CURATIVE ASPECTS OF AEGLE MARMELOS (BAEL) IN DRUG BIOAVAILABILITY

Shaili Yadav, Neeti Sharma and Jyoti Srivastava*

Department of Bioscience and Biotechnology, Banasthali University, Banasthali-304022, Rajasthan, India.

ABSTRACT

Ayurveda is supposed to add a step on to the curative aspects of many diseases and provides appropriate therapies continually. Thousands of herbal and traditional compounds are being screened worldwide to validate their use as drugs in medicinal field. Herbal decoctions and medicines consisting of multiple herbs each possessing tremendous potential for cure are commonly used in ayurveda. Aegle marmelos, a medicinal plant that also has been used as an herbal medicine for the management and cure of many more health problems in ayurvedic systems of medicine is widely used in world at significant level. All parts of this tree - stem, bark, root, leaf and fruit have medicinal virtues and have been used as medicine for a long time. The objective of this review is to summarize various healing and curative properties of Aegle marmelos and its chemical compounds to achieve better therapeutic response in ayurveda (traditional) and medicinal (drug) bioavailability.

KEYWORDS: Aegle marmelos, ayurveda (traditional) and medicinal (drug) bioavailability.

INTRODUCTION

Medicinal plants are the local heritage with global importance. World is endowed with a rich wealth of medicinal plants. The plants that possess therapeutic properties or exert beneficial pharmacological effects on the animal body are generally designated as “Medicinal plants”.[1]

Medicinal plants are generally used in two different ways; as complex mixture made of single plant extract containing a broad range of constituents or multi component mixture comprised of several closely related biologically active compounds. The active ingredients in medicinal
plants are defined as chemical compounds that act directly or indirectly prevent or treat disease. Selection of plant species to be studied when screening for biologically active constituents is a crucial factor for success of the investigation. The selection should be mainly based on the ethano pharmacological selection process that is based on the therapeutic use of plant species by a specific ethnic group.

*Aegle marmelos* (L.) is important medicinal plant available in TamilNadu, India and are reported to have various medicinal properties in Traditional medical systems.

The medicinal properties of *Aegle marmelos* plant have been described in the “Ayurveda” also which translates as "knowledge of life," dates back 5,000 years to the ancient Sanskrit texts, the Vedas [2]. Ayurveda is a branch of medicine which originated and is practiced in India for more than 5000 years. It is as fresh and useful to humans today as it was in the ancient times yet more relevant and applicable in these modern times.

Vedic medicine, considered one of the oldest systems of medicine in the world, was developed in India during the period 2000-1000 B.C. As ayurveda has its own unique theory and treatment, it describes the beneficial, nonbeneficial, happy and unhappy aspects of life. Ayurvedic medicine also helps in rapidly removing toxic elements from the body if one gets sick enabling him to recover his health quickly. Ayurveda has thus been a tradition in India for thousands of years. It is also practiced in various forms in neighbouring countries of South-East Asia, according to their own sociocultural background.

**Ayurved in health**

Ayurveda is a medical system that deals not only with body but with the mind and spirit as well. According to ayurveda, most diseases connected with the psychophysiologic and pathologic changes in the body are caused by imbalance in three different dosha (i.e., vata, pitta, and kapha,). The fundamental aim of ayurvedic therapy is to restore the balance between these three major body systems. Any imbalance can lead to inflammation (also called sopha). Almost seven different types of inflammation have been described in ayurveda. The ayurvedic definition of pittaja sopha (inflammation) encompasses the modern concept of inflammation, which is defined as redness, pain, heat, loss of function, and swelling. The balanced coordination of body, mind, and consciousness is the ayurvedic definition of health.

