

Bael (Aegle Marmelos): An Overview of Its Nutritional Value, Phytochemical Composition, and Medicinal Uses

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Abstract

Aegle marmelos, commonly known as the Bael tree, holds a significant position in traditional medicine systems owing to its diverse pharmacological properties. This review provides an overview of *Aegle marmelos*, encompassing its botanical characteristics, geographical distribution, and traditional uses. Additionally, it explores into the phytochemical composition of various parts of the plant, highlighting its rich reservoir of bioactive compounds such as alkaloids, flavonoids, tannins, and essential oils. Furthermore, the review discusses the pharmacological activities attributed to *Aegle marmelos*, including antioxidant, anti-inflammatory, antimicrobial, antidiabetic, and hepatoprotective effects, among others. Moreover, recent scientific investigations validating its traditional uses and exploring novel therapeutic applications are elucidated. Understanding the multifaceted properties of *Aegle marmelos* contributes to its potential utilization in modern medicine, functional foods, and nutraceutical formulations, thereby fostering further research and development in this field.

Introduction

Aegle marmelos (bael) is an Indian origin herbal plant belonging to the rutaceae family. It may also be referred golden apple, bengal quince, bilva, stone apple, indian quince holy fruit, Indian quince, and maredo there. because of its importance, Hindus worship the aegle marmelos tree, also known as Shiva duma (the tree of shiva), and they offer it in prayers to the gods lord shiva and parvati. aegle marmelos belongs to the following groups. Class magnoliopsida, division magnoliophyte, order spanidales, species marmelos, genus aegle, and

family rutaceae. [1] bael is a subtropical plant that may grow to a height of 1200 meters above sea level. it grows in dry forests that are situated on hills and grasslands across India, Vietnam, Malaysia, Tibet, Ceylon, china, Nepal, Sri lanka, Myanmar, Pakistan, Bangladesh, java, Fiji Cambodia, Laos, Thailand, Indonesia, and Philippines. Bael is a plant that grows worldwide. it may be found throughout central and southern India, also subtropical regions crossing west Bengal and Jhelum in an eastern direction. it is present in almost every Indian state. [2]

Biophysical Limits:

Bael's height ranges from 0 to 1200 meters, with an average yearly temperature of 6-28 Celsius and an average per year precipitation of 570 to 2000 millimeters. it also needs soil with adequate

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drainage and grows best in muddy, alkaline, or sandy soils with a slightly acidic pH. [3]

Morphology

The tree aegle marmelos grows slowly and to an average size that may reach heights of 12 to 15 meters and spreads its spiny branches. [3] It has a short trunk and dense, fuzzy, separating bark. [2]

Leaves:

The three to five oval, pointy, shallowly toothed leaflets that collectively make up the deciduous, alternate leaves single, pair, or trio are each 4 to 10 cm long, 2 to 5 cm thick, and have a long petiole terminal one. When mature leaves are injured, they create an offensive odor [3]

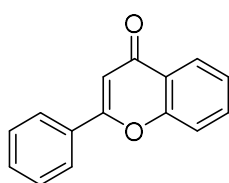
Fruits:

The fruit may appear round, pyriform, oval, or oblong, with a diameter ranging from 10 to 20-cm. It has a thin, tough, woody covering, or it has a grey-green skin that is relatively soft up until it ripens and becomes yellow. It has small, fragrant oil glands covering it. There are eight to twenty weakly defined triangle segments inside, along with thin, dark orange walls and a sticky, sweet, aromatic,

slightly bitter pulp that is pale orange and resinous. There is also a firm core inside. Fruit ripens during a period of 10 to 11 months, starting from blossom. [3]

