

INCREDIBLY VIVACIOUS *AEGLE MARMELLOS* L. CORR. (GOLDEN APPLE) AND ITS COMPREHENSIVE THERAPEUTIC BENEFITS: AN EYE-CATCHING REVIEW

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ABSTRACT

Medicinal plants are used in herbalism. They form the easily available source for healthcare purposes in rural and tribal areas. Several parts of *A. marmelos* have been reported as various traditional healers for treating various ailments of mankind. These contains Antioxidant, Antibacterial, Antifungal, Antidiarrheal, Antidiabetic, Antiproliferative, Cytoprotective, Hepatoprotective, Antifertility, Analgesic, Antiarthritis, Contractile, Antihyperlipidemic, Cardioprotective, Radioprotective, Anticancer, Antiviral, Anti-ulcer, Immunomodulatory and Wound Healing properties. A number of biologically active compounds isolated from various parts of *A. marmelos* which Baelongs to various chemical groups. The isolated components Baelong to Alkaloids, Terpenoids, Vitamins, Coumarins, Tannins, Carbohydrates, Flavonoids, Fatty Acids, Essential Oils and some other miscellaneous compounds. This review mainly focused on several phytochemical and pharmacological studies which have explained phytoconstituents and therapeutic potential of *A. marmelos*.

KEYWORDS: Phytochemistry, Pharmacological properties, Therapeutic potential, Ehnomedicinal uses.

INTRODUCTION

Aegle marmelos (L.) Correa (*A. marmelos*), commonly known as Bael Baelonging to the family Rutaceae, has been widely used in indigenous systems of Indian medicine due to its various medicinal properties. *A. marmelos* is native to Northern India, but widely found throughout the Indian Peninsula and in Ceylon, Burma, Bangladesh, Thailand and Indo-China. Bael is a sacred tree native to India and has great aesthetic value among Hindus as tree is worshiped in rituals by masses.

The plant is also known by different names as stone apple or wood apple, bili, bilva patra, Bengal quince or golden apple. The plant is mentioned as Tripatra in ancient Indian scriptures such as Yajurveda and Mahabharata. Its leaves are ternate and scented named as tripatras and are used in enchantments. The plant is also figured in Aranyakas and Hindu Sahintas. This plant is as old as Hindu civilization and has great aesthetic, cultural, and medicinal value. Bael fruit looks like a skull with a white, bone-like outer shell and a soft inner part that is why it is called as Seer Phael (head-fruit) or most likely Seer Phal. Sanskrit literary books and in ritualistic literature, it is mentioned as "ShreePhal." Bael tree is grown in gardens mainly near to the Shiva temples for worshiping of Lord Shiva. Devotees offer scented leaves

and fruits to Lord Shiva. Bael tree (Fig. 1) is also called Shivadurme because it is Baelieved that tree signifies the presence of Lord Shiva or Kailashnath.



Fig. 1: Bael Tree (*Aegle marmelos* L. Corr.).

In the traditional Newari culture of Nepal, Shivadurme is worshiped by young girls in fertility rituals and by a married woman to seek longevity of their husband. Both leaves and fruits are of great religious importance since the tree is regarded as one of the sacred trees of Indian heritage. Bael is a sacred tree having sacrificial importance. The plant is straight, strong, having an axillary spine. It is common belief that planting of this tree by the waysides gives long life.



Fig. 3: Bael Fruit (Unripe & Ripe).

