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Review Article

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BAEL (AEGLE MARMELOS L. CORRE^A), A MEDICINAL TREE

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INTRODUCTION

Plants are particularly significant to humans since they contain various active ingredients that are the precursor for the creation of many drugs.^[1] For thousands of years, plants have been used in India as natural or herbal medicine. Plants used in Indian medicines are regarded as a rich source of numerous pharmacologically active principles and active ingredients, which are often employed in home treatments for a variety of diseases.^[2] Aegle marmelos (L.) Correa (A. marmelos), often well-known for Bael and belongs to the Rutaceae family, has been widely employed in indigenous systems of Indian medicine due to its many therapeutic characteristics.^[3] A. marmelos leaves are presented to Lord Shiva, whose devotion would be incomplete without them. Shivadurme, or Shiva's tree, is another name for it. Ancient Indian texts such as the Yajurveda and the

Mahabharata4.Bael includes a variety of phytochemicals such as alkaloids, tannins, essential oils, gums, resins, coumarin, and polysaccharide, which makes it effective for a variety of diseases. When compared to other fruits, it has a substantially higher nutritional value. It is also quite important in terms of the environment.^[4]

Bael mentioned in the renowned book Charaka Samhita, a comprehensive compilation of all the essential ayurvedic information, which identified bael as a necessary item in ayurvedic medicine. Bael fruits and leaves are used to treat dysentery, dyspepsia, mal-absorption, neurological diseases, edema, vomiting, and rheumatism. In addition to the essential medicinal values, bael is reported as an important item in industrial food processing and an excellent source for extracting pharmaceuticals and many other economically important herbal compounds. Unfortunately, bael is still considered an underutilized tree fruit species in South Asian countries, and its real economic potentials have not been exploited.^[1]

Synonyms

Hindi (Bel, bael, sripal); Sanskrit (Bilva, sriphal, shivadruma, Shivapala); Telugu (Maredu); Bengali Cambodia (Phneou or pnoi); Vietnamese (Baunau); Malayan (M (Modjo). (Bel); Gujrati (Bil); Kannada (Bilpatra, kumbala, malura); Tamil (Kuvalum); Thai (Matum and mapin).^[4]

Ecology

Bael is of Indian origin and can be found in Bangladesh, Egypt, Malaysia, Myanmar, Pakistan, Sri Lanka, and Thailand. The tree fills wild in dry woodlands on the slopes and fields of focal and southern India, just as in Burma, Pakistan, and Bangladesh, just as in blended deciduous and dry timberlands.^[4] Bael is a sub-tropical species, although it can grow well in tropical environments. Bael can thrive well in high altitude as high as 1,200 m and withstand without any significant growth retardation at 50°C and -7° C. In the prolonged droughts, fruiting may cease, but the plant can survive with shallow soil moisture. Bael trees generally require well-drained soil (pH: 5–8), but many studies and grower-reports suggest that it can grow equally well in alkaline, stony, and shallow soils. Bael grows well and produces bountiful harvests of fruits in the "oolitic-limestone" soils of southern Florida. In India and Sri Lanka, bael is famous as a fruit species, which can grow in very tough soils where other trees and other crops cannot grow.^[1]

Botanical description of A. marmelos

Aegle marmelos is a spinous, slow-growing, medium sized tree belonging to the family Rutaceae. The plant grows up to the height of 12-15 m and 90-120 cm in girth. The trunk is short, thick, soft, flaking bark with spreading spiny branches. Spikes present are long, sharp and axia.^[3]

Tree Morphology

Bael tree is deciduous, and the crown is compact or dense, with no weeping branches. Sometimes the lower limbs are drooping. tree is tough and widely adaptable to adverse soil and climatic conditions.Bael tree can grow up to 10 m or higher with medium or large sizes with numerous branches, fruits mainly occur in the periphery of the canopy trunk is short and thick with narrow oval shape ends. Wood is rigid and slow-growing.)e young wood has a Central pith. Under natural habitats, the trees are smaller and irregular trees possess short, sturdy, Nonspiny, or piercing-spiny branches.^[1]