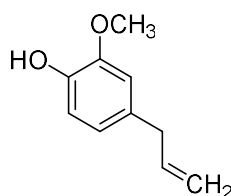
Phytoconstituent

Bael fruits are rich in nutrients through having a high moisture content. As their contents include fat, carb, protein vitamins b1, b2, b3, c, and amino acids such as methionine, isoleucine, leucine, and threonine, lysine, valine. Fat, fibre (hemicellulose, cellulose, lignin, pectin), and minerals [5]. Bael fruit is rich in vitamins A, B2, and C, as well as minerals like phosphorus, calcium. It contains carbohydrates, fibers, amino acids, and fats. Seeds have the highest calorific value at 244 Kcal, followed by fruit pulp at 139 Kcal. Leaf and fruit pulp have the lowest fat concentrations, with seeds having the highest. The fruit pulp has the second highest protein content, while leaves have the lowest. The leaves have the most Vitamin C content, while the fruit pulp has the most minerals. [8]



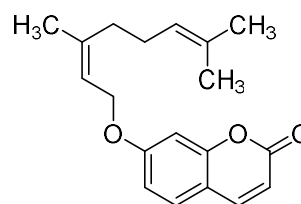
Flavone

Antidiabetic



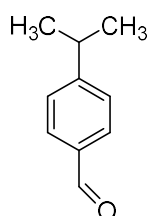
Eugenol

Antibacterial



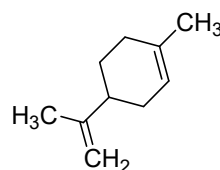
Auraptene

Anticancer



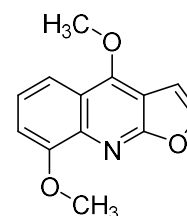
Cumin Aldehyde

Insecticidal



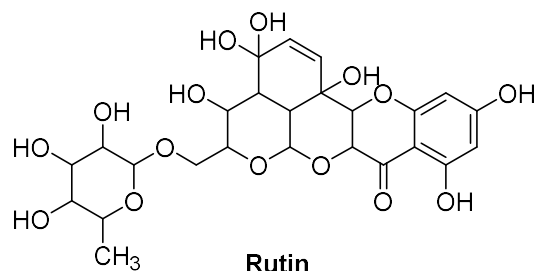
D-limonene

Anti-Ulcer



Fagarine

Antimalarial



Rutin
Antioxidant

Phytochemicals

Polyphenols and coumarins (scoparone, marmin, methyl ether, psoralen, alloimperatorin, zanthoxol, imperatorin, xanthoxol, isoimperatorin, umbelliferone, marmelide, scopoletin, marmelosin, scopoletin, marmesin, psoralen-a) constitute some of the many beneficial bioactive compounds and phytochemicals identified in bael fruit, in accordance to a phytochemical profiling study. Alkaloids (ethylcinnamate, aegelinosides a, ethyl cinnamamide, aegelinosides b, dictamine, fragrine, aegeline, halfordinol, aegeline,) phenolic acids (p-coumaric acid, flavonoids, vanillic acid, rutin), tocopherols, and carotenes. Tannins (4,7,8-trimethoxyfuroquinoline, skimminianine) [5] throughout the kingdom of plant life, a class of compounds known as tannins is abundantly distributed and contains both astringent and antioxidant properties. High concentrations of tannins, which are present and shown to have potent antioxidant and anti-inflammatory properties, are existing in a. Marmelos fruit. Under the kingdom of plants, flavonoids are a class of chemicals that have anti-inflammatory, antioxidant and anti-cancer properties. Flavonoids, which are abundant in the leaves and roots of bael, have been shown to have antinociceptive (pain relieving) and antipyretic (fever-reducing) effects. Across the kingdom of plants, terpenoids are a class of molecules that are well-known for their therapeutic qualities. A. Marmelos has been shown to contain terpenoids, some of which have been demonstrated to have

antifungal and antibacterial properties. Within the kingdom of plants, a class of molecules known as saponins is extensively dispersed and possesses emulsifying and foaming abilities. The fruit and leaves of bael have been shown to contain saponins, some of which have been demonstrated to have anti-inflammatory and antinociceptive activity. Within the nation of plants, glycosides are a class of chemicals that are widely spread and have been connected to certain medical benefits. Glycosides have been found in the fruit and leaves of Bael, and some of these have been shown to have anti-inflammatory properties. Applying the collected bibliographic data, the most extensively researched compounds from a. Marmelos were identified by a study and evaluation of the components. [19]