It is incumbent upon all Hindus to cultivate and cherish this tree, and it is sacrilege to cut it down. Bael flowers are scented, and perfume is distilled from the flowers. Oil is limonene-rich and used for scenting hair. Bael fruit (Fig. 3) is used in the treatment of scum in vinegar manufacture. Bael tree wood is light, durable, and is used for small-scale turnery, tool and knife handle, pestles, and combs making. Shell of hard fruits fashioned into pill and snuff boxes. Aegle seeds are a good source of gum that is used as household glue and adhesive by jewellers. Fruit pulp shows detergent action and is used as a soap substitute for washing clothes. It is also used for construction as water-proofing walls-mixed with lime plaster and added to the cement. It is also used in watercolors or as protective coating for paintings. Bael fruit pulp contains 9% tannin that is used for tanning. Pulp yields a yellow dye for calico and silk fabrics From

demographic and social studies, it is well-recognized plant whose various parts such as fruit, root, bark, leaves as well as flowers of Bael tree have a high ethnomedicinal use. Due to its dense distribution in most of the states of India, local people use Bael fruits and leaves for wound healing, for curing digestive disorders, ulcers, headache, hypertension, diabetes, and numerous other ailments. The ripe fruit is used as a laxative but is not digested easily. Aqueous extract of unripe Bael fruit promotes digestion and cures diarrhea. Bael fruit is recognized by different name by local people. More popular name prevalent among Newari, Tharu, and Gond is wood apple, Bael, elephant apple, and monkey fruit. The name is given because of liking of fruit by the animals. The fruit is eaten fresh or dried by the local people as a nutritive substitute and treats gastro-ulcerative problem. This review emphasis on recent scientific evidences on nutrition and bioactive profile of *A. marmelos*, health benefits along with clinical and nonclinical trials of various phytoconstituents and *A. marmelos* potential in food processing industry for various food products. Our study suggests that this plant does indeed have pharmacological properties of interest, however, further extensive research is needed to establish a potential strategy that can balance the pharmacological and toxic effects of bael.

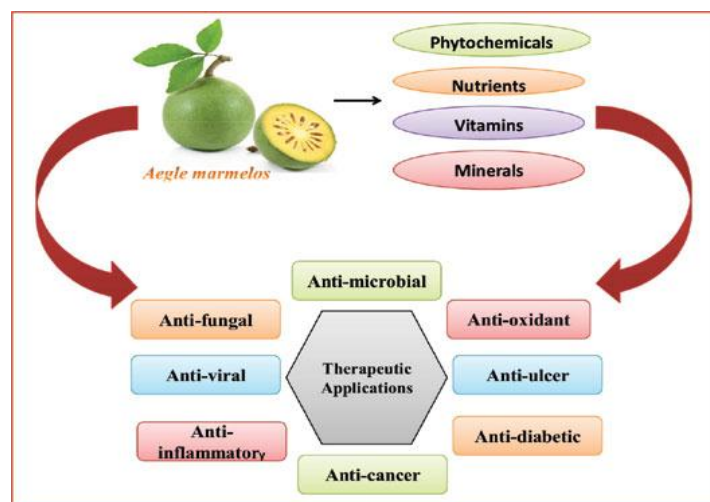


Fig. 4: Pictorial Representation of Pharmacological Properties of Bael.

Phytochemistry of *A. Marmelos* and Therapeutic Applications

This plant is gaining popularity because of its nutrient-rich fruits and immense traditional medicinal usage and pharmacological properties (Fig. 4). The health promotive and protective effect of bael fruit is accounted by fibers, carotenoids, phenolics, terpenoids, coumarins, flavonoids, and alkaloids. The curative relevance of these compounds has been assessed by various *in vivo* and *in vitro* studies. Fruit shows numerous possible health benefits, namely, radio-protective effects, peroxidation, antibacterial, inhibition of lipid, antidiarrheal, gastroprotective,

antiviral, antidiabetic, anti-ulcerative colitis, cardioprotective, free-radical scavenging (antioxidant) and hepatoprotective effects. *A. marmelos* has been reported to contain several phytoconstituents mainly marmenol, marmin, marmelosin, marmelide, psoralen, alloimperatorin, rutaretin, scopoletin, aegelin, marmelin, fagarine, anhydromarmelin, limonene, β -phellandrene, betulinic acid, marmesin, imperatorin, marmelosin, luvangentin and auroptene. Seed oil composed of palmitic, stearic, oleic, linoleic and linolenic acid. Apart from these, seed oil has been found to contain 12.5% of an unusual fatty acid, ricinoleic acid along with other normal fatty acids. Bael.

