A REVIEW ON PHYTOCHEMICAL AND PHARMACOLOGICAL VALUES OF FRUIT PULP OF AEGLE MARMELOS

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ABSTRACT

In the traditional system of medicine, medicinal plants form the back-bone in India. The Phytochemical ingredients from these medicinal plants serve as key compounds in drug discovery and design. A diverse range of bioactive molecules are produced by plants which make them a rich source of different types of medicines. Plants have unimaginable healing power. Aegle marmelos is commonly known as Bilva tree belong to family Rutaceae. This plant is considered as a medicinal tree as it has several curative properties in treating different diseases. The present study reports an overview about the medicinal plant, Aegle marmelos (Linn.) Correa (Bael). In particular, it provides information relating to the phytochemical, antioxidant, antidiabetic, antimicrobial, antidiarrheal activity and other therapeutic benefits.

KEY WORDS: Aegle marmelos, Medicinal plants, Phytochemical Screening, Antibacterial activity

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**INTRODUCTION**

India is considered as a bank of medicinal and aromatic plants. It is estimated that nearly 7500 of the 17000 higher plant (angiosperms) species have medicinal values (Prabhakar et al., 2013). The Ayurveda system of medicine uses about 700 species, Unani 700, Siddha 600, Amchi 600 and modern medicine around 30 species (Kushagra et al., 2011). These plants are used for health, fragrance, cosmetics etc. The fourth largest pharmaceutical industry is Indian pharmaceutical industry. The Cultivation of Medicinal and Aromatic plants is a good option in this semi-arid region. Medicinal plants provide rich source of novel drugs, modern medicines, food supplements, folk medicines, pharmaceutical intermediates, neutraceutical bioactive principles and lead compounds in synthetic drugs (Saradha and Annapoorani, 2012).

Phytochemical extracts from medicinal plants holds promises that can be used in all types of allopathic medicine due to their anti-viral, anti-tumoral and anti-microbial properties. India has occupied one of the twelve mega biodiversity centers having more than 45000 useful plant species. Nearly about 15 biotic provinces, 10 vegetative zone and 16 different agro climatic zones contribute to its unmatched diversity in the world (Prabodh et al., 2007).

Bael (Aegle marmelos (Linn.) Correa) belongs to family Rutaceae. Its golden colored fruit resembles golden apple hence the generic name-Aegle, and the species name is derived from marmelosin contained in the fruit. It is a divine tree having curative properties. Marmelosin derived from the pulp is laxative and diuretic (Bag et al., 2009). The bark contains tannin and the coumarin, aegelinol; also the furocumarine, marmesin; umbelliferone, a hydroxyl coumarin; and the alkaloids, fagarine and skimmianine (Morton and Miami, 1987). Leaf contains alkaloid ‘Aegeline’ used as antiasthamatic agent (Priya et al., 2013). The roots and fruits of A.marmelos possess antiamoebic and hypoglycemic activity (Ponnachan et al., 1993). Fruit of A.marmelos contains Aurapten, Marmelosin, Psoralen, Luvangetin, Marmelide, Tannin, Phenolic compound and has several curative properties in curing ailments like diarrhea, gastric troubles, tonic, and constipation, digestive, stomachic and laxative. Root possesses Halopine, Alkaloid, Terpines, Coumarins and attributes for healing heart disorders, hypoglycemic, fever, antiamoebic and rheumatism (Pushpendra et al., 2012). In the Ayurvedic, Siddha and Unani systems of medicine in India, A. marmelos has occupied as an important herbal medicinal plant for the treatment of diabetes mellitus (Ganesh et al., 2011). In the Ayurveda system of medicine, Bael has been praised for its contribution in treating chronic diarrhea and dysentery (Chandra, 2006).

