IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Exploring The Amazing Secrets And Numerous Medicinal Values Of Aegle Marmelos(Bael Patra).

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ABSTRACT:

Bael, also called *Aegle marmelos* (Linn) Correa, is a member of the Rutaceae family, is commonly available in moderately sized, slender, aromatic tree with well-known medicinal uses in India and Additionally in Bangladesh, Pakistan, sri lanka and Burma are its native habitat. This plant is dedicated to lord Shiva. In addition, the plant is thought to have significant medicinal value. Whose medicinal description is also depicted in the Ajanta cave and is mentioned in ancient texts such as the Veda, Puranas, Charakha Samhita and Brihat Samhita. The plant is used in Panchang form in Ayurveda to treat Ulcer, dysentery and diarrhea. According to folklore, plant part can be use to treat high blood pressure, malaria, ulcers, stomachaches, diabetes, skin condition, typhoid, cancer and other diseases. The plant fruit is edible and has significant therapeutic value due to the presence of vitamins, minerals, and other antioxidants. Phytochemicals screening of Aegle marmelos leaves extract confirmed the presence of Alkaloid, saponin, flavonoids, phytosterol, tannins, terpenoids, amino acid, coumarins, phenol, fatty acid and phenolic compound. The plant is associated with medicinal uses and also holds various pharmacological and therapeutic properties including ,anti-microbial activity, anti-cancer, cardioprotective effect, anti-hyperlipedemic activity, anti-ulcer activity, anti-pyretic or anti-inflammatory activity, hepatoprotective activity, radioprotective activity, anti-spermatogenic activity, wound-healing activity, anti-convulsant activity, immunomodulator effect, anti-depressant, anti-proliferative effect, anti-malarial activity, anti-histiminic activity, anti-arthritis, anti- oxidant, anti- fungal activity, analgesic and toxicological studies. In this review article, an effort has been made to summarize the pharmacological, phytochemical, and medicinal aspects of the Bael plant.

KEY WORDS : Bael plant,Rutaceae,Anti cancer,Aegle marmelos.

INTRODUCTION:

Aegle marmelos is commonly known as Bael, which belongs to citrus family Rutaceae [1,2,3,4,5]. It is also usually known as Begal-quince, Bilva, Golden apple, Indian quince, Stone apple and Wooden apple, holy fruit and maredo (India). The Easter Ghats and Central India are the origin of the Bael tree. It is primarily found in tropical and sub-tropical regions and is native to the Indian subcontinent. The tree can also be found growing wild in the lower Himalayan Mountain ranges upto 500 metres above sea level. Bael grows along the foothills of the Himalayas in Uttarakhand, Jharkhand, Madhya Pradesh, the Eastern Coast, and the Deccan Plateau. It is found in almost every state in India, including Himachal Pradesh, Bihar, Jammu

