-calorie level, with 100 g containing only 94 calories. The carbohydrate content of various Jackfruit seed cultivars can range from 37.4% to 42.5%. The starch from Jackfruit is thought to be an inexpensive and sustainable source of carbs since it makes up the majority of the seeds of the Jackfruit (60-80%, dry matter basis), These constituents constitute approximately 8-15% of the fruit's weight. Due to its distinct structural and functional characteristics, Jackfruit starch (JS) offers a lot of promise for use in a variety of applications (Zhang *et al*., 2021). Jackfruit contains a variety of amino acids, including arginine, histidine, cystine, lysine, leucine, threonine, tryptophan, and methionine.100 g of flesh from ripe Jackfruit provides 1.9 g of protein. Jackfruit seeds can contain about 5.3 and 6.8 per cent protein. Vitamin C is abundant in Jackfruit. Moreover, it is among the rare fruits that contain significant amounts of B-complex vitamins, including vitamin B_6 (pyridoxine), folic acid, riboflavin, and niacin. The nutritional content in ripe Jackfruit flakes is excellent 100 g of mature flakes include 11–19 g of carbohydrates, 11-19 g of carbohydrates, 287-323 mg of potassium, and 30.0-73.2 mg of calcium are present. Different Jackfruit seed variants can range in carbohydrate content from 37.4% to 42.5%. According to reports, the kernel contains crocetin, a dicarboxylic carotenoid, zeacarotene, carotene-5,6-epoxide, and carotene (Chandrika *et al*., 2004). sitosterol, tannins, cycloartenone, cycloartenol, and sapogenin are claimed to be present in the leaves and stems. Vitamins, minerals including calcium and magnesium, organic acids, and vitamins, can be found in ripe Jackfruit. The seed satisfies the nutritional needs of rural people since it is high in lectins, calcium, iron, magnesium, and manganese (Khan *et al*., 2021). This fruit contains sterols, volatile acids, tannins, carotenoids, flavonoids, and carotenoids. There are several phytochemicals in Jackfruit, with different quantities according to the cultivar. Jackfruit contains various carotenoids, with the main ones being all-trans-carotene (24-30%), trans-lutein (24-44%), and four types of xanthophylls; namely, all-trans-neoxanthin (4-19%), 9-cis-neoxanthin (4-9%), all-trans-violaxanthin (4-10%), and 9-cis-violaxanthin. The number of equivalents to gallic acid in a of dry weight in Jackfruit is 36 mg GAE/g DW. However, the fruits obtained from various types of trees varied both in terms of quality and quantity. According to reports, the heartwood contains 22 ,42 -dihydroxyflavone, 2-methylpent-2-ene, oxyresveratrol, kuwanon C, norartocarpetin, apigenin, prenylapigenin, cudraflavone C, artocarpin, morin, albanin A, brosimone, 3-Methylbut-2-en-1-ol, and cudraflavone B, (Arung *et al*., 2007).

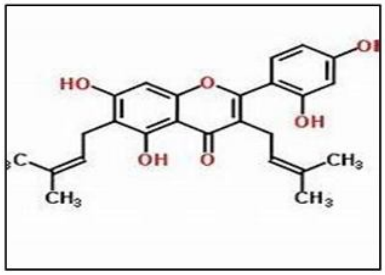


The Jackfruit tree is extremely important in Asia's different folk and traditional medical systems. According to reports, nearly every component of Jackfruit is used in the manufacturing of Unani and Ayurvedic remedies. The mature Jackfruit's edible bulbs, which make up approximately 10% to 15% of the fruit's overall weight, are frequently consumed either in their natural state or preserved in canned form. These plants are used by Asian people as food, medicinal, antibacterial, diabetic, inflammatory, and helminthic agents (Khan *et al,* 2021). Ripe Jackfruit is regarded as nourishing, refreshing, delicious, and gratifying and stops excessive bile development, flesh development, phlegm, body strengthening, and boosting virility. To have an anti-inflammatory effect, dihydro isocyclo artomunin reduced the rat peritoneal mast cells' ability to produce histamine and beta-glucuronidase after being triggered by P-methoxy-N-methylphenethylamine (Wei *et al.,*2005).