There are no more fruits with such a high concentration of riboflavin in bael fruit. The individual phenolic compound found in bael fruits is tannic acid. The fruit includes b-sitosterol, marmelosin (which is similar to imperatorin), and allo-imperatorin. It was discovered that marmolide, an imperatorin isomer with tyrosinase-accelerating and tryptophan pyrrolase-inhibiting furocoumarin characteristics, could be isolated from ripe fruits. The fruit yields two percent water soluble dry gum. The gum's hydrolysis produced a number of products: 20.4% galactose, 10.7% arabinose, 25.2% d-galacturonic acid, and traces of rhamnose. The bark of bael has also been shown to be rich in chemical molecular compounds, such as auroptin, marmin, umbelliferone, and lupeol; indications of the presence of these chemicals in the

roots of the plant have also been recorded along with these substances, other chemicals that have been extracted from bael roots consist of tembamide, scopoletin, xanthotoxin, and psoralen. It has been confirmed that the leaves of the bael fruit contain the alkaloid aegeline. Based on a dry basis examination of the leaves,

The bael fruit contains various medicinal substances, including memelosin, juniperine, umbelliferone, lupeol, marmin, and auroptins. The mature bark contains juniperine, umbelliferone, lupeol, marmin, and auroptins. The mucilage of the fruit contains galactose, arabinose, and rhamnose. The seed generates oil, with a fatty acid composition of palmitic acid, stearic acid, oleic acid, linoleic acid, linolenic acid. Bael leaves contain steroids, triterpenoids, pseudotannins, and cardiac glycosides. [8]

Numerous bioactive substances, including tannins, psoralen, aureptene, marmelide, luvangetin, and marmelosin, are found in fruit. Ripe fruits are high in pectin. Bael fruit pectin (bfp) was extracted using bael fruits. Although bael has a flavor which is sweet, fragrant, and pleasant, in some varieties it can also be slightly tannic and acidic. Phenolic molecules possess a role in the antioxidant activity of medicinal plants. An esteem increase to waste bael-patra, the phytochemicals and antioxidant capabilities completely different from fried clears out of a. Marmelos. Essential oils found in seeds include cineol, d-limonene, a-dphellandrene, citronellal, citral, p-cyrene, and cumin aldehyde. [4]

The unripe bael fruit was extracted using a mixture of water, and methanol chloroform, ethyl acetate. The aqueous extract taken from the fruit included flavonoids, glycosides, alkaloids, terpenoids,

proteins, and carbs. While steroids were also present in the petroleum ether extract, and the triterpenoids also seen in the methanol extract. The ripe bael fruit pulp extracts in aqueous and methanolic forms include flavonoids, saponins, and tannins, proteins, phenolics, glycosides and alkaloids. The bael fruit's methanol and aqueous extracts indicated the existence of phenols, terpenoids, alkaloids, flavonoids, and saponins. However, none of the bael fruit extracts contained any phlobatannins and anthocyanins. Proteins, alkaloids, coumarins, glycosides, phenol, tannins, and terpenoids were found in the bael fruit and peel in hydroethanolic extract, along with resins and carbohydrates. Alkaloids, flavonoids, glycosides, terpenoids, phlobatannins, and reducing sugars were identified in the bael fruit's aqueous extract. [5] The active components of plant material were shown to migrate into organic solvents and exhibit biological action. Leaf extracts from bael methylene chloride, chloroform, methanol, and aqueous petroleum ether were mixed to test for antibacterial activity against gram-positive and gram-negative bacteria. Bael fruit extracts, both methanolic and aqueous, show a significant impact on multidrug resistance in typhoid fever caused by salmonella typhi. By inhibiting inflammatory mediators such as 5-hydroxytryptamine, bradykinin, histamine, prostaglandins, etc., extract assists in relieving pain. Rhizoctonia solani renu species of fungal showed 100% fungal toxicity to leaf extract a. Marmelos. There have been reports of essential oils produced from a. Marmelos leaf having antifungal effects. [4]

