

A Brief Synopsis of the Extensive Therapeutic Potential of the Bael (*Aegle marmelos*): Introduction, Biochemical Composition, their Medicinal Usage and Plausible Underlying Mechanisms:

Sangeeta Sharma ¹ & Dr. Rupal Babel²

Research Scholar¹, Associate Professor & Head of Department²

MPUAT, Udaipur

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Introduction:

The bael tree is revered in several cultures. Sanskrit refers to it as Adhararutha; Tamil and Telugu call it Iyalbudi; Gujarati calls it Billi; English call its Bengal quince or stone apple; Hindi and Bengali call it Bel. It may turn out to be one of the most significant medicinal plants in India, Ceylon, and Burma. Its scientific name is *Aegle marmelos*. The Bael fruit is the narcotic that Indians have used for the longest time and value the most, according to Chopra's book Indigenous Drugs of India (1982). From ancient times, bael has been used in Ayurvedic formulations to treat a variety of ailments, including fever, cold, earaches, dysentery, boils, and discharge from the ears^{1,2}

Nutritious Value of Bael:

Nutrients	Percentage content (%)
Proteins	1.8
Fats	0.3
Minerals	1.7

Fibre	2.9
Carbohydrates	31.8
Calcium	0.085
Phosphorous	0.050
Potassium	0.60
Vitamin C	0.008

Phytochemical components of Bael and their possible therapeutic roles:

Bael's medicinal qualities stem from its unique phytochemical composition. The primary bioactive components of bael are triterpenoids as alkaloids, coumarins, flavonoids, and tannins. The following are a few of the important chemical components:

A) Aegeline, aegirine, marmeline, and mamelon are the principal alkaloids present in bael. Alkaloids are nitrogen-containing organic compounds that have medicinal properties.

B) Coumarins: Aesculetin, umbelliferone, and scopoletin are the three principal coumarins present in bael. The biological effects of coumarins, a class of phenolic compounds, are diverse and include anti-inflammatory, antiviral, and anti-cancer properties.

C) Flavonoids: compound rutin and kaempferol are a few of the flavonoids found in the bael. Flavonoids are polyphenolic compounds with anti-inflammatory, antibacterial, and anti-oxidant properties.

D) Tannins: ellagic acid, corilagin as, and gallic acid.

E) Triterpenoids: A substance called, botulinic acid, and oleanolic acid, are the three primary triterpenoids found in bael. Terpenoids are known to have anti-viral, anti-inflammatory, and anti-cancer effects.^{3,4}

Mechanisms underlying the therapeutic properties of constituents:

The health benefits of bael (*Aegle marmelos*) are due to its rich phytochemical composition, which influences many physiological modes of action in the body and brain. We shall discuss a few of these mechanisms here:

1. **Antioxidant Mechanisms:** Bael's phytochemicals, particularly flavonoids and tannins, may dissolve metal ions involved in oxidative stress and scavenge free radicals like reactive oxygen species (ROS). Bael can prevent damage to biological structures like lipids, proteins, and DNA by neutralizing Reactive and reducing oxidative stress. Bael's anti-oxidant characteristics help to prevent oxidative stress-related chronic diseases such as cancer, diabetes, and cardiovascular disease.
2. **Anti-inflammatory Mechanisms:** Bael's alkaloids, coumarins, and triterpenoids can modulate the production of inflammatory substances such as tumor necrosis factor-alpha (TNF-) and interleukin-6 (IL-6), as well as suppress the activity of inflammatory enzymes such as cyclooxygenase-2 (COX-2) and inducible nitric oxide synthase (nitric oxide). These anti-inflammatory properties can reduce the symptoms of long-term inflammatory conditions such as inflammatory bowel disease, asthma, and arthritis.
3. **Anti-diabetic Mechanisms:** It has been shown that alkaloids derived from Bael, such as Aegeline, improve insulin sensitivity, promote cell uptake of glucose, and alter the metabolism of carbohydrates. Bael's anti-inflammatory and antioxidant properties can also reduce inflammation and oxidative stress associated with diabetes. These connected effects provide Bael with its anti-diabetic properties.
4. **Anti-microbial Mechanisms:** Bael's phytochemicals, especially its tannins and flavonoids, can damage the cell membrane integrity of bacteria, fungi, and viruses, preventing their growth

and multiplication. The ability of Bael to inhibit bacteria may help cure and prevent infections caused by a range of pathogens, including *Escherichia coli*, *Staphylococcus aureus*, and *Candida albicans*.

5. Gastroprotective Mechanisms: Bael has gastroprotective effects because of its anti-inflammatory, antioxidant, and antibacterial properties, which help to soothe and mend the gastrointestinal system. Bael may also increase the production of mucus, which can protect the inside of the stomach by forming a barrier and reducing the likelihood of ulcers and damage from irritants like stress and non-steroidal anti-inflammatory drugs (non-steroidal anti)^{1,5,6}

Therapeutic attributes of Bael:

Bael is known to possess a variety of qualities that can be useful in treating a wide range of diseases. Some key medicinal properties are as under:

- It may act as an antidiarrhea agent: Most ancient Indian scriptures have recognized the potential use of Bael's root extract and unripe fruit pulp in treating diarrhoea. This might be a result of its possible ability to combat different bacteria that cause stomach illnesses.
- It might have anticancer potential: Bael treatment showed the ability to impede tumor growth in one of the research projects. While the exact mechanism is still unknown, the alcoholic extract of Bael may be able to inhibit the growth of cancer cells. A bioactive component found in Bael leaf extract may have the ability to inhibit the growth of breast cancer cells.
- It may have anti-ulcer properties: Bael may have protective benefits on the stomach. Oxidative stress, or the buildup of free radicals in the stomach cells, is the primary cause of stomach ulcers. Bael has the potential to be an antioxidant, which could help prevent oxidative stress in the stomach lining and the development of ulcers. Furthermore, the harm to the stomach lining caused by 100% ethanol (alcohol) in the stomach may be mitigated by the unripe Bael fruit.
- It may act as an anti-inflammatory agent: Bael extracts may be able to lessen temperature, discomfort, and edema. The activation of the histamine receptor, which is



in charge of inflammation and the majority of allergy and asthma symptoms, may be inhibited by the alcoholic extract of Bael leaves.^{7,8}

Other therapeutic values of Bael:

- It may be an antimicrobial (effectively kills various microorganisms)
- It may have radioprotective potential (protects the body from the harmful effects of radiation)
- It may be antigenotoxic (prevents damage to DNA)
- It may be a diuretic (increases urine output)
- It may act as an antipyretic (fever-reducing) agent
- It was observed that Bael might even lower thyroid hormone levels.
- Bael seeds may aid in the destruction of the parasite that causes malaria.^{9,10}