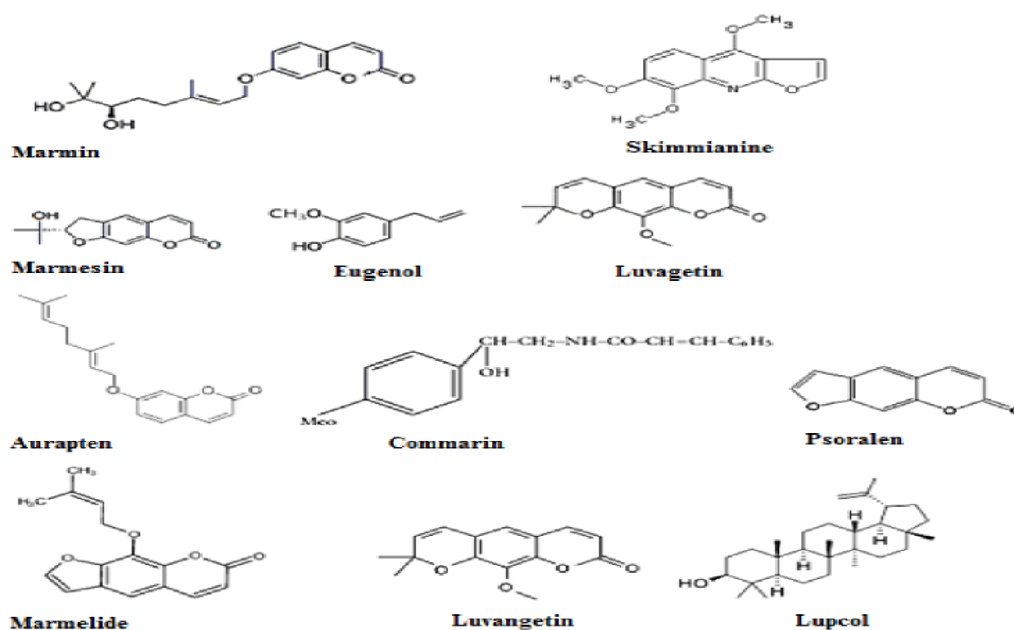


Fig. 5: Structure of Some Bioactive Components Isolated From Various Parts of the Bael Tree.

The health benefits of bael are not only limited to edible portion (fruit), but it also extends to nonedible portion (root, trunk, bark, leaf, flower and seed) having comparable biologically active compounds. Increasing awareness about the role of diet among health-conscious consumers for human well-being has increased the interest in functional foods thereby exploration of the functional attributes of various underutilized plants is being reaffirmed and various sources are emerged out as suitable food material for processing industry. The various scientific reports collected from different bibliometric sources suggested that *A. marmelos* and its bioactive constituents could play a vital role in the prevention of several chronic and degenerative diseases associated with oxidation stress.

Bael is a holy native tree of India, which has high ethnomedicinal, therapeutic, and pharmaceutical importance. Bael contains many diverse bioactive components (Fig. 5) in leaves, flowers, fruits, wood, root, and bark which show multiple biological activity and high therapeutic importance. Plant contains coumarins, marmelosin, marmesin, imperatorin, marmin, alloimperatorin, methyl ether, xanthoxol, scoparone, scopoletin, Baelliferone, psoralen and marmelide and marmenol, aegelin, aegelenine, marmeline, dictamine, fragrine which show anticancer, antioxidant, antimicrobial, anti-plasmodial, and hepatoprotective activities. Plant possesses various polysaccharides such as galactose, arabinose, uronic acid, and L-rhamnose. Its seed oil contains palmitic, stearic, oleic, linoleic, and linolenic acids which possess very high nutritive value. Plant also possesses very high tannin contents (9%) in fruits, pulp leaves. Tannin found in leaves as skimmianine. Marmelosin, skimmianine, and umbelliferone are therapeutically important active principles.