Part of plant	Extract Type	Phytochemicals
Fruits	Aqueous, Ethanol, Hexane, Petroleum Ether, Methanol, Acetone	Alkaloids, Anthocyanins, Cardiac Glycosides, Flavonoids, Glycosides, Steroids, Terpenoids, Tannins, Lignins, Carotenoids, Ascorbic Acid, Phenols, Polyphenols, Phíchatannins, Saponins, Sterols, Innfin, Proteins, Carbohydrates, Amino Acids, Reducing, Sugars, Nonreducing Sugars, Galletannic Acid, Oxalates, Fat, And Oils [18-20]
Roots	Ethanol And Aqueous	Phenols, Flavonoids, Alkaloids, Proteins, Quinones, Reducing Sugars, Saponins, Sugars, Tannins, Triterpenoids, And Coumarins Alkaloids, Flavonoids, Glycosides, Phenols, Tannins, Stervés, Terpenoids, Proteins, And Amino Acids [21-23]
Stem	Aqueous Ethanol, Ethyl Acetate	Alkaloids, Flavonoids, Glycosides, Phenolics, Stertids, Tannins, Carbohydrates, Proteins, Amino Acids. [24]
Leaf	Aqueous, Chloroform, Ethanol, Hexane, Petroleum Ether, Methanol, Acetone, Ethyl Acetate, Phosphate Buffer	Alkaloids, Flavonoids, Anthraquinone Glycosides, Cardiac Glycosides, Catechins, Coumarins, Diterpenes, Emodins, Fored Oils, Fats, Furanoids, Leucoanthocyanins, Steroids, Stercks, Triterpenoids, Pseudotannins, Proteins, Phenolics, Carbohydrates, Fatty Acids, Phlobatannins, Quinones, Tannins, Terpenoids, Reducing Sugars, Sugars and Saponins. [25,26,27]
Seed	Aqueous And Menthol	Alkaloids, Flavonoids, Glycosides, Phenolics, Stertids, Tannins, Carbohydrates, Proteins, Amino Acids, Volatile Oils, And Fats [28-30]

Table 1: Variety Biological constituents in different parts of the plant

Polyphenol/phenolic compounds

Polyphenolic compounds due to their role in antioxidant activity, polyphenolic chemicals are an extremely important component of plants. In one research, the total phenolic content (tpc) of bael fruit was determined utilizing reversed-phase high performance liquid chromatography (rp-hplc). Quercetin, protocatechuic acid, gallic acid, ellagic acid, ferulic acid, and chlorogenic acid are among the phenolic compounds that were found in a bael

investigation using lc-ms and lc-ms/ms scans in addition to the hplc approach. [5]

Area and distribution

Aegle marmelos, often known as bael, is a modestly large, fragrant tree that grows naturally in the forested areas of the subcontinent. The tree's slightly twisted bole can reach a height of 6–7.5 m and a diameter of 3–4.5 m. The bael tree has trifoliolate leaves and white or pale green flowers with a pleasant scent. the bael tree produces globe-like, woody fruits that resemble enormous

grapefruits in size. The fruit's pulp is aromatic and sweet, but it must be cracked open to reveal the fruit's hard, woody shell. [7] originating from the southeast asia and indian subcontinent which includes indonesia, malaysia, philippines, tibet, java, vietnam, and sri lanka, bangladesh, myanmar, pakistan, thailand, nepal, china, cambodia, fiji, laos bael is a subtropical plant. Bael grows up to 250–1200 meters above sea level in hilly regions, dry forests and plains. Including south india, shivalik hills and the himalayas. It's planted all over the world and grows well in a variety of environments. Jharkhand, maharashtra, punjab, uttar pradesh, uttarakhand, rajasthan, madhya pradesh, jammu and kashmir, karnataka, assam, bihar, chhattisgarh, gujarat, haryana, himachal pradesh, kerala, tamil nadu, and west bengal are among the states in india where bael is grown. Because of its significance in indian mythology and religion, it is typically planted close to temples. It is regarded as an idol by hindus, who place its trifoliate leaves on the lord shiva lingam during prayer [8]. Most of gujarat's genotypes produce small-sized fruits. Bael trees are planted for a variety of reasons in parks, roadsides, nutritious gardens, and temple gardens in addition to organized orchards. In 1759, it was imported from india to europe. [6]