*Aegle marmelos* (Bael)
Bael (*Aegle marmelos*), Bilva, Bilwa, Bel, Kuvalam, Koovalam (in Malayalam), Madtoum, or Beli fruit, Bengal quince, stone apple, Maredu (in Telugu), and golden apple [3,4]. The tree, which is the only species in the genus, Sanskrit names: Bilva, Śalātu, Hṛdyagandha, Karkaṭa, Samirasāraka, Śivadruma, Triśikha, Śiveṣṭa, Dūrāruha, Lakṣmī phala, Śalya, Mahākapithya etc is one of the divyoushada (divine medicine) of ayurveda belonging to the family Rutaceae. The tree comes under the 10 great trees of medicinal value. Its leaves are said to please even Shiva if used for ebullition on Shiva Linga. It is a great medicine for Diabetis, Diarrhea, Detoxification, skin ailments, Asthma, cold, fever. In its fruit, the folowing are abundant Contains Embratorium A and Embratorium B act against intestinal worms. Riboflavin, Pepsin, Tanin, Resin, Sugar, Evaporative oil, Marmelosin (alkaloid) Marmin (alkaloid), Sodium, Pottassium, Calcium carbonate, Ejilin (alkaloid). The leaves, roots, bark, seeds and fruits of *Aegle marmelos* are edible astringent, a laxative, and an expectorant and are useful in treating ophthalmia, deafness, inflammations, cataract, diabetes and asthmatic complaints. The leaves are bitter and are used as a remedy for ophthalmia, ulcers, dropsy, cholera and beri beri.

**Scientific Classification**

Kingdom: Plantae  
Division: Magnoliophyta  
Class: Magnoliopsida  
Family: Rutaceae  
Tribe: Clauseneae  
Genus: Aegle Correa  
Species: *A. marmelos*

**Distribution**

The tree grows wild in dry forests on hills and plains of central and Bangladesh also in mixed deciduous and dry dipterocarp forests of former French Indochina. Mention has been found in writings dating back to 800 B.C. it is cultivated throughout India, including moist and deciduous forests of Eastern and Western ghats. It is present in the states of Himachal Pradesh, Uttar Pradesh, West Bangal, Tripura, Maharashtra, Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu, in India. Also in Ceylon and northern Malaya, the drier areas of Java and to a limited extent on northern Luzon in the Philippine Islands where it first fruited in 1914. It is grown in some Egyptian gardens and in Surinam and Trinidad. The *A. marmelos*
tree grows throughout the dry hilly areas, reaches up to 1,300 m tall. Bael fruits were introduced in Europe in 1959 [5].

**Morphological Properties**

It is a moderate-size, slender, aromatic tree, 6.0 - 7.5 m in height and it will be girth, with a somewhat fluted bole of 3.0 - 4.5 m and spines are straight, strong and axillary on branches. Bark is soft, corky, light grey, exfoliating in irregular flakes. Leaves are alternate, foliate occasionally digitately five foliate. Leaflets are ovate lanceolate, crenate, acuminate, lateral sessile, terminal long petioled. Flowers are large, greenish white, sweet scented in short axillary panicles (figure. 1). Fruits are globas, grey or yellowish, rind, woody, seeds numerous, oblong, compressed, and embedded in sacs covered with thick orange, coloured sweet pulp. It flowers during April-May and fruits ripen during March-April [6].

![Figure 1: Showing leaf, flower and fruit of Aegle marmelos](image-url)

**CHEMICAL CONSTITUENTS IN AEGLE MARMELOS**

It was shown that dry pulp of fruit contains mucilaginous mass. It was found that leaves, stem and root of this plant contains significant amount of tannins, alkaloids, coumarins, steroids and many more phytoconstituents (Table 1).

**Alkaloids**

Leaves mainly contain rutacine, y-sitosterol, aegelemine and aegeline, marmeline, fragrine, dictamine, cinnamid and different derivatives of cinnamid [7].

**Coumarins**

Marmin, marmesin, umbelliferine, umbeliferone, skimmianine, Scoporone, scofoletin, psoralen, marmelide, xanthotoxol and impertonin were identified from the bark leaves, fruit and root of Plant [8,9].
Terpenoids

α-Phellandrene, p-cymene, Limonene, γ-Sitosterol, α- and β-amyrin were reported from leaf oil \[^{10,11,12}\].

Seed oil

Seed oil is bitter and contains 15.6% palmitic acid, 8.3% stearic acid, 28.7% linoleic and 7.6% linolenic acid while seed residue contains about 70% protein.

Polysaccharide

Reducing sugars such as galactose, arabinose and L-rhamnose are found in fruit \[^{13}\]. Carotenoids are present in fruit and responsible for characteristics color of fruit. It was found that root of *Aegle marmelos* tree contain psoralin, xanthotoxin and scopoletin.