Many of the researchers have validated the pharmacological importance of different parts of Aegle marmelos which includes antioxidant, free radical scavenging antibacterial, antiviral, anti-diarrheal, hepatoprotective, anti-diabetic, cardioprotective, gastroprotective, anti-ulcerative colitis and radioprotective effects (Manjeshwar et al., 2011; Rajan et al., 2011; Anurag et al., 2014; Patel et al., 2012). As at present scenario, only a few articles are available on the phytochemical and pharmacological values of fruit pulp of A. marmelos, the present review attempts to summarize the different bioactive compounds present in the fruit pulp of the plant which contributes to its medicinal properties in curing different ailments.

**TAXONOMY OF AEGLE MARMELOS**

Bael (Aegle marmelos) is a tree, native to biodiversity rich India. It is considered as most sacred plant by the Hindus.

**English names:** Golden apple, Stone apple, Bengal quince.

**Indian names:** bil (Gujurat), bel (Assam), bil (Himachal Pradesh), bilpatre, kumbala, malura (Karnataka), kuvalum (Kerala), maredu
Botanical Classification

Kingdom: Plantae
Division: Magnoliophyta
Class: Magnoliopsida
Order: Sapindales
Family: Rutaceae
Subfamily: Aurantioideae
Tribe: Clauseneae
Genus: Aegle
Species: marmelos

MORPHOLOGICAL DETAILS OF AEGLE MARMELOS

Habit- Tree

Description: Bael is a medium sized deciduous tree greater than 8 m tall. The tree has unusual branches with aromatic leaves, sweet scented and greenish-white flowers.

Leaves: The leaves are alternate, pale green, trifoliolate, having a long petiole. The petiole is 3.2 cm long and the two lateral leaflets are almost sessile, 4.1 cm long, 2.2 cm wide along with terminal leaflet, 5.7 cm long, 2.8 cm broad, ovate to lanceolate, reticulate pinnate venation.

Flowers: The flowers are greenish white, sweetly scented and have Bisexual, actinomorphic, ebracteate, hypogynous, stalk. The stalk which holds the flower is 8 mm long. The calyx of the flower is gamosepalous and five-lobed. The corolla is polypetalous, with 5 petals, imbricate, leathery, pale yellow from above and green from beneath. The Androecium is consists of stamens of length 4 mm with polyandrous condition, numerous, basifixed, dehiscence longitudinally. The Gynoecium is light green with capitate stigma hosting terminal style. The Fruit of the plant is very smooth, woody in nature, 5–15cm in diameter containing numerous seeds which are densely enclosed with fibrous hair and are entrenched in a thin aromatic pulp (Patel et al., 2012).

Origin and Distribution: Bael tree found its existence somewhere back in 800 B.C. The tree grows wild in dry forests on hills and plains of central and southern India, Northern Malaya, Java and Philippine Islands, Burma, Pakistan, Bangladesh, Sri Lanka. It is cultivated in some Egyptian gardens, Trinidad and in Surinam. It is also found in the hilly areas of Himalaya, Uttar Pradesh, Uttarakhal, Bihar, Chhatisgarh, Deccan Plateau and East Coast (Prabodh et al., 2007).

Nutritional values of Bael Fruit: Studies on Bael fruit shows that it consists of moisture 61.5 percent, minerals 1.7 percent, fibre 2.9 percent, fat 0.3 percent, protein 1.8 percent, and carbohydrates 31.8 percent per 100 grams of edible portion. The mineral and vitamin contents present in fruit includes calcium, carotene, phosphorus, iron, thiamin, riboflavin, niacin and vitamin C. Its calorific value is 137 (Panda, 2000; Morton and Miami, 1987).

Propagation: Bael fruit is commonly grown in nurseries and the young plantlet are transplanted into the field. Seedlings show great variation in form, size, quantity, texture of rind and quality of pulp and number of seeds. The flavor ranges from unlikable to pleasant. Therefore, superior types must be grown vegetatively (Morton and Miami, 1987).

Flowering/Fruiting: Flowers-May to June, Fruits-May-June of following year (Dinesh et al., 2011).