Climate Condition for Growth:

The beel tree is a highly adaptable deciduous plant that grows best on stony, alkaline, swampy soils with a ph range of 5.0 to 10.0. Its trees may grow up to 1200 meters above mean sea level and are known to be cold hardy. It can adapt to a wide-ranging of unfavourable climate and land conditions. The degree of resilience of bael plants in hot, semi-arid environments has also been noted, and the plants produce well when rain is provided. The degree of durability exhibited by bael plants in the desert has also been noted, as the plants have been known to regenerate themselves even after dying in sand for two to three months. bael has a natural ability to

withstand temperature fluctuations and soil moisture stress because it presents its herbs in the summertime. On the other hand, young plants need to be protected from hot, drying winds and cold temperatures (4°C). In deserts that are sandy, saline, or sodic, it may also be grown successfully if pyrite and gypsum are given to the soil before planting. [6]

Cultivation by Cutting

Cuttings of the stem and roots are a method of propagating bael. This isn't a commercial technique for spreading bael. Growth regulators can be used to achieve the greatest amount of success.

Root cuttings: bael can also successfully grow through root cuttings. During the monsoon, root suckers can be planted and separated. To ensure establishment, uprooted suckers are planted in nursery beds and allowed there for about two years before being transferred to the main field. During the monsoon, some of the root suckers that emerge from the extensive roots of bael plants can be detached and put straight into fields. However, the success rate is really low. For arid and semi-arid climates, it is not advised.

Stem cutting: bael can also be multiplied by air layering and cutting its own roots. Induced roots in ringed stem cuttings of a. Meleolos were greatly improved by etiolation and growth regulator treatments. The creation of water shoots after large branches are removed, known as invigoration treatment, when combined with growth regulator and etiolating treatment, greatly improved the cuttings' root quality.

Uses of Bael

Bael is one of the most important medicinal herbs in india. In ethnomedicine, aegle marmelos's antidiarrheal, astringent, demulcent, antidysenteric, antiinflammatory and antipyretic, and properties have all been used to profit from its leaves, fruits, stem, and roots. [9]

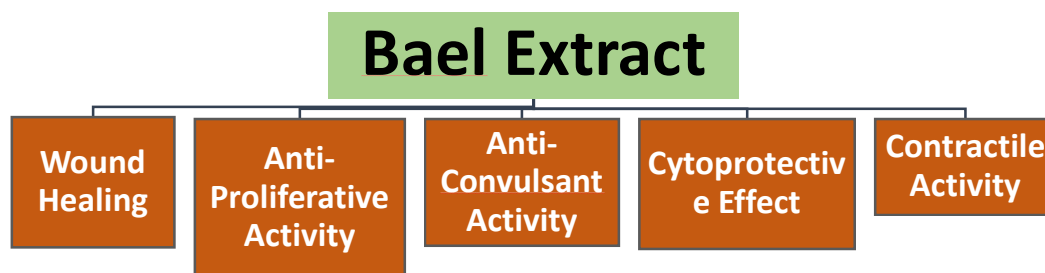


Figure 1: Numerous Biological activities of Bael Extract

1. Antidiabetic activity

The extract has a multifaceted antidiabetic effect because it may significantly lower hemoglobin glycosylated and blood glucose levels while increasing hepatic glycogen and plasma insulin levels in diabetic rats. [9] aegle marmelos leaf extract lowers blood glucose levels by increasing serum insulin levels. [10] when administered intraperitoneally or orally to rats with streptozotocin-induced diabetes, the aqueous extract of bael fruit produced a hypoglycemic effect. The fruit extract's coumarin content, which increases the insulin release from the island of langerhans' already-existing beta cells, is most likely the cause of this antidiabetic action [9]. Gireesh et al. Report that extracts from bael leaves block the actions of aldose reductase, anticataract, and free radical scavenging, all connected to diabetes, and can lower mi receptor gene expression. The antihyperglycemic action of bael leaves is attributed to the chemical aegeline-2. [12]