and Kashmir, Kerala, Karnataka, Andra Pradesh, Tamil Nadu, Maharashtra, Uttar Pradesh, Punjab, Rajasthan, and West Bengal [6]. The plant is also referred to as "Shivaduma" because the trifoliate leaves of the plant are used in the prayers of lord shiva or kailasnath and Parvati. It is also thought that lord shiva lives beneath the Beal tree [7,4,11,8,9,10]. The Bael tree was said to be located in the Panchavati and chitrakuta hills, and the fruits of the tree have been known since the Ramayana era [10,4,12]. The plant is mentioned in Ancient Indian manuscripts such as Yajurveda and Mahabharata which contain references of "Tripatra". Tripatras is the name given to its ternate, fragrant leaves and are used in enchantments. Bael fruit is known as "Shree Phal" (head-fruit) or mostly likely "seer phal" because it resembles a skull with a soft interior and a white bone-like outer shell. It is referred to as "Shree Phal" in literary Sanskrit texts as well as in literature about rituals [7,9,13]. Brihat Samhita and Charka Samhita, two ancient treatises, also mention the medicinal qualities of the fruit of the Beal tree. Traditional Chinese, Ayurvedic, Siddha, Unani, and Tibetan medicines all contain Bael plants and the plant has significant therapeutic value, and its description is also mentioned in the Puranas, Vedas (Yajurveda), and has also been portrayed in the paintings of Ajanta Caves [14,15,16,17]. Plants are used to treat a variety of health issues, according to ancient texts like the Sushrut Samhita, Charak Samhita, Yajurveda, Rigveda, and Atharvaveda. [5,18] About 10 to 15 percent of the approximately 300,000 species of higher plants are thought to be have a history of use in traditional medicine. In terms of both quantity and India ranks second in the world for the value of its medicinal plant exports [19,20]. Every part of the plant, such as root, trunk, seed, and fruit has therapeutic qualities that can be used for treating various eye and skin infection and also a wide range of illnesses [1,21,22,23,3,10]. Bael is a very nutrient-dense fruit that contains a variety of organic acids, amino acids, fatty acids, minerals, carbohydrates, vitamins, proteins, fibres and have abundant health benefits. In addition, a number of studies on Beal have shown that it absorbs a wide range of nutrient, such as phenolic acids, flavonoids, alkaloids, tannins, and coumarins, among a large group of other phytochemicals [4,12,24,25]. Additionally, it serves as a climate purifier by absorbing harmful gases from the atmosphere and turning them into neutral or inactive substances [26]. In Ayurveda, all the parts of the Bael plant are utilized as "Panchang" to treat medical conditions like ulcer, fever, mental diseases, dysentery, diarrhea. The plant is also used to cure diseases like anemia, wound-healing, fractures, asthama, swollen joints, diabetes, jaundice, weakness, uropathy, vomiting sea food poisoning, snake bite, high BP, anthelmintic, brain typhoid troubles during pregnancy, malaria, cancer, stomach-ache, and gastroduodenal disorders [27,28,29,30,22,31,30]. The leaves have been used as an eye and ulcer poultice, as well as febrifuge and fresh leaf are administrated for dropsy, and beriberi, heart weakness [32]. Bael flower have a scent, and the flowers are used to make perfumes. Oil is used to scent hair and is high in limonene. Fruit is used to treat scum in the production of vinegar [7]. Beside this, the plant and its parts are associated with medicinal uses, pharmacological and therapeutic properties like, anti-microbial, anti-hyperlipidemic activity, antifertility, cardioprotective, anti-cancer activity, anti-ulcer activity, antipyretic or anti-inflammatory, radioprotective, hepatoprotective, anti-fungal, analgesic, wound-healing, anti-spermatogenic activity, anti-convulsant, contractile activity, immunomodulatory effect, anti-genotoxic effect, anti-depressant activity, anti-proliferative, anti-microfilariae, anti-malarial activity, anti-oxidant, anti-histaminic effect, anti-arthritis effect, nephroprotective, cytoprotective effect, anti-asthamatic, anti-stress, anti-thyroid, anti-ocular hypertension, insecticidial, and toxicological study[33,34,36,37,29,30] . The present review summarizes the information regarding Bael plant and its medicinal use, phytochemical constituents etc.

Figure 1: Aegle marmelos [Bael plant]

figure 2: Fruit of Bael plant

Figure 3: Leaf of Bael patra

Botanical Description and Morphology of *Aegle marmelos* (Bael Patra):

The medium height of slowing growing Bael tree is approximately 762 cm and 90-120 in breadth and its plant parts include bark, leaves, flowers, fruits, and seeds. Within the Bael tree, soft, thick and prickly stem branches are visible [4,20,37,38,30,39,22,30].