PHYTOCHEMICAL ANALYSIS AND THE METHODOLOGY FOR EXTRACTION

A. marmelos plant has been blessed with seven major phytochemicals such as alkaloids, cardiac glycosides, terpenoids, saponins, tannins, flavonoids and steroids which are biologically active and have been the major source in curing different diseases. In the past, many research has been done on this
Phytochemical aspects and the studies have shown that the fruit pulp of Bael contains bioactive substance like carotenoids, tannins, flavonoids, terpenoids, alkaloids, pectins, reducing sugar, saponins, carboxyls, phlobatanins and steroids (Manjeshwar et al., 2011; Dhanaraj et al., 2011; Venkateshan et al., 2009). The detailed analysis and findings of phytoconstituents in Fruit pulp of A. marmelos by different researchers has been described below.

Alkaloids

Alkaloids have been considered as the largest class of secondary bioactive compound present in plants which includes an array of compounds such as skimmianine, fagarine, aegelin, aegelinosides, anhydro marmelin which are found in Bael fruit (Manjeshwar et al., 2011). The qualitative study by Dhanaraj et al. (2011) showed the presence of alkaloids using Mayer's, Wagner's, Hager's, and dragoncliff's reagent and was found to be more in alcohol, water and chloroform extracts. Venkateshan et al. (2009) using dragoncliff's reagent has performed qualitative test to show the presence of alkaloids in different plant extracts of A. marmelos. Rajan et al. (2011) performed qualitative test both for aqueous and alcoholic plant extracts and found the presence of alkaloids only in alcoholic extracts of fruit pulp along with the presence of cardiac glycosides in aqueous extracts. Two alkaloids 4, 7, 8-trimetoxyfuroquinoline (skimmianine) and N-2-hydroxy-2-(4-methoxyphenyl)-ethylvinnamamide (aegeline) were isolated by Sugeng et al. (2001) from the plant parts (leaves, roots) of A. marmelos and was confirmed by spectroscopic analysis.

Phenolic compounds

Phenolic compounds are aromatic secondary metabolites in plants which include a wide range of classification as soluble (phenol acids, flavonoids, quinines) and non soluble compounds (tannins, lignins, cell wall bound hydroxyccinnamic acids) (Harborne, 2000). Phenols are aromatic compounds which offer resistance to diseases and pests in different plants. It includes an array of secondary metabolites like tannins and flavonoids. Rajan et al. 2011 using folin-ciocalteau reagent estimated quantitatively total phenolic contents in fruit pulp. The study showed the presence of tannins and phenolic compounds were more in aqueous extracts than alcoholic fruit extracts. In another study, Dhanaraj et al. (2011) showed the presence of tannins and phenols in alcohol and water extracts of both variant of A. marmelos. Venkateshan et al. (2009) showed the presence of tannins, phlobatanin, and terpenoids in ethanolic extracts of A. marmelos qualitatively. Total phenolic and flavonoid contents of different parts extract of A. marmelos was carried out by Nadeem et al. (2010) using Folin Ciocalteu reagent and found leaf contains larger amount of these phytoconstituents than other parts of the plant.

Flavonoids

Flavonoids are bio active compounds which normally accumulate in plant body as secondary metabolites in large quantities. Anthocyanin and Leucocyanin are the flavonoids present in Bael fruit (Manjeshwar et al., 2011). Venkateshan et al. (2009) noticed the presence of flavonoids in Ethanolic extracts of A. marmelos which relates its role as an antimicrobial activity against tested bacteria such as E. coli, Pseudomonas aeruginosa and Bacillus subtilis. Quantitatively, Rajan et al. (2011) estimated total flavonoids content using aluminium chloride colorimetric method and the study showed the presence of flavonoids was more in alcoholic extracts (166.33 ± 09.60 mg/g) than the aqueous extracts (129.00 ± 07.00 mg/g) in fruit pulp of A. marmelos (*p<0.05).

