

A review on Bael tree

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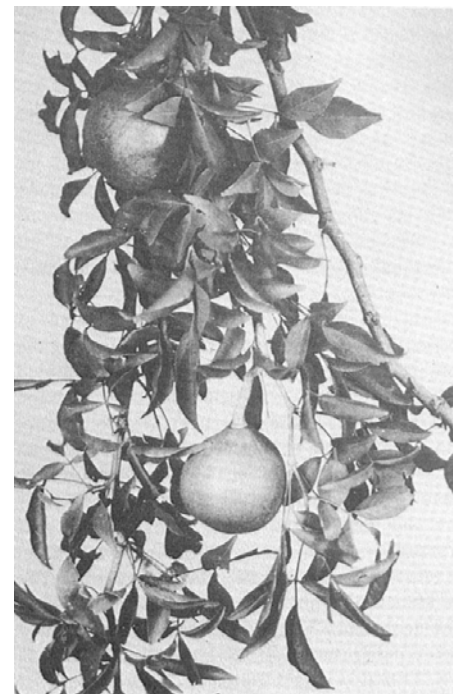
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Abstract

Bael, *Aegle marmelos* (Linn.) Correa ex Roxb., a tree of Indian origin is known from pre-historic time. It has a great mythological significance for Hindus. Utilization of bael in day-to-day life has great nutritional, environmental as well as commercial importance. It has been in use from time immemorial in traditional systems of medicine for relieving constipation, diarrhoea, dysentery, peptic ulcer and respiratory infections. Important medicinal properties of bael are antidiabetic, antimicrobial, anti-inflammatory, antipyretic, analgesic, cardioprotective, antispermatogenic, anticancer and radioprotective. The present review deals with general and chemical profile and its economic importance including medicinal and other uses.

Keywords: Bael, *Aegle marmelos*, Medicinal plant.

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Aegle marmelos fruiting branch

Introduction

World Health Organization has listed over 21000 plant species used around the world for medicinal purposes. In India, about 2500 plant species belonging to more than 1000 genera are being used in indigenous system of medicine¹. In terms of both quantity and value of the medicinal plants exported, India ranks second in the world². India is one of the 12 mega biodiversity centers of the world with 16 agro-climatic zones^{3,4} and has about 45000 plant species of which 15000 species are of flowering plants having about 7000 species identified as medicinal plants⁵. There are about 400 families in the world of the flowering plants, of which at least 315 are represented by India⁴. Despite of our rich heritage and knowledge of the use of plant drugs, little attention has been paid to harness the inexpensive remedies to modern requirements³. Only 40 plant species are currently used by the

pharmaceutical industries (29 indigenous species and 11 exotic). Similarly, aroma chemical industries are currently using only 42 plant species from a diverse genetic base of more than 1300 plant species known for their aromatic properties. Among these 42 plant species, 20 are indigenous and rest being of exotic introduction⁶. Tandon and Thayil stated that India's medicinal heritage; one of the world's oldest living traditions has been in danger of sliding down towards extinction⁷. Bael, *Aegle marmelos* (Linn.) Correa ex Roxb., a plant of Indian origin having tremendous therapeutic potential is not fully utilized. It belongs to family Rutaceae, the family of citrus fruits. It is known with different names in different languages⁸⁻¹². *Bel*, *Beli*, *Belgiri* (Hindi); *Bilva*, *Shivadruma*, *Shivaphala*, *Vilva* (Sanskrit); Bael, Bengal quince, Golden apple (English); *Bel*, *Bel Kham* (Urdu); *Bel* (Assamese and Marathi); *Bilivaphal* (Gujrati);

Marredy (Malyalam); *Belo* (Oriya); *Vilvama*, *Vilva marum* (Tamil); and *Bilva*, *Bilva pandu* (Telugu).

Bael is known in India from pre-historic time¹³ and has been mentioned in the ancient system of medicine. It has a great mythological significance also. Every part of plant such as fruit, seed, bark, leaf and root are important ingredients of several traditional formulations. Due to its curative properties, it is one of the most useful medicinal plants of India. It is utilized in day-to-day life in various forms. The products obtained from bael, being highly

nutritive and therapeutic are getting popularized in Indian as well as in international market. In India, there is a large area, which is waste land and remains unproductive which can be exploited with bael cultivation. It can be cultivated commercially on waste land and unproductive land for the upliftment of farmers¹⁴.