Table 1: List of Phytoconstituents isolated from various parts of *Aegle marmelos*

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Part</th>
<th>Phytoconstituents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Leaf</td>
<td>Skimmianine, Aegeline, Lupeol, Cineol, Citral, Citronella, Cuminaldehyde, Eugenol, Marmesinine</td>
</tr>
<tr>
<td>2.</td>
<td>Bark</td>
<td>Skimmianine, Fagarine , Marmin</td>
</tr>
<tr>
<td>3.</td>
<td>Fruit</td>
<td>Marmelosin, Luvangetin, Aurapten, Psoralen, Marmelide, Tannin</td>
</tr>
</tbody>
</table>

Traditional Medicinal and Nutrient Value

According to scientist \[^{6}\], every part of plants including leaves, root, and fruit is a rich source of fat, vitamins, carbohydrates, minerals (table 2). A number of chemical constituents from different parts of plant have been extracted like aegelin marmelosin, coumarin, β-sitosterol and alkaloids. The compound isolated from plant show a variety of pharmacological activity. The fresh ripe pulp of the higher quality cultivars, and the "sherbet" made from it, are taken for their mild laxative, tonic and digestive effects. A decoction of the unripe fruit, with fennel and ginger, is prescribed in cases of hemorrhoids. It has been surmised that the psoralen in the pulp increases tolerance of sunlight and aids in the maintaining of normal skin color. It is employed in the treatment of leucoderma.

Marmelosin derived from the pulp is given as a laxative and diuretic. In large doses, it lowers the rate of respiration, depresses heart action and causes sleepiness. For medicinal use, the young fruits, while still tender, are commonly sliced horizontally and sun-dried and sold in local markets. They are much exported to Malaya and Europe. Because of the astringency, especially of the wild fruits, the unripe bael is most prized as a means of halting diarrhoea.
and dysentery, which are prevalent in India in the summer months. Bael fruit was resorted to by the Portuguese in the East Indies in the 1500's and by the British colonials in later times.

A Bitter, light-yellow oil extracted from the seeds is given in 1.5 g doses as a purgative. The bitter, pungent leaf juice, mixed with honey, is given to allay catarrh and fever. With black pepper added, it is taken to relieve jaundice and constipation accompanied by edema. The leaf decoction is said to alleviate asthma. A hot poultice of the leaves is considered an effective treatment for ophthalmia and various inflammations, also febrile delirium and acute bronchitis. The dried powder of leaf is used in the treatment of irritable bowel syndrome.

A decoction of the flowers is used as eye lotion and given as an antiemetic. The bark decoction is administered in cases of malaria. Decoctions of the root are taken to relieve palpitation of the heart, indigestion and bowel inflammations; also to overcome vomiting.

The fruit, roots and leaves have antibiotic activity. The root leaves and bark are used in treating snakebite. Following uses described in folk medicine (not supported by experimental or clinical data)

**Abdominal discomfort**

Boil together 50 g bark of *Aegle marmelos*, 25 g flower of caraway, 25 g of dried ginger and take the decoction twice daily in empty stomach for two to three days.

**Acidity**

Grind together the leaves of *Aegle marmelos* and black pepper (2 g) with water. Take this paste orally once only.

**Burning sensation**

While urinating: grind together the leaves of *Aegel marmelos* and entire plants of *Cynodon dactylon* with a little water. Take this paste in the morning with a glass of water (in which sugar candy has already been dissolved) in empty stomach once a day for 15 day.

**Constipation**

Make a drink (shrabat) of the fruit pulp of *Aegel marmelos*. With 50 g sugar take this sharbat orally early in the morning once a day till it cures or grind roots of *Aegle marmelos* with cold water and make a paste. Take the paste orally in empty stomach once a day early in the morning till it cures.
Diarrhoea
Boil the bark of *Aegle marmelos* in water. Filter this and add some powdered long pepper to it. Take the decoction twice daily for two to three days.