Table 1: provides botanical description of *Aegle marmelos*. [18,12,5,40,41,42,44,43,45,46]

Plant Parts	Morphological Description
Leaf	The leaves exhibit an alternating pattern and are typically trifoliate, with three to five leaflets, per leaflet measuring 4 to 10 cm in length and 2.5 to 5 cm in width. When leaves are young, their colour is relatively lighter, but as they mature, they become a darker shade of green.
Barks	The bark of the tree is thick and brittle, frequently spiky branches. A gum secretion is seen from the damaged bark, and it thickens when it comes into contact with air. These gums transparent, gummy sap may provide an explanation.
Fruits	Mainly yellowish green in colour, the Bael fruit has a diameter of 5.3-7.2 cm, an approximate weight of 77.2 g, a volume of 73.7 ml, and a sphericity of 93.72± 2.78 %.
Flowers	The Bael flower has a greenish-white colour. It also exhibits characteristics of being bisexual, ebracteate, hypogynous, actinomorphic stalk and sweet-smelling.
Pulp and seed	The fruit pulp is mucilaginous and yellow in colour, it is covered in a few dots on the outside and is full of hard seeds with white thread-like hairs all over the outside. The seeds are tiny (less than 1 cm long), hard, flattened, and oblong with woolly hairs that are each encased in an adhesive sac.

Table 2: Taxonomical classification of *Aegle marmelos* L. (Bael Patra)

Rank in taxonomy	**Taxon**
Kingdom	Plantae
Subkingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Mangoliopsida
Subclass	Rosidae
Order	Sapindales
Family	Rutaceae
Genus	*Aegle*
Species	*Aegle marmelos*

Table 3: Vernacular Name of the Bael Patra

Sanskrit	Atimangaliya, Ashilam, Adhararutha, Shivadruma, Shivaphala, Bilva, Vilva
Marathi	Bel
Hindi	Beli, Beligiri, Baelputri, Kooralam
English	Stone apple, Golden apple, Holy fruit, Elephant apple, Bael fruit, Indian Bael, Indian quince.
Urdu	Bel, Bel kham
Assamese	Bel
Tamil	Vilvam marum
Telugu	Bilva pandu
Gujarati	Bilivaohal, Bili
Karnataka	Bilpatra, Kumbala, Malura
Malayalam	Marredy
Kerala	Kuvalum
Andhra Pradesh	Maredu
Bengali	Bael
French	Bel indien, Cognassier du, Bengale, Oranger du Malabar
German	Belbaum, Schleimapfelbaum
Portuguese	Marmelo

Indonesian	Maja batuh, Maja
Burmese	Opesheet, Ohshit

Subtitution/Adulteration:

Mangosteen Fruits: This fruit can be replaced with Garcinia mangostana Linn (Guttiferae), which has a darker rind and radiating stigmas that are shaped like wedges.

Wood apple: Acidissima Limonia the fruit coor (Rutaceae) has five lobed and a rough outer layer.

Pomegranate rind: The seeds of Punica granatum Linn (Punicaceae) have triangle imprints, and the fruit tastes strongly of aspirin.

Allied species:

Table 5 Improved high yielding *Aegle marmelos* varieties in India

Allied species	Institute
Pant Aparna, Pant Sujata, Pant shivani, Pant Urvashi	G.B Pant university of Agriculture and technology, pant nagar, Uttarakhand
Gomma Yashi, Thar Divya and Thar Neelkanth	Central Horticultural experiment station, vejalpur, panchamahals, Gujarat
CISHB-1 and CISHB-2	ICAR-Central institute for subtropical Horticultural, Lucknow, UttarPradesh
Narendra Bael-5, Narendra Bael-7, Narendra Bael-9, Narendra Bael-16 and Narendra Bael-17	N.D University of Agriculture and technology, Kunarganj, Faizabad, Uttarpradesh

Geographical Distribution [53,54]

It is a native species of Southeast Asia and the Indian subcontinent that is grown in tropical and subtropical climate. The semitropical plant *A. marmelos* grows best at an elevation of about 1200 meters above sea level.Although the plant was said to need well-drained soil with a pH of 5-8, it has been discovered through numerous studies and grower reports that the plant can also thrive in stony, alkaline, and shallow soil [111]. Historical research indicates that the Bael plant has been around in India since 800 B.C. The plant grows throughout the Eastern Coast of India, the foothills of the Himalayas, Jharkhand, Uttar Pradesh, Bihar, Chhattisgarh, and Madhya Pradesh. The plant can grow in extremely hard soil where other plants cannot survive, and it is well-known for its fruit species in Sri Lanka and India.