Bael plant acts as a 'Sink' for chemical pollutants as it absorbs poisonous gases from atmosphere and make them inert or neutral. It is a member of plant species group known as 'Climate Purifiers', which emit greater percentage of oxygen in sunlight as compared to other plants. The tree is also considered under the category of 'Fragrant' species, whose flowers and volatile vapours neutralize bad smell of perferified organic matter or decaying refuge and thus save human life from bacterial attack by making them inert and deodorizing the bad odour of the air¹⁵.

The present review deals with general and chemical profile of the tree and its economic value including medicinal and other uses.

Origin and Distribution

The Bael tree has its origin from Eastern Ghats and Central India. It is indigenous to Indian subcontinent and mainly found in tropical and subtropical regions. The tree is also found as a wild tree, in lower ranges of Himalayas up to an elevation of 500 meters. Bael is found growing along foothills of Himalayas, Uttar Pradesh, Bihar, Chattisgarh, Uttaranchal, Jharkhand, Madhya Pradesh, The Deccan Plateau and along the East Coast^{8, 12}.

Hiuen Tsiang, the Chinese Buddhist pilgrim who came to India in

1629 A.D. noticed the presence of this tree along with other trees in this region¹⁶. It is also grown in some Egyptian gardens in Surinam and Trinidad. Specimens of Bael have been procured and maintained in Citrus Collection in Florida¹⁷. Bael fruit has been used traditionally in making paints in Burma¹⁸. In Bangladesh, the tree has been used for fertility control and antiproliferative and in Sri Lanka it has been used for its hypoglycemic activities¹⁹⁻²¹. Bael fruit was introduced in Europe in 1959(Ref.22). The tree has also been reported to be cultivated in Ceylon, Northern Malaya, Java and Philippine Island where it was first fruited in 1914(Ref.23).

Bael in Mythology

Hindus hold the tree in great veneration. It is one of the most sacred trees of India. The leaves are ternate and hence one of the vernacular names is *Tripatra*²⁴. It is generally cultivated near temples and is offered to Lord *Shiva*, whose worship cannot be completed without the leaves of this tree. Lord *Shiva* is believed to live under the Bael tree. It is also called *Shivadurme*, the tree of *Shiva*. According to Hindu mythology, the tree is another form of *Lord Kailashnath*¹². It is also sacred to *Parvati* and is the *Vilva rupra*, one of the *Patricas*, or nine forms of Goddess *Kali*. The planting of this tree by the waysides gives long life. Its leaves are also used as enchantments. It is incumbent upon all Hindus to cultivate and cherish this tree and it is sacrilege to cut it down¹¹. The mentions of plant have also been found in ancient Indian scriptures such as *Vedas* and *Purana*²⁵ like *Yajurveda* and *Mahabharata*¹².

Cultivars

In India, the plant is widely cultivated particularly in Uttar Pradesh and Bihar. So far around twelve distinct cultivars, viz. 'Basti No.1', 'Kagzi Gonda', 'Gonda No.1', 'Gonda No.2', 'Gonda No.3', 'Kagzi Etawah', 'Sewan Large', 'Mirzapuri', 'Deoria Large', 'Chakaiya', 'Baghel' and 'Lamba' have been reported. Out of these four cultivars 'Kagzi Etawah', 'Sewan Large', 'Mirzapuri' and 'Deoria Large' have been found to be superior and excellent in taste and other qualities²⁶.

Chemical composition

Various chemical constituents like alkaloids, coumarins and steroids have been isolated and identified from different parts of tree, such as leaves, fruits, wood, root and bark.

Coumarins

Marmelosin, marmesin, imperatorin, marmin, alloimperatorin, methyl ether, xanthotoxol, scoparone, scopoletin, umbelliferone, psoralen and marmelide²⁷. Marmenol, a 7-geranyloxy coumarin [7-(2, 6-dihydroxy-7-methoxy-7-methyl-3-octaenyloxy) coumarin] has also been reported²⁸.