The straight shaped spines are 3 cm in length when fully grown and originate from the leaves' axis tree's bark is flacking, bluish-grey, soft, and contains irregular furrows on the younger branches trees possess dimorphic twigs, regular twigs have 3–5 cm long internodes with a leaf at each node and one to two spines other type of twigs, the foliage spurs, are arising on the primary branches foliage spurs are shorter than usual twigs (1–3 cm) with copious diminutive internodes. In foliage spurs, each node has a leaf; however, the spine is absent. Further twigs produced on the first-year twigs have glabrous surfaces, whereas the new twigs produced in the second- and third-year twigs have striated surfaces prickles are generally absent on the stem, or if present, they are not persistent. suckers originate from the main bael trees when they grow up to a sufficient height and crown width. young suckers have the stout and sharpest spines to protect the suckers from the herbivores. Usually, gum-like sap is secreting out from the wounds. Initially, the sap secretions appear as long thick threads and later become dried up long solid crystals.^[1]

Crop Improvement

The studies on improving bael as a crop using agronomic and genetic approaches are limited. Some important mother plants or cultivars have been selected in India and Sri Lanka grafting is done to propagate the elite mother plants for cultivation. Besides the selected mother plants, no standard cultivar produced through breeding is available for large-scale cultivation of Bael breeding is not conducted for bael mainly because it is a long-generation species, and the plant's reproductive biology is not well understood. Cytogenetic studies have been conducted, and the ploidy level of A. Marmelos could be diploid or tetraploid with normal and remarkably high pollen fertility at each ploidy level.)e large fruits are often correlated with the tetraploid genomes phenological events such as leaf emergence and falling, flowering, and fruiting are the same for the wild and cultivated types. Exceedingly high open pollination is observed, and common pollination agents are insects and wind. Fruiting is enhanced by insect pollinators such as honeybees. However, propagation through seeds very much lacks as ants and fungi damage seeds. Therefore vegetative propagation through agamospermy, coppices, and root suckers are prominent. However, detailed studies on bael's reproductive biology are required under local conditions before implementing any crop improvement programs.^[1]

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Morphological Characterization

Bael Varieties/Accessions characterized different bael selections under the rainfed tropical semiarid western India environment, reported a higher degree of variation in vegetative, reproductive, yield, and phytochemical characters. Fourteen Bael genotypes were characterized in Bangladesh, and four varieties were identified as the superior genotypes. Although the morphological variations of bael have been observed in Sri Lanka, no systematic studies to characterize the entire germplasm within the country are available.

Genetic Characterization and DNA Fingerprinting.

Bayer has conducted a molecular phylogenetic study for the subfamily of bael, Aurantodeae of family Rutaceae, using chloroplast DNA sequences and identified Bael a monophyletic group.) e bael is located significantly distant to the Citrus clade, consisting mostly of the known Citrus species) is finding is in line with the inferences made by Swingle and Reece where bael was considered as the bael-fruit group. However, the samples studied by then were taken from ex situ germplasm collections, and it seems that they do not contain samples from Sri Lanka. Pathirana et al.^[8] have estimated that A. marmelos is evolutionary related to African genus Afraaegle arguing that the genus Aegle would have been evolved in Africa and later disseminated to South Asia. Large-scale genetic characterization using DNA markers is remote for bael. Furthermore, the National Center for Biotechnology Information (NCBI) nucleotide sequence citations for A. marmelos are only 253 by the year 2020 true-to-typeness of the tissue-cultured bael plants was confirmed by using randomly amplified polymorphic DNA (RAPD) marker, OPA2, and Inter-simple sequence repeat (ISSR) marker, MP2-based DNA fingerprinting.^[16] Nayak et al.^[17] used RAPD markers for genetic diversity assessment of a selected set of Bael germplasm and which is the only study published on molecular characterization of bael germplasm. As RAPD markers are not very robust in assessing genetic diversity, they are not currently used in molecular diversity studies. Therefore, detailed molecular diversity assessment efforts are required using robust DNA markers such as microsatellite and SNP use of molecular marker-based DNA fingerprinting is crucial for bael germplasm to understand the domestication events, to determine the effective population sizes for conservation, to accurately tag the superior cultivars for large-scale clonal propagation, and to map genes and Quantitative Trait Loci (OTL).^[1]

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Figure No: Seedling Bael plant.^[6]

Table 1: Botanical Description of Aegle marmelos (L.).^[4]