2. Antidiarrheal activity

Diarrhea is the term for the loose, watery stools that pass more frequently than usual. bael pulp, which is made from unripe fruit, regulates the colonization and activity of bacteria. [10]. Fruit that has tannins or other mucilaginous compounds that have a demulcent effect that cause it to be unripe or only partially ripe; this fruit can be sliced, roasted, sun-dried, and prepared as a preserve or a powder. when there is no fever, it is advised for intestinal disorders

such intestinal debility, persistent diarrhea, and dysentery in youngsters. [13] examined the antimicrobial and antidiarrheal qualities of the hot water soluble pectic polysaccharide (hwspp), which was taken out of the semiripe aegle marmelos fruit pulp aqueous extract. examined the hot water soluble pectic polysaccharide (hwspp), which was isolated from the aqueous extract of bael's semiripe fruit pulp, for its antibacterial and antidiarrheal qualities. after 48 hours, hwspp exhibited approximately 32% antibiocide activity compared to the control at a 500 µg/ml concentration. At 500 µg/ml, ciprofloxacin demonstrated 33% antibiocide effect compared to the control after 48 hours of similar experimental circumstances. In comparison to the control, hwspp (500 µg/ml) showed 18.7% anti-e. Coli activity after 48 hours, while ciprofloxacin (500 µg/ml) demonstrated 32% inhibition in the same experimental settings. The antiamebic activity of hwspp (200 µg/ml) against entamoeba histolytica (hm1: imss) was found to be modest, at 40%. The reference substance caryophyllene α-oxide (200 µg/ml) demonstrated 47% anti-entamoeba histolytica activity under similar experimental circumstances. Under comparable experimental conditions, the reference material caryophyllene α-oxide (200 µg/ml) showed 47% anti-entamoeba histolytica activity.

3. Antiulcer activity

For 21 days, an oral dose of 1 gm/kg body weight of the bael leaf aqueous extract was provided.

[11]. After receiving aqueous extract treatment, the observation showed a substantial decrease in the number of ulcer lesion, gastric juice volume, acidity (ph rise), and hexosamine. [11] a pyranocoumarin called liganetin, which is found in bael seeds, has been shown to have protective effects preventing gastrointestinal ulcers in rats caused by aspirin and pylorus. An additional investigation on the extract of unripe bael fruit demonstrates gastro-protective effect when applied to mucosal injury caused by ethanol [10]

4. **Antioxidant activity**

Antioxidant indices including reduced glutathione reductase, superoxide dismutase (sod) glutathione, glutathione reductase and catalase have shown a dose-related increase in their level /activity and a decrease in lipid peroxidation after being treated with bael leaf extract. leaf extract (200 mg/kg) is equally effective as alpha tocopherol (60 mg/kg) in rats given isoproterenol. free radicals can be scavenged by antioxidant phytochemicals included in the leaf extract, such as phenolobotannins, and flavonoid glycosides, flavonoids, alkaloids, sterols, tannins.

5. **Anti-inflammatory**

Numerous bael leaf organic compounds have potent analgesic, antipyretic, and acute and subacute anti-inflammatory properties. These activities may be due to the presence of luteol and skimmianine in the leaves, as both have shown the same potential in pure form. This impact may be due to the presence of multiple anti-allergenic and anti-inflammatory compounds, such as citral and luteol, which are present in the alcoholic extract. This is because the majority of anti-inflammatory and anti-allergenic chemicals function by blocking histamine-mediated signalling. [9]

6. **Anticancer activity**

It has been discovered that bael fruit extracts with a high alcohol content work well against cancer patients receiving gamma radiation

therapy. [12]. The extract's maximum anticancer efficacy has been shown when given at a 400 mg/kg dosage. [9] furthermore, the extract has anti-proliferative properties against the mcf7 and mda-mb-231 breast cancer cell lines. A significant anticancer medication that is frequently utilized in clinics is taxol.[9] bartalinia robillardoides (strain amb-9) is an endophyte fungus that was isolated from the medicinal plant bael. This endophytic fungus has a yield of 187.6 µg/l of taxol, which makes it a potential resource for genetic engineering to increase taxol production.[9] bael's carotenoids, phytochemicals, and polyphenols may be able to lessen cell mutation, which would lessen DNA damage.[10] Bael extract has been shown to include d-limonene, eugenol, and citral, which have anti-neoplastic properties[10].