Epilepsy
Grind together the leaves of *Aegle marmoles*, *Cassia fistula*, *Lagerstroemia reginae*, *Premna mucronata*, whole plants of *Solanum xanthocarpum*, *Tribulus terrestris*, *Desmodium gangeticum*, *Desmodium pulchellum* branches and leaves of *Solanum indicum*. Boil the paste in water. Filter with a cloth. Administer orally with honey. Dosage: one teaspoonful twice daily for seven days or till it cures.

Fever
Make a paste of 50 g leaves of *Aegle marmelos*. Apply the paste on head and chest daily till it cures. Or boil 100 g leaves of *Aegle marmoles* with water. Filter and take the decoction orally twice daily for two days. (or) grind together the barks of *Aegle marmoles*, *Cassia fistula*, *Gmelina arborea*, *Premna mucronata* and the whole plants of *Solanum xanthocarpum*, *Tribulus terrestris*, *Desmodium gangeticum*, *Desmodium pulchellum* and the twigs of *Solanum indicum* all in equal proportion. Boil these plants/plant parts with water. Filter with a cloth. Administer one teaspoonful of this decoction twice daily orally with honey for seven days or until cured. (Or) boil the bark of *Aegle marmelos* with water and filter it. Add a little juice of garlic to this decoction. Take this orally twice daily for two days.

Indigestion
Grind the leaves of *Aegle marmelos* with 7 nos. of black pepper. Take this orally twice or thrice for one day only.

Leprosy
Sun-dry the leaves of *Aegle marmelos* and then powder them. Sinkle this powder on the wound after taking bath. Continue this process till it cures. Avoid taking dried fish, pumpkin and tomato in diet.

Myalgia
Grind the roots of *Aegle marmelos* with cold water and make a paste. Take this paste orally in early morning in empty stomach.
Smallpox

powder the leaves of *Aegle marmelos*. Take one teaspoonful of this paste orally once a day with water till it cures.

Spermatorrhoea

Grind together the leaves of *Aegle marmelos* and a few plants of *Cynodon dactylon* with water. Take this paste orally in the morning with a glass of water (in which sugar candy has already been dissolved) in empty stomach. Continue this process for 15 days. (or) Powder together a fruit of *Aegle marmelos*, 10 g tuber of *Salmalia malabarica*, 5 g dried ginger, 5 g long pepper, 5 g aniseed, 5 g fenugreek, 1 g cloves and 1 g cinnamon. Take orally one teaspoonful of this powder with cold water twice daily for seven days.

Table 2: Modern nutritional value of (Bael) *A. marmelos* in 100 gms

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>1.8 gm</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td></td>
</tr>
<tr>
<td>Total carbohydrate</td>
<td>31.8 gm</td>
</tr>
<tr>
<td>Fat</td>
<td></td>
</tr>
<tr>
<td>Total fat</td>
<td>0.3 gm</td>
</tr>
<tr>
<td>Vitamins</td>
<td></td>
</tr>
<tr>
<td>Riboflavin</td>
<td>1.19 mg</td>
</tr>
<tr>
<td>Niacin</td>
<td>1.1 mg</td>
</tr>
<tr>
<td>Thiamin</td>
<td>0.13 mg</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>55 mg</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>8 to 60 mg</td>
</tr>
<tr>
<td>Minerals</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>85 mg</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>50 mg</td>
</tr>
<tr>
<td>Potassium</td>
<td>600 mg</td>
</tr>
</tbody>
</table>

PHARMACOLOGICAL ACTIVITIES OF BAELE

Diarrhoea and Dysentery

Generally dried fruit pulp and its powder are used for the treatment of diarrhoea. The dried powder is also used as an important remedy for chronic dysentery conditions characterized by alternate diarrhoea and constipation [14].

It has been found that bael extract significantly reduces blood urea and cholesterol level in diabetic animals. Also, decreases oxidative stress in diabetic animal. For analysing this, scientist [15] studied on leaf extract of *Aegle marmelos* on alloxane induced diabetes and reported that used extract was enough capable to reduce oxidative stress by scavenging lipid
peroxidation and enhancing certain anti oxidant levels which causes lowering of elevated blood glucose level.