Aegle marmelos is also a good source of gum, wound healers, carotenoids, vitamins, sugars, and nutritive oils. The plant is used to cure digestive disorders, ulcers, headache, hypertension, diabetes, constipation, and numerous other ailments. The ripe fruits are used as a laxative, while unripe Bael fruit, promotes digestion, and cures diarrhea. *A. marmelos* contains plant essential oil which shows chemotypic and seasonal variations. *A. marmelos* fruits are also used in the treatment of chronic diarrhea, dysentery, and peptic ulcers, as a laxative and to recuperate from respiratory affections in various folk medicines. Scientific studies have validated many of the ethnomedicinal uses and reports indicate that the fruit possesses broad range of therapeutic effects that includes free radical scavenging, antioxidant, inhibition of lipid peroxidation, antibacterial, antiviral, anti-diarrheal, gastroprotective, anti-ulcerative colitis, hepatoprotective, anti-diabetic, cardioprotective and radioprotective effects.

For the first time, this review critically assesses the nutritional values, phytochemistry and preclinical pharmacological properties of the bael fruit. Attempts are also made at emphasizing the dietary and pharmaceutical potential of bael fruit that has been largely underutilized and neglected. Bael plant is a rich source of proteins, carbohydrates, vitamins, and minerals. The plant contains important vitamins such as carotene, thiamin, riboflavin, and niacin and minerals, Viz. Ca, Fe, P. Plant shows a vast array of health benefits due to the presence of both macro and micronutrients such as vitamins, organic compounds including tannins, alkaloids, polyphenols, terpenes, fiber, protein, and oil. Bael pulp is a rich source vitamin C (ascorbic acid 66 mg/100 g). The fruit pulp of wild Bael plant also possesses very high tannin contents (9%).

Culinary and Traditional Uses

Bael fruits are of dietary use and the fruit pulp is used to prepare delicacies like Jam (Fig. 6), puddings and juice (Fig. 6). The raw Bael fruit is sour to taste and is used to make chutney while the leaves of the Bael fruit are used as salad ingredients.



Fig. 6: Sun-dried hardy (leathery) Slice.

Fresh juice of leaves or flowers reduces the appetite while an infusion of the flowers mixed with sugar and milk is used as a cooling drink. Milk and sugar added to fruit juice make it more palatable. The pulp of this fruit is used for making squash, nectar, jellies, marmalades, and candies. Fresh ripen fruit pulp is used to make a cold drink and squashes or juice that is strained and sweetened to make a drink similar to lemonade. Fruit juice cleans and tones up the intestine and assists in the evacuation of even the old accumulated fecal matter from the bowels. The ripe fruits are edible; its yellow pulp is solubilised in water, sugar, and lime juice to make squash to beat heat stress in hot summer. It is most preferred refreshing drink used in UP, Bihar, MP, Rajasthan, Odisha, and WB. For soft drink preparations, fruit is sliced, and sun-dried, and hard leathery slices (Fig. 6) are then immersed in water. Green fresh leaves and small shoots are eaten as salads while unripe fruits are eaten after roasting. The pulp can be eaten raw, but it is popularly scooped out and frozen, or made into jam (Fig. 7). The seed powder is mixed with coconut milk for making a delicious, healthy beverage, or frozen into ice cream. The fruit pulp is blended with 30% sugar, and dehydrated powder is used for the preparation of soft squash (Fig. 8).



Fig. 7: Jam & Juice Prepared from Bael.

Bael fruit is used for the preparation of toffee by combining the pulp with sugar, glucose, skim milk powder, and hydrogenated fat. Bael fruit processing is highly promising, and many more nutritive biproducts are made for safe dietary use. The young leaves and shoots are used as a vegetable in Thailand and as seasonal food in Indonesia. A concoction of Bael leaves is used in the treatment of acute shigellosis. Soup prepared from green leaves, and fruit pulp is used as diuretic, benefits in gonorrhoea and conjunctivitis.