Alkaloids

Aegelin, aegelenine, marmeline, dictamine, fragrine (C₁₃H₁₁O₃N), O-methylhalfordinine, O-isopentenylhalfordinol²⁷, N-2-[4-(3',3'-dimethylallyloxy) phenyl]ethyl cinnamide, N-2-hydroxy-2-[4-(3',3'-dimethylallyloxy) phenyl]ethyl cinnamide, N-4-methoxystyryl cinnamide, N-2-hydroxy-2-(4-hydroxyphenyl) ethyl cinnamide^{29,30}, O-(3,3-dimethylallyl) halofordinol, N-2-

ethoxy-2-(4-methoxy phenyl) ethyl cinnamide, N-2-methoxy-2-[4-(3',3'-dimethylallyloxy)phenyl] ethylcinnamide, N-2-methoxy-2-(4-methoxyphenyl)-ethylcinnamide^{31, 32}.

Polysaccharides

Galactose, arabinose, uronic acid and L-rhamanose are obtained on hydrolysis³³.

Seed Oil

Composed of palmitic, stearic, oleic, linoleic and linolenic acid²⁷.

Tannins

The maximum tannin content in bael fruit was recorded in the month of January. There is as much as 9% tannin in the pulp of wild fruits, less in cultivated type. Tannin is also present in leaves as skimmianine.

Carotenoids

Carotenoids are responsible for imparting pale colour to fruit.

Marmelosin, skimmianine and umbelliferone are the therapeutically active principles of bael plant.

Minor constituents like ascorbic acid, sitosterol, crude fibres, tannins, α -myrin, carotenoids, crude proteins are also present. Roots of the tree have also been found to contain psoralen, xanthotoxin scopoletin and tembamide^{27, 34}.

Compounds such as praealtin D, trans-cinnamic acid, 4-methoxy benzoic acid, betulunic acid, and montanin have also been reported³⁵.

Utilization

General uses

Every part of the bael tree is utilized for various purposes. The wood is yellowish or grayish white, hard lustrous, aromatic when freshly cut. It takes a fine polish and is suitable for house building, cart construction, agricultural implements, carving, pestles, tool handles, combs, etc., but the tree is too valuable to be felled for its timber^{18, 36}. Wood is employed for making producer gas plant³⁷ and also used for making small household articles and cattle sheds¹². The twigs and leaves are used as fodder. The twigs are also used as tooth brushes or chew-sticks. A sweet-scented water is distilled from the flowers. Leaf juice is applied to the body before taking a bath to remove bad smell²⁵. The most valuable part of the tree is the fruit. A yellow dye is obtained from the unripe rind, which is used with myrobalans in calico printing. In Siam, the shell is used for scenting hair oil. On distillation, the rind yields the essential oil known as 'Marmelle oil'. The sweet aromatic fruit pulp is very nutritious, which is used for making *Sharbat*³⁶. Mixed with lime the pulp makes a tenacious cement, which is used for the construction of wells. It is also employed as a varnish (where a polished surface is required) for pictures and adds brilliancy to water colour paints¹². The pulp is often used as a substitute for soap for washing clothes as it has detergent properties³⁶. The dried fruits, after separating the pulp from the rind, are used as pill boxes for keeping valuable medicine, sacred ashes and snuff balls. Gum from stem is non edible but acts as a good adhesive and used often for book binding^{12, 18}. The tree

has been identified as suitable windbreak or wind barrier¹⁴.

In Indonesia, it is a common practice to take bael fruit in breakfast either by cutting or breaking open the soft fruits and eating the pulp of fruit dressed in palm sugar. Beating the seeded pulp together with milk and sugar makes a popular drink called *Sharbat* in India. The fruits carry large quantity of tenacious transparent gluten, which becomes hard on drying but continues to be transparent and when ripe and mixed with juice of tamarind, forms an agreeable drink. These drinks are consumed less as food or refreshment than for their medicinal effects. Mature (full grown) but still unripe fruits are made into jam with addition of citric acid. The pulp is also converted into marmalade or syrup, which is used as food material as well as a therapeutic agent in relieving diarrhoea and dysentery. A firm jelly is made from the pulp alone or combined with guava to modify the astringent flavour. The pulp is also pickled^{12, 38}.

