

Pharmacological significance of Bael- *Aegle marmelos* L.

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Introduction

Traditional medicines have always been a backbone of the rural inhabitants of nations worldwide. Majority of global population heavily rely on it. Medicinal plants hold their treasure onto their secondary metabolites which are potential drug sources. These secondary metabolites are responsible for the pharmacological activities of the plants. *Aegle marmelos* (L.) belongs to family Rutaceae and it is also known as Bael, Bilva, Golden Apple, and Stone Apple. It is well known for its therapeutic activities and medicinal properties. It is a native tree of Southeast Asia and the Indian Subcontinent. This monotypic genus has one species i.e. *A. marmelos*. As a naturalized species, it can be found in Bangladesh, India, Sri Lanka, Nepal and Pakistan. It grows in hills and plains with elevations ranging from 0-1200 m. It can grow in a huge variety of soil conditions (range of pH 5-10), and with a mean yearly rainfall of 570-2000 mm. It can show an unusually wide temperature tolerance (-7 to 48°C). It is found in tropical or sub-tropical regions. It prefers hot and arid, open and deciduous forests. It is extensively explored for its medicinal properties.

Morphological Characteristics and Habit and Distribution of *A. marmelos*

A. marmelos is medium sized tree that possess open or irregular crown, with slightly drooping branches. The leaves are highly aromatic and trifoliate. Hard shelled fruits and deep taproot system is found in it. It is a drought tolerant tree. In India, it is well known for its ability to grow where other trees are unable to grow and can thrive in drought conditions.

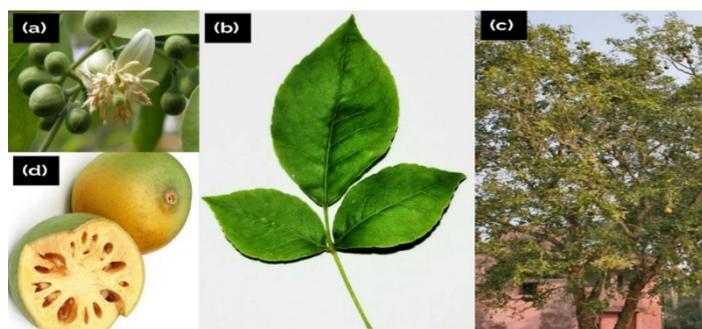


Figure 1. *Aegle marmelos* L., **a**; Flower, **b**; Leaves, **c**; Tree **d**; Fruit

Ethnomedicinal and religious significance- *Aegle marmelos* L. holds immense ethnomedicinal as well as cultural significance. Traditionally it is used for stomach-related ailments, to treat constipation, soothe stomachache, typhoid and jaundice, diabetes, BP, chronic diarrhoea, inflammation, acute bronchitis, cough, and asthma etc. A major part of *Aegle marmelos* is water, ranges from 60-65%, followed by carbohydrate, sugars, fibres, and other compositions includes vitamins, minerals, amino acids and various fatty acids (Gupta et al., 2018). As salad greens, the leaves and young shoots are consumed. Bael fruits are edible, and the pulp is used to make puddings, juices, and murabba, among other treats. The fruit pulp is used in various herbal

formulations. Bael tree is revered by Hindus and is utilized in ceremonial practices mainly on Mahashivratri. Both Buddhists and Hindus regard the tree as sacred.

Phytochemicals-Phytochemicals are crucial natural products with therapeutic and commercial benefits, contributing to plant defense, communication, and environmental adaptation, influencing crop yield and homeostasis (Islas, 2019). Various phytochemicals like aegelin, a-phellandrene, auroptene, marmelin, fagarine, anhydromarmelin, limonene, betulinic acid, marmesin, imperatorin, luvangentin, and marmelosin are among the phytoconstituents that have been reported to be present in *A. marmelos*. Contents of riboflavin and tannin are also present.

Product name	Category	Part used	Quantity of part used	Used for	Products available on platforms	Products developed by	Country of Origin
DR WAKDE'S Bilva Fruit Capsules	Food supplement	Fruit powder	470 mg of fruit powder per capsule	Supporting digestive health	Dr Wakde	DR WAKDE'S	United Kingdom
Merlion Naturals Bael Pulp Extract Tablets	Food supplement	Fruit powder	500 mg of fruit powder per tablet	Digestion, skin and hair nourishment	Merlion Naturals	Infinator Pvt Lmt	India
Yuvika Belgiri Powder	Food supplement	Fruit powder	Loose Fruit powder	Gastri-intestinal, stomach ailments	Tata 1mg	DKC Agroteck Pvt Lmt	India
Darshini Belgiri/ Bael Phal/Aegle Marmelos Powder	Food supplement	Fruit powder	Loose Fruit powder	Gastri-intestinal stomach ailments	Tata 1mg	Shree Surya Masale Udhog	India
Vyas belgiri churn	Food supplement	Fruit powder	Loose Fruit powder	Diarrhea, dysentery, anti-toxins	Tata 1mg	Vyas pharmaceuticals	India

Table: 2. Commercial products incorporating *A. marmelos* in the market

Pharmacological Significance

The plant possesses medicinal properties due to its rich therapeutic activities. Its therapeutic activities show a great range including antidiarrheal, antimicrobial and antiviral, anti-ulcer, antigenotoxic, anti-inflammatory, radioprotective, anticancer, chemo-preventive, antipyretic, Diuretic, antifertility activities. This vast range of activities advocates the medicinal claims of this plant, making it highly sought after medicinal plant for herbal remedies and Ayurvedic drug formulations.