7. **Radioprotective activity**

Lipid peroxidation increased and glutathione levels decreased in a dose-dependent manner after radiation exposure. [9] In mice subjected to various dosages of gamma radiation, the hydro alcoholic extract of bael fruit studied for its radio protective qualities. Mice that received the bael fruit extract before radiation showed a large decrease in lipid peroxidation as well as a significant rise in GSH concentration in their stomach, gut, liver, and kidney.[9]

8. **Antihyperlipidemic activity**

Aegle marmelos leaf extract pre-treatment at 100 mg/kg and 200 mg/kg doses for 35 days significantly improved the activities of marker enzymes and decreased plasma lipids, lipoproteins, and lipid peroxides in rats treated with isoproterenol, indicating an anti-hyperlipidemic activity. [9] Bael fruit powder has been shown to lower both free and ester cholesterol levels.[10] rats with streptozotocin-induced diabetes were given an aqueous extract of bael fruits and seeds separately at a concentration of 250 mg/kg, which dramatically reduced the lipid profile in both the serum and the tissue[9]. A test using rats that have been

promoted with streptozotocin may be used to control the lipid profile of serum using aqueous bael extract [10]

9. **Antifungal activity**

The bael tree's essential oil has been shown to have antifungal effect against fungus that affect both humans and animals, including *t. Rubrum*, *microsporum gypseu*, *m. Cookie*, and *epidermophyton floccosum*., *aspergillus niger*, *trichophyton mentagrophytes*, , *m. Audounii* the root's ethanolic extract exhibited anti-*a. Fumigatus* and anti-*t. Mentagrophytes* properties. Elixir extracted from bael leaves the leaves of the bael plant yield essential oil.

10. **Antiviral activity**

The effectiveness of the bael tree's in vitro viral activity against human coxsackie viruses b1–b6 has been assessed. when it comes to disrupting the first stages of its replication cycle, marmelide is the most potent virucidal drug. Unlike current virucids, bael appears to have antiviral activity in the early phases of viral propagation with minimal host damage. Bael has greater virucidal capability and could be used in the near future as a strong antiviral drug. [9]

11. **Antibacterial activity**

Aegle marmelos (indian bael) was used to synthesise metallic silver nanoparticles with antibacterial activity, which was monitored. bacterial cultures containing gram-positive *b. Aryabhattai* (mtcc 10859), gram-positive *b. Megaterium* (mtcc 428) *s. Aureus* (mtcc 96), and *p. Putida* (mtcc 1194), and gram-negative *s. Marcescens* (mtcc 4822), bacteria were used with minor modifications. Liquid nutritional broth was used to pre-inoculate the bacterial cultures. A sterile steel cork borer was used to punch 7 mm wells in a muller-hinton (himedia) agar plate. next, varying doses (25-100 µg/ml) of synthesized am-agnps were added to the wells, and a single positive control (25 µg/ml) of kanamycin was placed onto a separate plate. a negative control was provided by 100 µl of d.d h₂o. the zone of inhibition was measured

in millimeters following a day of incubation at room temperature. [18]

12. **Antiproliferative activity**

It was discovered that the various solvent fractions of the ethanolic extract of *a. Marmelos*' stem barks had antiproliferative effects on human tumor cells. [2]

13. **Hepatoprotective effect**

The hepatoprotective properties of *aegle marmelos* leaves have been documented in albino rats with alcohol-induced liver damage. for forty days, rats were given 30% ethyl alcohol treatment. For 21 days, the induced rats were given leaves of *a. Meleolos*. the tbars values were 123.35, 235.68, and 141.85 µg/g tissue for rats that were in good health, inebriated by alcohol, and treated with herbal drugs, respectively. this suggests that bael leaves have an strong hepatoprotective effect. [2]