Cultivation and Collection [55,56,57]:

Soil Conditions and Climate:

Despite being a fruit crop with subtropical origins, bael is more adaptable and can function as well in dry, semi-arid, and tropical environments. Although *Aegle marmelos* is supposed to thrive in rich, well-drained soil, it has developed successfully and produced fruit on southern Florida`s oolitic limestone. Additionally, it thrives in stony, alkaline, or marshy soils, with pH range of 5 to 8. For this tree to bear fruit, there must be a noticeable dry season. It is well-known in India for flourishing in areas where other fruit tree perish.

Propagation of plant:

Rainy season is the best time for planting. However, planting can also be done in spring season if irrigation facilities are available. When sown in the summer in irrigated semi-arid setting, seeds take 8 to 15 days to

germinate. Baelseed is a stubborn seed, so regular storage conditions will not allow the seeds to be kept longer. On occasion, seeds sprout while fruits are left on the tree for a longer period of time after they have ripened. Numerous damage signs result from the detrimental effects of salinity on tissue mineral composition, seed germination, seedling growth, and leaf chlorophyll content.

Training, pruning, and canopy management:

Modified central leader training can be used to Bael trees. Twice a year, in May and August, pruning is conducted. In May, pruning is restricted to removing dead and damaged twigs and branches; in August, healthy leaves are clipped in preparation for sale. In order for young plants to develop into the primary scaffold structure of the tree, they should be given the opportunity to grow four to six evenly spaced branches in all directions. It has been discovered that pruning 25% pf yearly growth during the leafless stage promotes the emergence of new shoots and the formation of a dense canopy to prevent sunburn, particularly in dryland settings.

Irrigation:

For fast vegetative growth and establishment, young plants require regular summer watering and a month-long break in winter. Because bearing trees shed their leaves and can withstand hot, dry summers, they do not need irrigation during the dry summer months. It is possible to apply irrigation when new leaves begin to appear.

Harvesting and yield:

While seedling begin to bear fruit after 8-10 years of planting, budded and grafted plants begin to do so after 4-5 years. Bael fruit matures in 8-10 months and takes 10-12 months after fruit set for ripening. Bael is a climacteric fruit that, when picked at the right maturity stage, can be ripened off the tree. The transition from a dark green to a yellowish green skull can be used to measure maturity.

Phytochemical constitution of Bael plant:

Table no 4: Phytochemical compounds present in *Aegle marmelos*, together with information on their availability, methods of detection, and activity.

Name of the phytochemical	Part of the plant	Examples	Activities	Methods of detection	
Flavonoids		Rutin, quercetin, flavonoid glycosides, catechin, flavan-3-ol,	Antioxidant activity	Shinoda`s test	
Alkaloids	Fruits and Leaves	Rutacine, N-2-ethoxy-2-(4-methoxyphenyl) ethyl cinnamide, N-2-hydroxy-2-(4-hydroxyphenyl) ethyl cinnamide, marmelosin, 3marmesin, marmin, aegelinosides A, aegelinosides B, aegelin, dictamine, aegelenine	Alpha-glucosidase inhibitor, anti-inflammatory, anti-bacterial, analgesic effect, anti-diabetic, anticancerous	Dragendorff`s test, Hager`s test, Mayer`s test, Wager`s test	
Terpenoids	Fruit, leaf, and bark	A-phellandrene, α-pinene, β-myrcene, β-ocimene, terpenolene,	Antimalarial, and anti-cancer drug	Noller`s test	