Other chemical constituents of Bael fruit

Literature shows the presence of wide variety of chemicals in fruit pulp of Bael which contributed to its anti-microbial and medicinal properties. Pulp contains coumarins like marmelosin, aegeline, marmelein, alloimneeratorin, psoralen, marmelide (Uttara
et al., 2012). Fruits of Bael also contain tartaric acid, pectins, linoleic acid and terpenoids (Manjeshwar et al., 2011). Seed contains different oil compounds (terpenoids) such as essential oil –D- limonene, Cineol, Citral, P-cymene, Cumin aldehyde, A-D-phellandrene and Citronellal (Pushpendra et al., 2012). Polysaccharides like galactose, uronic acid, arabinose are isolated from fruit pulp on hydrolysis (Prabodh et al., 2007). Tannins such as skimmianine (4,7,8-trimetoxyfuro,quinoline) and Carotenoids which are helpful in imparting colours to the fruit such as umbelliferone are also noticed in fruit pulp of A. marmelos (Patel et al., 2012).

**ANTI MICROBIAL AND PHARMACOLOGICAL PROPERTIES OF BAEL FRUIT**

Bael tree is a gift from God to mankind as it has several medicinal properties in curing various ailments and diseases affecting people in both developing and developed countries. Several studies have been done to validities the anti microbial and pharmacological properties of Bael fruit.

**Antioxidant activity**

Antioxidants are the natural occurring compounds produced during oxidative stress with strong free radicals scavenging activity helpful in protecting the plants. Many antioxidant compounds such as flavonoids, flavones, isoflavones, coumarin, anthocyanin, lignans, catechins and isocatechins are found in the fruit pulp of A. marmelos (Maity and Hansda, 2009). Free radical scavenging activity and antioxidant activity of both ripe and unripe fruits were conducted by Sharmila & Vasundra, (2011) to compare in-vitro antioxidant activity of the ethanolic extract of ripe and unripe fruit of A. marmelos and the study indicated that the enzymatic antioxidants increased in ripe fruit when compared to unripe fruit extract (except glutathione peroxidase). Rajan et al. (2011) studied the antioxidant potential of both aqueous and alcoholic extracts of fruit pulp using DPPH standard assay. The extracts showed significant free radical scavenging action against nitric oxide. Several antioxidative parameters like glutathione reductase reduced glutathione, super oxide dismutase (SOD), glutathione peroxidase and catalase have shown an increase in their dose–related activity and decrease in lipid peroxidation when treated with Bael leaf extract (Sabu and Kuttan, 2004). DPPH radical scavenging assay showed the efficient antioxidant activity of fruit pulp in the aqueous extracts compare to other extracts (Gheisari et al., 2011). Hence from the above it can be stated that different extracts of Beal shows antioxidant activity in protecting the plant in various oxidative stress conditions which has to be further analyze in order to make a hypothesis which can be implemented in curing prevailing disorders.

**Antidiabetic activity**

Diabetes is a common major metabolic disease prevailing in the present scenario and most of the populations are suffering with it, where cure becomes inevitable. Hence plant products and different animal models have been exploited to find the solution in overcoming this disease. In this regards, Bael plant has become an icon and helps in stimulating glucose uptake mechanism similar to insulin treatment (Upadhya et al., 2004). Lowering of Hypoglycemic effect was shown using aqueous extracts of Fruit of Bael against STZ induced diabetes rats and in rabbit model, alcoholic extracts shown its effect in lowering the glucose level when oral administration was done (Patel et al., 2012). The study by Sevugan et al. (2008) shown that the leaf and callus extracts possess the ability to stimulate the insulin secreting cells of pancreas. Among the various extracts used, the methanol extracts of the leaf and callus revealed the maximum anti-diabetic effect. The results suggested that both the callus and leaf materials contain anti-diabetic active principles, which reduced the sugar level in STZ-diabetic rabbits. Aqueous extract of A. marmelos fruits can be used as an anti-hyperlipidaemic agent as found in the streptozotocin-induced diabetic wistar rats.
Antimicrobial activity of fruit pulp