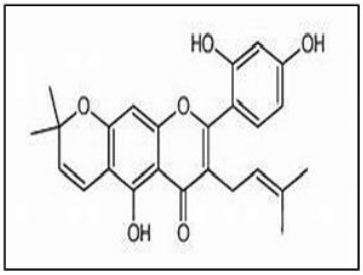
A fresh seed extract can be used to treat diarrhea and dysentery. Extracts derived from seeds or bark are believed to have properties that can aid in the process of digestion. Roots can be used as a treatment for various skin ailments, asthma, and diarrhea. Abscesses and ear troubles are said to be cured by the ash formed by burning bark. Fe (Iron) (0.5 mg/100 g) is also present in this fruit, which improves blood circulation and prevents anemia. The traditional uses of Jackfruit in Ayurveda include pectoral and cooling tonics (Shedge *et al.,* 2022). Copper (10.45 mg/kg) is essential for its effects on the thyroid gland metabolism like hormone absorption, and generation in Jackfruit is high for that micronutrient. Artocarpain-H, a phytochemical that may be isolated from fruit stem latex, has anti-inflammatory properties. On multidrug-resistant bacteria, methicillin Refractory *A. staphylococcus*, the efficacy of Jackfruit seed powder methanolic and ethanolic extracts has been demonstrated. When it comes to having cytotoxic effects on B_{16} melanoma cells, the fruit's 6-prenylapigenin, kuwanon-C, brosimone-I, cudraflavone-B, artocarpin, cudraflavone-C and norartocarpin, are more effective compared to the mostly used 5-fluorouracil, carmustine, and vinblastine (Arung *et al.,* 2010). The major cariogenic bacteria are significantly inhibited by the leaf's methanolic extract. fractionated research with a bioactivity-based focus revealed which mediated this impact was 5,7,2,2,4-tetrahydroxy-6-isoprenyl flavone, 6-trihydroxy-3-isoprenyl-7-methoxy flavone, and 6-(3-methyl-L-butenyl)-5,2,4 (Baliga *et al.,*2011).



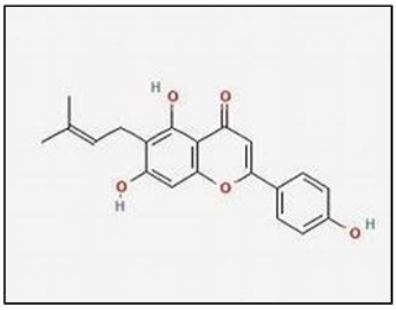
Artocarpain-H



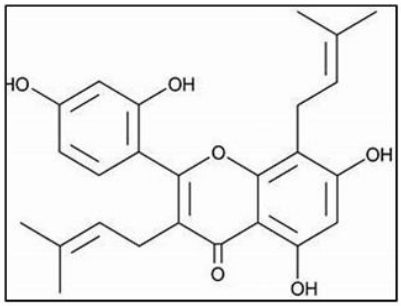
Cudraflavone-C



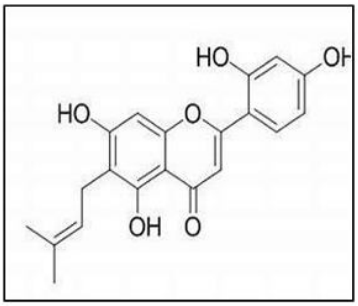
Cudraflavone-B



6-prenylapigenin



Kuwanon-C



Artocarpesin

Table 4: Constituent compounds and nutritive values of underutilized fruits

Fruit	Constituent compounds	Nutritive values	References
Amla	Vitamin C Antioxidants Polyphenols Minerals Fiber	High in vitamin C, boosts immune system Protects against oxidative stress Anti-inflammatory and antioxidant effects Provides essential minerals Promotes digestive health	Mathur *et al*., 2018
Bael	Tannins Flavonoids Essential oils Vitamins Fiber	Provides antimicrobial properties Anti-inflammatory and antioxidant effects Aids digestion Provides essential vitamins Promotes digestive health	Kaur *et al*., 2021

Jamun	Polyphenols Flavonoids Anthocyanins Tannins Minerals Fiber	Antioxidant and antidiabetic properties Anti-inflammatory and anticancer effects Promotes heart health and brain function Provides antimicrobial properties Provides essential minerals Promotes digestive health	Jaiswal *et al*., 2019
Ber	Tannins Flavonoids Antioxidants Minerals Fiber	Antioxidant and anti-inflammatory effects Supports cardiovascular health Protects against oxidative stress Provides essential minerals Promotes digestive health	Shah and Shri, 2013
Fig	Polyphenols Flavonoids Vitamins Minerals Fiber	Antioxidant and anti-inflammatory effects Supports cardiovascular health Provides essential vitamins Provides essential minerals Promotes digestive health	Gulçin, 2010

8. Conclusion

This review reveals the evidence that the minor fruit crops containing phytoconstituents which are very important in regarding medicinal and therapeutic value. Due to a lack of knowledge on the medicinal importance of minor fruit crops, they lack in utilization. Plant components have been utilized for medical reasons for ages., but due to the low commercial value of minor fruit crops, there is less cultivable area under minor fruit crops leading to less utilization. As interest in plant-based therapies increases dramatically on a global scale, studies must be carried out on the minor fruits to look into how they interact with other medicinal and therapeutic activities.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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