

A REVIEW: PHYTOCHEMICAL AND PHARMACOLOGICAL EVALUATION OF *AEGLE MARMELLOS* PLANTS

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ABSTRACT

Aegle marmelos (Bael or Bilva), a member of the Rutaceae family, is an important medicinal plant widely used in traditional medicine. The plant has been utilized since ancient times for the treatment of various health disorders. Different parts of *A. marmelos* possess numerous pharmacological properties, including wound healing, antipyretic, antidiarrheal, diuretic, anti-ulcer, antithyroid, immunomodulatory, antifungal, antimicrobial, antioxidant, radioprotective, anti-arthritis, analgesic, and cytoprotective activities. It also exhibits contractile and anti-constipating effects. These therapeutic properties are mainly attributed to the presence of diverse phytochemical constituents such as alkaloids, terpenoids, vitamins, coumarins, tannins, carbohydrates, flavonoids, fatty acids, and essential oils. This review summarizes the available

information on the morphology, geographical distribution, phytochemical composition, traditional uses, and biological activities of *Aegle marmelos*.

KEYWORD: *Aegle marmelos*, Rutaceae, Medicinal Values, Pharmacology.

INTRODUCTION

Aegle marmelos (L.) Corrêa, commonly known as Bael, is an important medicinal tree belonging to the Rutaceae family. Among the approximately 250,000 terrestrial plant species, Bael is highly valued for its therapeutic properties. In India, it is also known as Bengal quince, golden apple, and stone apple, and it holds significant religious importance as a sacred tree often planted near temples dedicated to Lord Shiva.^[1]

Bael has been widely used in Ayurvedic medicine since ancient times, with historical records indicating its use as a medicinal and food plant since around 5000 B.C. The plant is also mentioned in classical Ayurvedic texts such as Charaka Samhita. Various parts of the plant including fruits, leaves, bark, roots, and seeds are traditionally used in Ayurvedic and folk medicine to treat a wide range of ailments.^[2]

Bael contains numerous phytochemicals such as alkaloids, tannins, essential oils, gums, resins, coumarins, and polysaccharides that contribute to its medicinal value. In addition to its rich nutritional composition compared to many other fruits, Bael also plays an important environmental role by acting as a natural air purifier and releasing a higher proportion of oxygen than many other plants. It exhibits several therapeutic properties, including antifungal, analgesic, anti-inflammatory, antipyretic, hypoglycemic, hypolipidemic, antioxidant, antiproliferative, wound-healing, antifertility, and insecticidal activities. Furthermore, the fruit is processed using various post-harvest technologies to produce value-added products such as candy, toffee, jelly, and juice, which help reduce post-harvest losses and extend shelf life. These applications also provide an additional source of income for farmers. Therefore, the present analysis aims to review the phytochemical constituents, traditional uses, and innovative applications of Bael fruit.^[3-4]

Therefore, the present review aims to summarize the botanical description, phytochemical constituents, traditional uses, and pharmacological activities of *Aegle marmelos*, highlighting its potential role in modern medicine and healthcare

Biological Profile

The various synonyms of Bael in different languages include: Hindi (Bel, Bael, Sripal); Sanskrit (Bilva, Sripthal, Shivadruma, Shivapala); Telugu (Maredu); Bengali (Bel); Gujarati (Bil); Kannada (Bilpatra, Kumbala, Malura); Tamil (Kualum); Thai (Matum, Mapin); Cambodian (Phneou, Pnoi); and Vietnamese (Baunau).^[6]

Taxonomy

- Kingdom: Plantae
- Order: Sapindales
- Family: Rutaceae
- Subfamily: Aurantioideae
- Genus: *Aegle*

- Species: *Aegle marmelos*

This classification places *Aegle marmelos* (Bael) within the Rutaceae family, which also includes several important citrus plants.



Fig. 01: *Aegle marmelos*.

Botanic Description: *Aegle marmelos* is a medium-sized, slow-growing tree that typically reaches a height of 12–15 m. It has a short trunk with dense, rough, and flaky bark, and a spreading crown with spiny branches. When the branches are injured, a clear gummy exudate similar to gum arabic is released, which hangs in long threads and gradually solidifies. This gum initially tastes sweet but later produces an unpleasant sensation in the mouth.

Leaves: The leaves are deciduous and arranged alternately, occurring singly or in groups of two or three. They are compound, consisting of 3–5 ovate, pointed leaflets with shallowly toothed margins. The leaflets measure about 4–10 cm in length and 2–5 cm in width, with the terminal leaflet having a longer petiole. When crushed, the mature leaves emit a characteristic unpleasant odor.^[8]

Flowers: Flowering occurs soon after the emergence of new leaves, typically during April and May. The flowers are fragrant and possess four curved, fleshy petals that are green on the outside and yellowish on the inside. They contain numerous greenish-yellow stamens (about 50 or more) and usually appear in clusters of 4–7 along young branches.^[7]

Fruits: The fruit is round, pyriform, oval, or oblong in shape, measuring about 5–20 cm in diameter. It possesses a thin, rough, woody shell or a grayish-green rind that remains somewhat soft until fully ripe and turns yellow upon maturity. The rind contains numerous small aromatic oil glands. Inside the fruit is a hard central core surrounded by 8–20 faintly defined triangular segments. These segments have thin, dark-orange walls and contain

aromatic, pale-orange, pasty pulp that is sweet, slightly resinous, and somewhat astringent.^[9-10]

Seeds: The pulp contains about 10–15 flattened, oblong seeds. Each seed is approximately 1 cm long and is covered with woolly hairs. The seeds are enclosed in a sac of clear, sticky mucilage, which solidifies upon drying.