Nutritional value

Physico-chemical studies have revealed that bael fruit is rich in mineral and vitamin contents^{26, 39, 40}. Major components of nutritional importance are listed in Table 1. Bael pulp is steeped in water, strained, preserved with 350 ppm SO₂, blended with 30% sugar, then dehydrated for 15 hours at 120°F (48.89°C) and pulverized. The powder is enriched with 66mg/100g Ascorbic acid and can be stored for 3 months for making cold drinks (Squashes). Bael fruit toffee is prepared by combining the pulp with sugar, glucose, skim milk powder and hydrogenated fat. Indian food technologists view the prospects for

Table 1 : Nutritional value of Bael fruit (% or per 100g)^{12, 39, 40}

Components	Value (%)	Components	Value (%)
Water (moisture)	64.2	Potassium	0.6
Protein	1.8	Iron	0.3
Fat	0.2	Vitamin A (IU)	186
Mineral	1.5	Vitamin B ₁	0.01
Fibre	2.2	Nicotinic acid	0.9
Carbohydrate	30.6	Riboflavin	1.2
Calcium	0.09	Vitamin C	0.01
Phosphorus	0.05	Calorific value	129

expanded bael fruit processing as highly promising. The young leaves and shoots are eaten as a vegetable in Thailand and used as seasonal food in Indonesia. These are said to reduce the appetite. An infusion of the flowers is used as a cooling drink²³.

Medicinal uses

Diarrhoea and Dysentery

The unripe or half ripe fruit is the most effective remedy for chronic diarrhoea and dysentery without fever. Best results are obtained by the use of dried fruit or its powder. The fruit, when it is still green, is sliced and dried in the sun. The dried fruit slices are reduced into powder and preserved in air-tight bottles. The unripe fruit can also be baked and taken with jaggery or brown sugar⁴¹. The fruit appears to have little effect in acute dysentery when there is definite sensation to defecate without the significant amount of faeces, blood and mucus alone are passed. The powdered drug is specially recommended in sub-acute or chronic dysentery. After the use of the fruit powder in these conditions, the blood gradually disappears and the stools resume a more feculent and solid form⁴². The mucus also disappears after continued use for

sometime. It is also a valuable remedy for chronic dysenteric conditions characterized by alternate diarrhoea and constipation^{43,44}. Its use has also been reported in the cases of amoebic dysentery⁴⁵.

Hypoglycemic/

Antidiabetic activity

Leaf extract has been used in Ayurveda as a medicine for diabetes. It enhances the ability to utilize the external glucose load in the body by stimulation of glucose uptake similar to insulin^{46, 47}. Bael extract significantly lowers blood urea and cholesterol in experimental diabetic animals^{21, 48}. Extract also decreases oxidative stress in experimental diabetic animals as indicated by significant reduction in lipid peroxidation, conjugated diene and hydroperoxide level and increased levels of superoxide dismutase, catalase, glutathione peroxidase and glutathione levels in serum as well as liver⁴⁹⁻⁵⁴. Juice of leaves is employed as anti-diabetic drug in Unani system of medicine also⁵⁵.

Anticancer activity

Bael inhibited *in vitro* proliferation of human tumour cell lines including the *leukemic K562*,

T-lymphoid Jurkat, *Beta-lymphoid Raji*, *Erythro leukemic HEL*²⁰. Extract of *A. marmelos* is antiproliferative but it produces effect on *MCF-7* and *MDA-MB-231* breast cancer cell line when it is in high concentration⁵⁶⁻⁵⁸.

Cardioprotective effects

The leaf extract has preventing effects in isoprenaline (isoproterenol)-induced myocardial infarction in rats. The activity of creatine kinase and lactate dehydrogenase was significantly increased in serum and decreased significantly in heart of isoprenaline-treated rats⁵⁹. Use of Bael as cardiac depressant and in palpitation has also been reported^{10-12, 18}.

Antispermato-genic activity

The leaf extract possesses anti-spermato-genic activity as it resists the process of spermatogenesis and decreases sperm motility in rats⁶⁰. Leaves were used for fertility control in Bangladesh^{29, 39}.