Plant Part	Morphological characteristics
Bark	The bark grey or brownish in colour, and it bears a number of long, straight
	spines. It includes gums, which form from wounded branches and harden
	over time. The easiest way to describe these gums is as a transparent, sticky
	sap. It tastes good at first, but it quickly gets irritating to the throat.
	Alkaloids, Fagarine, Marmin, Furoquinoline
Leaf	Skimmianine, Aeglin, Rutin, -sitosterole, -sitosterol, Flavone, Lupeol,
	Cineol, Citral, Glycoside, O-isopentenyl, Hallordiol, Mameline, Citronellal,
	Cuuminaldehyde phenylethyle cinnamamides, Euginol
Fruit	Psoralen, Marmelide, Tannin, Phenol, Marmelosin, Luvangetin, Aurapten,
	Tannin, Phenol, Tannin, Tannin, Tannin, Tannin, Tannin, Tannin, Tannin.
Seed	D-limonene, A-D-phellandrene, Cineol, Citronellal, Citral, P-cyrnene, Cumin
	aldehyde are essential oils.
Root	Terpines, Halopine, Coumarins, and Alkaloid



Figure No Bael Fruit.^[7]



Figure No: Bael leaves.^[8]

Ayurvedic View

A.Marmelos plant is acknowledged as the most significant plant in the Ayurvedic medicinal system. It balances the Kapha (water and earth component) and Vata (space and air component) dosha. The fruit of this plant is medicinally used in the Ayurvedic, Siddha and Unani medicinal system and is considered an excellent remedy for diarrhea. The medicinal properties of the plant are briefly described in Charaka Samhita. All the parts of the plant i.e. trunk, leaf, seed and fruit are used to treat various types of diseases. The leaves of the plant carry expectorant, astringent and febrifuge properties that help in treating bleeding disorders, edema, hemorrhoids and bowel complaints. In Ayurveda, the roots of the plant are commonly used as an important ingredient in the Ayurvedic drug named 'Dashamoola' which is used to cure dysentery, colitis, diarrhea, flatulence, loss of appetite and fever since ancient times. The fruits of the plant are used in making Chyavanprash. The unripe fruit in Ayurveda is used as a tonic for the heart and brain and is used to treat chronic diarrhea and dysentery. The tree barks and roots of the plant relieve urinary problems and palpitation of the heart. The juice of A. marmelos helps in improving digestion, scurvy and strengthens stomach actions. In Ayurveda, the plant is used to cure indigestion, intermittent fever, typhoid, cholera, heart palpitation, heart, stomach and intestinal disorders because of the presence of carminative and digestive properties. The unripe fruit is associated with more medicinal value as compared to ripe fruit. The leaves, fruits and bark of this plant have been reported to have Anti-diabetic property.^[3]

Actions and Properties of A. marmelos plant

Kapha vata shamaka: It balances the Kapha and Vata dosha. Shothahara: The leaves of the plant are used to cure edema. Vedanasthapan: The plant is associated with analgesic property which helps in reducing pain. Naaditantu: The roots of the plants are used to treat neurological disorders. Deepan: The unripe fruit of the plant acts as an appetizer. Krimighna: The plant is associated with an anti-helminthic property. Mridurechan: The ripe fruit of the plant acts as a mild laxative. Yakritdutejak: The leaf decoction of the plant helps in enhancing metabolism. Pittasarak: It stimulates the digestive juices. Hridya: It is used as a cardio-protective agent. Raktastambhak: It is used to cure the bleeding disorder.

Mutra: It is used to treat the micturition problem.

Garbhashaya shotha: It improves uterine health.
Jwarghna: It helps in treating chronic disorders and acts as an antipyretic agent.
Andria: It helps in treating insomnia.
Atisaar and Pravahika: It is used to treat diarrhea and dysentery disorders.
Grahni: It is used to cure irritable bowel syndrome (IBS).
Udarshool: It helps in relieving abdominal pain.
Vibandh: The ripe fruit of the plant helps in curing constipation.

Netrabhishyand: The leaf decoction or leaf paste helps to cure Cataract disease.^[3]

Modern View

In the modern world, people are taking more interest in herbal medicines because of their lesser side effects, easy availability and cheaper prices. The consumption of herbal medicines has increased world widely. Reported studies have revealed an increased growth in the sale of herbal products from the year 2000 to 2008 that is reached from 3% to 12% per year. With the increasing demand of the people, adulteration and substitution also rise in the herbal drug industry which is considered as a major threat to the quality and in the research areas on commercial natural products. The main reason for the adulteration is the non-availability of the original plant product, deforestation, extinction of many herbal plant species, confusion in the species identification, etc. Also, many herbal dealers have developed new methods of high-quality adulteration that can only be identified by using chemical analysis and microscopic examination. The poor quality of the drug and lack of standardization are the two weaknesses that lay behind the acceptance of herbal products which results in the decreased market value of the product. So, there is a need to develop an Herbal Authentication System (HAS) which can serve as a regulator and helps in improving the Quality of herbal trade. The herbal plant named Aegle marmelos is associated with multiple medicinal properties. The destruction and over-exploitation of the plant have their historical concerns.^[3]