**Antimicrobial Activity**
Scientists [16,17] observed significant antimicrobial effect of ethnolic extract of dried fruit pulp of *Aegle Marmelos* against various intestinal pathogens i.e. *Shigella boydii, S. sonnei* and *S. Flexneri* and bacteria like *E. Coli Salmonella typhi, Pseudomonas aeruginosa* and proposed that certain phytochemicals including phenols, tannins and flavonoids were effective against all.

**Antifungal activity**
The antifungal activity of essential oil isolated from leaves of bael plant was evaluated using spore germination assay and was found to possess variable efficacy against different fungal isolates by different scientists and they reported the antifungal activity of different extracts of the *Aegle marmelos* leaves. Scientists [18-19] evaluated anti fungal activity of essential oils isolated from the leaves of bael using spore germination assay. The oil exhibited variable efficacy against different fungal isolates and 100% inhibition of spore germination of all the fungi tested was observed at 500ppm. They proposed that essential oil from bael leaves may interfere with the Ca^{2+}-dipicolonic acid metabolism pathway and possibly inhibit the spore formation.

**Anticancer Activity**
Scientist [20] studied the significant antiproliferative activity of *Aegle marmelos*. It was also reported that *Aegle marmelos* (L.) inhibits the proliferation of transplanted *Ehrlich ascites* carcinoma in mice. Scientist [21] studied the effects of extracts from Bangladeshi medicinal plants on *in-vitro* proliferation of human breast cancer cell lines and expression of estrogen receptor alpha gene, according to this study extract from *Aegle marmelos* is antiproliferative on both cell line MCF7 and MDA-MB-231cells, but at a higher concentration.

**Cardioprotective Activity**
Scientists [4,22] reported significant cardioprotective activity of leaf extract of bael in isoprenaline- induced rats.
Anti-inflammatory
Scientist [23] evaluated anti-inflammatory activity of leaves extract of *Aegle marmelos* using rat as experimental animal and aspirin as standard drug. Results easily predicted the fact that leaf extract of this plant have sufficient anti-inflammatory activity.

Antiulcer Activity
Bael fruit and leaf infusion is used for antiulcer activity [24]. He reported that pretreatment of rats with unripe bael fruit extract produce a significant inhibition of absolute ethanol induced gastric mucosal damage.

Anti thyroid Activity
Scientist [25] isolated scopoletin (7-hydroxy-6-methoxy coumarin) from *Aegle marmelos* leaves and evaluate for its potential to regulate hyperthyroidism. It was observed that scopoletin (at 1.00 mg / kg, p.o. for 7 days) to levo-thyroxine treated animals, decreased serum thyroid hormones level. It was also proved that the scopoletin have superior therapeutic activity than the standard antithyroid drug, propylthiouracil.

Analgesic anti-inflammatory and Antipyretic Activity
Scientist [3,26] reported anti-inflammatory, antipyretic and analgesic properties of serial extract of leaves of *Aegle Marmelos*.

Radioprotective Activity
Scientist [27] presented radioprotective activity of a leaf extract of *Aegle marmelos* in mice exposed to different doses of gamma-radiation. This treatment reduced the symptoms of radiationinduced sickness free-radical scavenging and increased survival.

Antifertility
*A. marmelos* is a rich source of antifertility in male in reversible manner. Leaf fruit and seed possess marmin and fagarine compounds, that reduce fertility in male. Scientist [28] reported antifertility activity of methanolic extracts of *A. marmelos* via reducing reproductive organ weight and serum testosterone level. Author also reported complete restoration in extract treated male wistar rat after withdrawal of treatment.

CONCLUSION
Bael is one of the most important tree species used in various indigenous systems of ayurvedic medicine in India. Every part of bael plant consist specific medicinal value.
Moreover, a number of chemical constituents and various therapeutic effects of leaves of *A. marmelos* have been reported by different workers. Studies have also indicated the presence of phenols, alkaloids, ployphenol and flavanoids compound in the different solvent extracts of the leaves of *A. marmelos*, which correlate the therapeutic activity with the chemical marker of the plant as well as the mode of action of that compound.

ACKNOWLEDGEMENT

The authors are thankful to Bioscience and Biotech Department and Prof. Aditya Shastri, Hon. Vice Chancellor, Banasthali University, for providing facilities to carry out the study.

REFERENCES