Different parts of A. marmelos plant have been found to inhibit the growth of various pathogenic micro-organisms. Several micro-organisms including fungi and bacteria have shown its growth inhibition effect in spreading a diseases when treated with different extracts of Bael. Rajan et al. (2009) studied different extracts of fruit pulp of A. marmelos against Escherichia coli, Shigella, Salmonella sp and hypothesized that the phytochemicals including Flavones, Coumarin and Tannins were effective against all. The crude ethanolic extracts of Bael fruits were effective against the tested organisms Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa and Bacillus subtilis due to the presence of chemicals like Alkaloids, Cardiac glycosides, Terpenoids, Saponins, Tannins, Flavonoids, and Steroids (Venkateshan et al., 2009). Using methanol and ethanol extracts, Ankur et al. (2010) evaluated the immunomodulatory activity in rats and found that the methanolic extract possess higher potential degree in stimulating cell mediated and antibody mediated immune response as compared to ethanolic plant extracts. Vijay et al. (2010) attributed the presence of coumarins, alkaloids, sterols and essential oils in possessing the properties like anti-microfilarial, hypoglycaemic, antimicrobial, immunomodulatory, antiproliferative, and wound healing, anti-fertility, antifungal, analgesic, anti-inflammatory, antipyretic and insecticidal activity in different parts of A. marmelos. The antifungal activity of the leaves was tested against clinical isolates of dermatophytes such as Trichophyton mentagrophytes, T. rubrum, Microsporum canis, M. gypseum, Epidermophyton floccosum (Balakumar et al., 2011). Hence from these studies we can conclude that an elaborate investigation has to be made in order to correlate the importance of these bioactive constituents in antimicrobial properties shown in different plant extracts.

Antidiarrheal Activity

Gastrointestinal infections (Diarrhoea and Dysentery) are now days the major cause of morbidity and mortality in the developing countries. Since from the ages man has born, exploring and exploitation of the plants has been a routine work in treating this global problem. In this regard, the unripe and half ripe fruit of Bael has been extensively used as the remedy (Prabodh et al., 2007). Crude aqueous extract of unripe fruits exhibited inhibitory activity against Giardia and rotavirus, the causative organisms for diarrhoea (Brijesh et al., 2002). The unripe fruit of Bael can be used in different combinations in cure of chronic diarrhea and the fruit pulp possess antiprotozoal activity which can be explored in treatment of dysentery and loose motions (Gupta et al., 2011).

Miscellaneous Uses

Bael is a medicinal plant and possesses a wide variety of medicinal properties. Apart from the uses mentioned above its contribution has been marked significantly in the area of insecticidal activity (Kumar et al., 2008; Dinesh et al., 2011), Antispermatic Activity (Sur et al., 1999), anti-lipid-peroxidative activity, Toxicity Studies (Veerappan et al., 2007), Anti thyroid Activity (Dinesh et al., 2011; Panda and Kar, 2006), Anticancer Activity (Leticia and Costa, 2005; Gagetia et al., 2005), Hepatoprotective activity (Singanan et al., 2007; Ramnik and Harwinder, 2008). This plant can be cultivated on waste land and unproductive agricultural areas and can be use as a medicinal plant on daily basis due to its blessed medicinal values in curing different ailments, diseases and disorders.
CONCLUSION

It is quite evident from this review that Aegle marmelos is a divine tree which has taken an important place in Ayurveda, Unani, Siddha traditional system of medicine. The plant has various therapeutic applications due to its blessed presence of phytoconstituents. Almost all parts of the plant have been used for the treatment of various diseases. Thus, upon conclusion, this review demonstrates the applications of the bioactive compounds of A. marmelos in a single roof, thereby paving way for the plant researchers to explore this plant for wider applications in the near future that might enable mankind to get maximum benefit from the Nature and Natural products.

REFERENCES


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