Antidiarrhoeal activity

The unripe fruit pulp of A. marmelos affected the bacterial colonization to gut epithelium and production and action of certain enterotoxins. These suggest the varied possible modes of action of A. marmelos in infectious forms of diarrhoea thereby validating its mention in the ancient Indian texts and continued use by local communities for the treatment of diarrhoeal diseases.^[2]

Antimicrobial and antiviral activity

Various extracts of A. marmelos leaves, roots and fruits have been reported to be active against many bacterial strains. There are several reports in the literature regarding the antimicrobial activity of crude extracts prepared from plants. In 2009, Venkatesan et al. showed that aqueous and ethanolic extract has activity against E. coli, Pseudomonas aeruginosa, Staphylococcus aureus and Bacillus subtilis. The ethanolic extract showed considerably more activity than the aqueous extract. Maximum antibacterial activity was shown against Bacillus subtilis followed by Staphylococcus aureus, E. coli and Pseudomonas aeruginosa. Jyothi and Rao showed that hexane, cold methanol and hot methanol extracts have inhibited Klebsiella pneumoniae, Micrococcus luteus, Entercococcus faecalis and Streptococcus faecalis groth in vitro. They also found that these three extracts have no effect on E. coli and Proteus vulgaris.It seems that A. marmelos has antiviral activities in the early stages of viral replication with minimum host cytotoxicity in contrast to modern virucidal chemotherapeutic agents (that is ribavirin), which usually act in the later stages of viral replication and have potent side effect.^[2]

Anticancer activity

Preclinical studies have shown that A. marmelos leaf extracts were effective in inhibiting the growth of leukemic K562, T-lymphoid Jurkat, B-lymphoid Raji, erythroleukemic HEL, melanoma Colo38, and breast cancer cell lines MCF7 and MDA-MB-231. A. marmelos extracts may increase ERa gene expression in MDA-MB-231 (ER α -negative breast cancer cells) and inhibited cell proliferation. A. marmelos leaf extract is also shown to have antineoplastic effects on the Ehrlich ascites carcinoma in Swiss albino mice. ethanolic fruit extract has cytotoxic effect on SKBR3 cells in vitro. Experiments have shown that the phytochemicals such as lupeol, eugenol, citral, cineole and d-limonene present in A. marmelos possess antineoplastic effects.^[2]

Marketed Preparations

- Food- Using a beal fruit made a jam, beverages, toffee, Tamarind, sauce, muramba, syrup (sarbat).
- Fodder- Leaves and twigs use for fodder.
- Timber- It is use for cards and construction. It is a base utilize for small scale turnery, tools, knife handles, pestles and combs etc.

- Gum and resins- It is commonly use as glue using a bael fruit or seed mix with lime plaster for water proofing walls and added cement making a buildings wall.
- Tannin or Dyestuff- Tannin present in fruit and leaves to yield and yellow dye for calico and silk fibric.
- Essential oil- The leaves use as a essential oil for a hair oil.
- Poison The leaves are cause the abortion and sterility in women. The bark is use as the fish poison in the celebes, Leaf extract of bael important pest of rice plant in Asia.
- Medicine Using a unripe bael fruit with funnel and ginger in a hemorrhoids, it is maintaning of a normal skin colour. It is use in treatment of leukemia. Marmelos found in bael fruit for using laxative and diuretic. Bael fruit use in most of diarrhea and dysentery prevalent in India for a summer month.
- Other Product The bael fruit is use for a detergent action for washing the cloths. Flower is use as the perfume.^[5]

CONCLUSION

From the literature study, it is quite evident that A. marmelos plant is associated with great medicinal properties and is considered as the most significant medicinal herb. It is used in Ayurveda, Siddha and other medicinal systems to treat various types of diseases.^[3] This medicinal plant can be used to treat many diseases in humans, such as diabetes, liver toxicity, fungal infections, microbial infections, immunomodulators, antiproliferative, wound healing, and antifungal analgesic, anti-inflammatory, antipyretic, hypoglycaemic, antidyslipidemic. Further Research carried out investigate potential value and marketed product their therapeutic benefits.^[5]

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