Phytochemical Constituents Table of *Aegle marmelos*^[12-13]

Plant Part	Phytochemical Constituents	Chemical Class
Leaves	Skimmianine, Aegeline, Lupeol, Rutin, Marmesinin	Alkaloids, Terpenoids, Flavonoids
Fruit (Pulp)	Marmelosin, Marmelide, Coumarins, Tannins, Pectin	Coumarins, Phenolics, Polysaccharides
Seeds	Fatty oils, Proteins, Mucilage	Lipids, Polysaccharides
Bark	Skimmianine, Fagarine, Aegelin	Alkaloids
Roots	Coumarins, Psoralen, Xanthotoxin	Furanocoumarins
Whole Plant	Alkaloids, Flavonoids, Tannins, Saponins, Glycosides, Essential oils	Secondary metabolites

Therapeutic Uses and Pharmacology

Anti-cancer Activity

Breast cancer is one of the most common cancers worldwide and remains a leading cause of cancer-related deaths among women. Despite the availability of several clinical treatment approaches, the disease is still associated with a high mortality rate. *Aegle marmelos* (L.) Correa is widely used in the Ayurvedic system of medicine because of its diverse medicinal properties; however, limited studies have investigated its potential anticancer activity. The present study aimed to evaluate the chemopreventive effect of *Aegle marmelos* fruit extract against breast cancer induced by 7,12-dimethylbenz(a)anthracene (DMBA) in rats. Female Charles Foster rats, aged 55–60 days and weighing approximately 150 ± 10 g, were used in the study. Breast cancer was induced by oral administration of DMBA (20 mg/mL) dissolved in olive oil.^[27]

Antihyperglycemic activity

The study evaluated the hypoglycemic and antioxidant effects of *Aegle marmelos* leaf extract in diabetic rats. Diabetic rats were administered *Aegle marmelos* leaf extract at a dose of 500 mg/kg. Male albino rats were randomly divided into three groups: Group I (control), Group II (diabetic), and Group III (diabetic rats treated with the extract). The results showed that, after

four weeks of treatment, Group III animals exhibited a significant reduction in blood glucose levels compared to the diabetic group (Group II).^[14]

Anti-Diarrhoea and dysentery Activity

Half-mature or unripe *Aegle marmelos* fruit is traditionally used for the treatment of chronic diarrhoea and dysentery without fever. The half-ripe fruit is considered most effective; however, beneficial results have also been observed with fully ripe fruit or fruit powder. The unripe fruit is usually sliced, dried, and ground into powder for medicinal use. It can also be baked and consumed with brown sugar or jaggery. Regular consumption helps reduce the amount of blood in the feces and improves the consistency of stool, making it more formed and stable.^[17]

Anticonvulsant activity

Extract from the aqueous leaves of *A. marmelos* has anticonvulsant efficacy against seizures caused by pentylenetetrazole in mice. The anticonvulsant function of the extract of a aqueous leaves *A. marmelos* was attributed to the existence of mass spectrometry detected by liquid chromatography of Lupeollinoleate, Skimmianine, Eugenol. Ethanolic leaf extract from *A. marmelos* reveals anticonvulsant activity due to flavonoid presence and interferes with the anticonvulsant activity of the GABAergic mechanism.^[21]

Antimicrobial activity

Aegle marmelos has been traditionally used for the treatment of various infectious diseases due to its ability to inhibit a wide range of pathogenic microorganisms. The antibacterial activity of *A. marmelos* leaf and fruit extracts has been evaluated against several microbial strains. The results showed inhibition zones of 11 mm and 9 mm for leaf and fruit extracts, respectively, against *Raoultella planticola*. In antifungal studies, the plant extract showed the highest inhibition zone (18 mm) against *Penicillium chrysogenum*, while the lowest inhibition zone (7 mm) was observed against *Candida albicans*.^[23]

Anti-inflammatory activity

The author evaluated the anti-inflammatory, antipyretic, and analgesic activities of various extracts of *Aegle marmelos* leaves. The extracts showed significant inhibition of carrageenan-induced paw edema and cotton-pellet-induced granuloma formation in rats. These anti-inflammatory effects are mainly attributed to the presence of bioactive compounds such as lupeol and skimmianine in the leaves.^[25]

Antiviral activity

Antiviral activity against the Ranikhet disease virus was demonstrated by the ethanolic Bael fruit extract. Bael fruit produces marmilide, the most powerful viricidal agent that interferes with the replicating period of early events.^[26]

Diuretic

Sharma GN et al. reported that the ethanolic extract of *Aegle marmelos* produced a significant increase in sodium excretion at a higher dose of 500 mg/kg, indicating notable diuretic activity. Additionally, bioactive constituents responsible for this effect were also found in the petroleum ether, chloroform, and ethyl acetate fractions of the extract.^[26]

CONCLUSION

Bael fruit possesses significant therapeutic and medicinal value. To fully utilize its potential, efforts should be made to reduce post-harvest losses and promote the development of value-added commercial products from Bael. Processing the fruit into suitable food products can provide nutritional benefits as well as therapeutic advantages to consumers. The present analysis highlights various therapeutic properties and innovative applications of the Bael tree with the aim of promoting its wider utilization and global recognition. Furthermore, there is a need to develop, preserve, and promote traditional medicinal knowledge to support and strengthen the healthcare system.

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