The leaf and Baelgiri powder are used as stomachic and treatment of irritable IBS (bowel syndrome). Similarly Bael fruit pulp mixed with jaggery (Fig. 9) if used once daily for 2-3 months heals constipation and indigestion. It also cures mouth ulcers. Dried slices of an unripe Bael fruit if taken with water dealing with acute or chronic diarrhea. A concoction of dried leaves in hot water reduces chronic, cough, sore throat, and hypertension. The leaf juice is mixed in warm water with a little pepper and is used to cure cold and sneezing. Applying a paste prepared from powdered root and butter on soles is an effective Bael home remedy for inducing sleep.



Fig. 8: Soft squash (Fruit Pulp blended with 30% Sugar & Dehydrated Powder).

Besides, the rind of Bael fruit benefits in reducing dandruff. The fruits are used as astringent, stomachic, and also in the treatment of diarrhea and dysentery. The mucilaginous substance of the fruits is used as gum and also used in making varnish. A yellow dye is obtained from the rind of the fruit. Bael is used to control hemorrhoids as the dose involves the intake of a combination of dried and powdered Bael leaves, dried ginger, carom seeds, and black pepper mixed in a glass of buttermilk or lukewarm water. Dried Bael leaves and pulp are used to restore appetite and eliminate helminths.

Dried pulp is used in relieving spasms and to treat irritable bowel syndrome. Hot leaf extract acts as an expectorant. Consuming about 20 ml juice extracted from Bael leaves is valuable in managing diabetes and reducing excess urination. Similarly, a combination of ripe Bael fruit pulp, sugar, and honey regularly after dinner can cure early stage tuberculosis if taken for 40

days regularly. Bael leaves assist in reducing excessive menstruation and is a natural treatment of jaundice. A green tea of Bael leaves provides quick relief in chronic or recurring colds and related respiratory conditions. Bael fruit pulp mixed with jaggery.



Fig. 9: Bael fruit pulp mixed with jaggery.

Roasted Bael leaves are used to cure asthma and relieve cough and cold. They also help in curing sore throat and treating chronic cough due to its function as an expectorant. Similarly, rind of Bael fruit mixed in coconut oil treat dandruff naturally. Bael leaves are used in healing stomach and mouth ulcers. Bael leaves soaked in a cup of water overnight and drinking this solution early in the morning for a few weeks improve in constipation. This mixture if intake along with 3-4 black peppercorns and drink a cup of warm milk afterward treat nausea, vomiting, and headache during summers. The extract of leaves is beneficial in the treatment of leucorrhea, conjunctivitis, and deafness. Juice of Bael flowers mixed with holy basil leaves is used to treat malaria. Regular consumption of fruit pulp is recommended for treatment of kidney complaints. Plant leaves and fruit pulp possess detoxifying powers and remove off xenobiotics from the kidney and liver or catabolize to non-toxic compounds and maintain its healthy levels.

The root urka of Bael tree is used to treat ear pain. It is also used to loosen phlegm and helps eliminate the buildup in the respiratory system. Bael plant shows radio-protective effects as both leaves and fruit are used to reduce the side effects of radiotherapy. The unripe Bael fruit, root, leaf, and branch are used to make medicine. Fruit provides freshness and energy. This is the best laxative that is used to relieve constipation and diarrhea. Daily consumption of Bael fruit provides relief from indigestion, peptic ulcer, piles, respiratory problems, diarrhea, and dysentery. In Ayurveda, the plant is used in the treatment of digestive disorders, wound healing, and to cure snakebites. Medicated oil prepared from leaves gives relief from recurrent cold and respiratory infections. In South India, juice of leaves is provided to bring relief from wheezing cough and respiratory spasm.