Anticancer effect- According to preclinical research, leaf extracts of *A. marmelos*, effectively suppressed the development of various cancer cell lines. Research has demonstrated that the phytochemicals found in *A. marmelos*, including cineole, d-limonene, citral, eugenol, and lupeol, have anti-cancer properties. The growth of epithelial cancer cells (HCT-116 colon and HEP-2, alveolar epithelial carcinoma cells) is inhibited by

marmelin, which is present in *A. marmelos*. Other substances found in *A. marmelos*, such as citral and eugenol, have antiproliferative properties.

Antifertility action- It is known that *A. marmelos* fruit, leaves and seeds can have a reversible effect on male fertility. The bark extract of *A. marmelos* is a rich source of fagarine and marmin which are known to lower male fertility. It shows negative impact on reproductive organ weight and serum testosterone levels in a dose and duration dependent manner. It was also reported that sperm density, motility, viability, and acrosomal integrity had decreased.

Antigenotoxic activity- The antigenotoxic potential of *A. marmelos* fruit extracts was evaluated using the peripheral human blood lymphocyte (comet assay) and *E. coli* PQ37 (SOS chromotest). Induced SOS response in the SOS chromotest caused by aflatoxin B1 and hydrogen peroxide can be effectively reduced by methanol and acetone extract. Aflatoxin B1 was 70.48% and H₂O₂ was 84.65% less genotoxic when extracted with methanol.

Anti-inflammatory activity- *A. marmelos* leaf extract in various organic forms have strong acute and subacute anti-inflammatory properties.

Antimicrobial, Antiviral activity and Antidiarrhoeal activity- Antifungal activity against animal and human fungi such as *Trichophyton rubrum*, *Microsporiumgypseum*, *Microsporiumaudounii*, *Microsporium cookie*, *Epidermophyton fluccosum*, *Aspergillus niger*, *Aspergillus flavu s* (Kanimozhi & Rose 2023), and *Histoplasma capsulatum* has been demonstrated by the essential oil extracted from the leaves of *A. marmelos* tree. It has been reported that leaf, root, and fruit extracts are effective against many bacteria like *E.coli*, *staphylococcus aureus*, *Pseudomonas aeruginosa*, and *bacillus subtilis*. *A. marmelos* has antiviral activities in the early stages of viral replication with minimal host cytotoxicity. A study revealed that the chloroform extract was largely acting against the stains of vibrio cholera, *Shigella spp.* and *Escherichia coli* and was comparable to ciprofloxacin. Also, it was reduced by a methanol extract of *A. marmelos* fruits.

Antipyretic potential- In a dose dependent way, the ethanolic extract significantly (P<0.001) reduced elevated body temperature at 200mg and 400mg of mg/kg body weight which supports the antipyretic potential claim.

Radioprotective effects- The side effects of radiosensitivity in neighboring healthy cells, which are always subjected to the cytotoxic effects of ionizing radiation during treatment, make radiotherapy less effective in curing and palliating cancer. Utilizing radioprotective substances, which shield healthy tissues from radiation damage, is extremely helpful in this case. The main cause of radiation's negative effects is the production of free radicals, which is why *A. marmelos* antioxidant compounds are thought to be extremely helpful in preventing radiation exposure. In cultured human peripheral blood lymphocytes and mouse bone marrow cells, *A. marmelos* leaf extract decreased radiation-induced DNA damage, suggesting that *A. marmelos* is an effective anticlastogen.

Ulcer healing potential- In a study it was shown that rats ligated with pylorus showed a marked decrease in the volume of gastric juice, as well as in the free and total acids, and an increase in pH. In this study, *A. marmelos* fruit extract was prepared by enhancing its activity by complexing it with phospholipid. In the phospholipid complexes of *A. marmelos* fruit extract potential antioxidants and anti-inflammatory phytoconstituents were found.

Conclusion

A.marmelos shows great potential as a medicinal plant with its various therapeutic values and commercial importance. Various pharmacological claims suggest immense potential of *A.marmelos*. Although it is being used as a medicinal plant, the structured Bael- cultivation is still a rare phenomenon. Hence its harvesting from wild poses threat to the wild population of Bael tree. Given Bael's medicinal value and adaptability, there is significant potential for expansion with the collaboration of market linkage.

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