Antimicrobial/Antifungal activity

Bael extract manifests antiviral and antimicrobial activities. It has been found active against various species such as *Staphylococcus aureus*, *S. epidermidis*, *Proteus vulgaris*, *Escherichia coli*, *Salmonella typhimurium* and *Bacillus subtilis*. It has also been used for Ranikhet disease virus and intestinal parasites^{9, 27}. The essential oil isolated from the leaves of Bael exhibits variable efficiency against different fungal isolates and causes concentration as well as time dependent inhibition of spore germination of all the fungi tested, including most resistant fungus, *Fusarium udum*⁶¹.

Radioprotective effect

Treatment with extract of bael reduces the severity of symptoms of radiation induced sickness and increases survival in mice. The radio protective action might be due to free-radical scavenging and arrest of lipid peroxidation accompanied by an elevation in glutathione concentration in liver, kidney, stomach and intestine^{62, 63}.

Antipyretic and Analgesic activities

Bael extract exhibits antipyretic, anti-inflammatory and analgesic activities, as it has shown a significant inhibition of the carrageenan induced paw odema, cotton-pellet granuloma and paw itching in mice and rats⁶⁴. It is also used as febrifuge in night and intermittent fever^{11, 15, 37}.

Constipation

Ripe fruit is regarded as best of all laxatives. It cleans and tones up the intestines. Its regular use for two to three months helps in evacuation of even the old accumulated faecal matter from the bowels⁶⁵. For best result, it should be taken in the form of *Sharbat*, which is prepared from the pulp of the ripe fruit. After breaking the shell, the seeds are removed and contents are then taken out with the help of a spoon and passed through a sieve. Milk and sugar may be added to make it more palatable. The pulp of ripe fruit can also be taken with the spoon without addition of milk and sugar. About 60g of the fruit/edible part is sufficient for an adult⁶⁶.

In Burn cases

The traditional healers of southern Chhatisgarh use dry powder of

fruit with mustard oil for the treatment of burn cases. One part of powder and two parts of mustard oil are mixed and is applied externally^{18, 67}.

Peptic ulcer

An infusion of leaves is an effective remedy for peptic ulcer. The leaves are soaked overnight in water. This water is strained and taken as a drink in the morning. The pain and discomfort are relieved when this treatment is continued for a few weeks. The fruit taken in the form of beverage has also great healing properties on account of its mucilage, which forms a coating on the stomach mucosa and thus helps in the healing of ulcers^{68, 69}.

Respiratory infections

Medicated oil prepared from leaves gives relief from recurrent cold and respiratory infections. The juice extracted from leaves is mixed with equal quantity of sesame oil and heated thoroughly, a few seeds of black pepper and half a teaspoonful of black cumin are added to the hot oil, and then it is removed from the fire and stored for use when necessary. A teaspoonful of this oil should be massaged onto the scalp before a head bath. Its regular use builds up resistance against cold and cough. A common practice in South India is to give the juice of leaves to bring relief from wheezing cough and respiratory spasm. The leaf juice is mixed in warm water with a little pepper and is given as a drink^{40, 70}.

Miscellaneous properties

Bael leaves are useful in jaundice and in the treatment of wounds. The extract of leaves is beneficial in the

treatment of leucorrhoea, conjunctivitis and deafness. Fruits give feeling of freshness and energy^{71, 72}. It is used as carminative and astringent and used in thyroid related disorders⁷³. It is also used in treatment of snakebite. It is a cardiac stimulant⁷⁴. Applications have also been reported in anaemia, fractures, swollen joints, pregnancy troubles, typhoid⁴⁰, coma⁷⁵, colitis³⁷, bleeding sores and cramps¹⁵. It is also used as anthelmintic. It is used in treatment of acute shigellosis⁷⁶, as diuretic, in gonorrhoea¹¹ and in conjunctivitis⁷². The powder is used as stomachic. It is used in the treatment of irritable bowel syndrome⁷⁷.

Conclusion

Looking upon wide prospects and potential of bael for various purposes, it is worthwhile to cultivate this plant on large scale especially on unproductive and wasteland. This will help in financial upliftment of poor and landless farmers. Furthermore, systematic and scientific research is required to explore the maximum potential of this under-utilized plant. Authors are of the opinion that we Indians equipped with modern scientific techniques and enriched with strong traditional knowledge are best suited and well placed harness to maximum potential of this *Plant of Panacea* for human and environmental well-being.

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