Essential oil obtained from Bael leaves show strong antimicrobial activity against a number of pathogens. It is prescribed for a smooth bowel movement to patients suffering from constipation and other gastrointestinal problems. Unripe Bael fruit is used for combating giardia and rotavirus, and to inhibit adherence and invasion of the bacteria on the gut wall (i.e., the ability to infect the gut). Leaves are used to lower high blood pressure and inflammation. Bael leaves also provide relief from menstrual problems. Bael also provides relief from cough, cold, asthma, bronchitis and influenza.

A. marmelos (L.) Correa (Rutaceae) leaves show hypoglycemic, radioprotective, antidiarrheal, and hepatoprotective potential. But overeating of Bael fruit high doses over a period time causes bloating, flatulence, and stomach problems. Bael leaves are rich in tannins, which help to treat diarrhea, but excessive consumption of Bael home remedies prepared from Bael leaves may give rise to carcinogenic effects. Similarly, excessive consumption of leaves is quite harmful to pregnant breastfeeding mothers. Bael is used as carminative, anti-venom, astringent, and used in thyroid-related disorders. It is also used as a cardiac stimulant, and to treat anemia, fractures, swollen joints, pregnancy troubles, typhoid, coma, colitis, bleeding sores, and cramps. It also boosts the immune system and shows antibacterial and antiviral activity. The physiological dosage of Bael pulp reduces inflammation, suppresses cancer, and increases milk production for nursing mothers.

The aqueous extract prepared by boiling the bark, leaves or roots is useful as a laxative, febrifuge, and expectorant. The extract is also useful in ophthalmia, deafness, inflammations, catarrh, diabetes, and asthmatic complaints. The fruits are used in treating diarrhea, dysentery, stomach ache, and cardiac ailments. Bael possesses diverse biological activities such as antimicrobial, hypoglycemic, astringent, antidiarrheal, anti-dysenteric, demulcent, analgesic, anti-inflammatory, antipyretic, woundhealing, insecticidal, and gastro-protective properties. Bael leaves are used to cure diabetes, increases ocular health, and help to prevent various sexual dysfunctions. Bael leaves are used to treat fevers, abdomen pain, and palpitation of the heart, urinary troubles, melancholia, anorexia, dyspepsia, diabetes, and diarrhea in Indian traditional systems of medicine.

CONCLUSION

Bael contains diverse bioactive components in leaves, flowers, fruits, wood, root, and bark which show multiple biological activity and high therapeutic importance. Plant contains coumarins, marmelosin, marmesin, imperatorin, marmin, alloimperatorin, methyl ether, xanthotoxol, scoparone, scopoletin, umbelliferone, psoralen, and marmelide and marmenol, aegelin, aegelenine, marmeline, dictamine, fragrine which show different biological activities such as anticancer, antioxidant, antimicrobial, anti-plasmodial,

and hepatoprotective. The plant possesses various polysaccharides such as galactose, arabinose, uronic acid, and L-rhamnose and seed oil that contains palmitic, stearic, oleic, linoleic, and linolenic acids which have very nutritive value. Plant leaves contain skimmianine, marmelosin, carotenoids, and umbelliferone which are therapeutically important active principles of Bael plant. A. marmelos plant leaves contain an essential oil that shows chemotypic and seasonal variations. Bael fruit restores digestive health and destroy worms in the intestine. It is a good remedy for digestive disorders and recommended for chronic dysentery. Plant unripe fruits are used for the treatment of diarrhea, dysentery, fever, diabetes, and to cure peptic ulcer or piles. Aqueous extract of ripen Bael fruit shows the laxative property. It is used to avoid constipation, discomfort, provide relieve from pain, and other associated health risks. Its leaves are used to reduce inflammation, appetite and water thrust. Dried flower, root, leaf extracts showed anti-inflammatory, anti-spermatogenic activity, improve and protect tissue antioxidant defense system.

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