14. **Antifertility effect**

Aegle marmelos leaf aqueous extracts have been shown to have an antifertility impact on male albino rats. For forty-five days, aqueous extracts of *aegle marmelos* leaves (250 mg/kg body weight) were given to the rats. the testis, epididymes, and seminal vesicles all lost weight because of the treatment. The extract also reduced testicular, epididymal, and motile sperm counts, as well as abnormal sperm counts. [2]

15. **Anti-arthritic activity**

It was discovered that *a. Marmelos* leaves had anti-arthritis action in wistar rats with collagen-induced arthritis. rats' paw edema and arthritic index decreased after they were treated with methanol extract. Rats given methanol extract showed a significant reduction in radiological and histological alterations. [2]

Impact on body: -

The acute toxicity data from the bael study showed that the medication was safe to use up to a dose of 1750 mg/kg. 2000 and 2250 mg/kg were determined to represent the ld₁₀ and ld₅₀. The tumor-bearing mice who received *aegle marmelos* once daily for six days in a row saw a dose-dependent tumour

remission at 400 mg/kg body weight, where the highest anticancer impact was noted and the higher doses manifested as toxic effects.[14] with an effective dose of 400 mg of aegle marmelos, which is one-sixth of the LD_{50} level, the mst and ast climbed to 27 and 29 days, respectively.[14] according to the aegle marmelos acute toxicity research, the medication was safe up to a dose of 1750 mg/kg b.wt. It was discovered that the LD_{10} and LD_{50} were 2000 and 2250 mg/kg.[14] when a substance is given to a biological system in a research study, certain interactions may occur. Certain interactions may happen when a drug is introduced to a biological system in a scientific study. When examining a novel medication, manufacturers conduct acute, subacute, and chronic toxicity tests.[15]

1. **Constipation:** bael fruit is ingested to treat diarrhea. Over enthusiastic treatment causes constipation and other digestive problems. Therefore, it is best to speak with your doctor about how much of this fruit to take in order to control your digestive system.[16]
2. **Hypoglycemia:** excessive intake of bael fruit may cause blood sugar levels to drop, perhaps lowering blood sugar levels. Headache, disorientation, and unconsciousness are possible. In these situations, you must cease eating bael fruit. And make an instant appointment with the physician.[16]
3. **Allergy response:** fruit that is high in phytochemicals and other components may cause an allergic reaction, even if no particular research has shown that fruit causes severe allergies. This could show up as nausea, vomiting, or more severe symptoms including skin rash or shortness of breath. Therefore, it is necessary to rule out allergies before consuming any fruit.[16]
4. **Pregnancy and nursing :** because there is a dearth of research on these women, bael fruit eating should be avoided to avoid any negative consequences.[16]
- 5.

Marketed Formulations

1. N- Bael [17]
2. Bael Nutritional Supplement [17]
- 3.

Conclusion:

In conclusion, the investigation into Bael (Aegle marmelos) reveals a multifaceted botanical treasure with significant nutritional, phytochemical, and medicinal attributes. Its nutritional value, characterized by essential nutrients and vitamins, underscores its potential as a dietary supplement. Moreover, the diverse array of phytochemicals present in Bael, including alkaloids, flavonoids, and tannins, contributes to its pharmacological potency, exhibiting antioxidant, anti-inflammatory, antimicrobial, and other therapeutic properties.

The traditional uses of Bael in various medicinal systems find validation in contemporary research, further cementing its status as a valuable herbal remedy for digestive disorders, respiratory ailments, and skin conditions. However, while scientific exploration has illuminated many of Bael's benefits, further studies are necessary to unlock its full therapeutic potential, optimize extraction methods, and ensure standardization for consistent efficacy and safety.

In summary, Bael stands as a promising botanical resource with a rich history of traditional use and modern scientific validation. Its nutritional richness, phytochemical diversity, and medicinal versatility underscore its importance in promoting human health and well-being, warranting continued research and exploration into its various applications and mechanisms of action.

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