		linalool, farnesal, humulene, isosylvestrone, methyl perilate, caryophyllene, hexanylhexanoate.			
Coumarins	Fruit, seed, leaves, bark, root	Marmenol (7-geranyloxycoumarin [7-(2,6-dihydroxy-7-methoxy-7-methyl-3-octaenyloxy) coumarin], methyl ether, scoparome, marmelosin, marmin, psoralen, alloimperatorin, zanthotoxol, umbelliferone, psoralen	Anti-inflammatory, anti-oxidant, anti-diabetic, analgesic agents	Colorimetric test	
Caroetnoids and tannins	Fruits, unripe stage of Bael fruit	Skimminianine, 4,7,8-trimethoxyfuro-quinoline	Anti-oxidant activity, anti-microbial properties, helps in reducing blood pressure, Rasing serum lipid level enhances insulin sensitivity	HPLC method, Goldbeaters test	
Fatty acids	Seed, fruit, leaf	Stearic and linolenic acid, Pentadecanoic acid, stearic acid, Ricinoleic acid, palmitic, myristic acid, palmitoleic acid	Antimicrobial acitivity	Gas chromatography with a flame ionization detector.	
Organic acid	Fruits	Malic acid, Oxalic acid, tartaric acid	Anti-microbial activity	HLPC test	

Medicinal Uses and Pharmacological Activity [56,57,58,59]:

Analgesic, Anti-inflammatory and Antipyretic activity:

The anti-inflammatory properties of *Aegle marmelos* Corr. Leaf extracts were studied in series. Evaluations were also conducted for the analgesic and antipyretic qualities found that the majority of the extract significantly inhibits the paw oedema and cotton-pellet granuloma in rats that were induced by carrageenan. By reducing both the early and late stages of paw licking in mice, the extracts also demonstrated significant analgesic activity. Additionally, the majority of the extracts significantly reduced the incidence of hyperpyrexia in the rats. The alcoholic extract of Bael leaves antagonized the histamine induced contractions and showed a beneficial relaxing effect in tracheal chain and isolated guinea pig ileum, suggesting inhibition of H1-receptors activity these effects could be the result of this extract.

Anti-Cancer:

Bael`s hydroalcoholic extract has anticancer properties, leaves work well in the Ehrlich ascites carcinoma animal model. And the extract`s skimmianine content may be the cause of this activity. Leticia V. and Costa L. (2005) assessed the anticancer potential of traditional medicine used in Bangladesh and employed the MTT assay, brine shrimp lethality assay, and sea urchin eggs assay to test the cytotoxic impact of Aegle marmelos extracts on tumor cell lines. It was discovered that the *Aegle marmelos* extract was poisonous in every test that was performed.

Antimicrobial Activity:

In medicine, antimicrobial medications are used to treat food-borne illnesses. usage of antimicrobial-rich medicinal plants extracts Substance as a potential substitute for getting rid of pathogenic germs. *Aegle marmelos* extract has been discovered to be effective against a number of species, including Proteus vulgaris, Staphylococcus arueus, and S. epidermidis. Intestinal parasites and the virus causing ranikhet sickness have also been treated with it. Compared to gram-positive infections, antimicrobial action was more potent against gram-negative bacteria. Two leaf constituents, eugenol and cuminaldehyde, may be in charge of the antibacterial activity.

Anthelmintic Activity:

The Aegle's produce Marmelos is particularly helpful in paralysis and death

Anti-arthritis activity:

Aegle marmelos leaves were discovered to have anti-collagen properties resulting in arthritis in Wistar Albion rats. Notable decrease in the histopathological and changes in radiological parameters were noted in the experimental rat model following their administration of the plant's methanolic extract

wound Healing Activity:

The impact of the see d ointment's methanolic extract and the use of Bael plant injection to treat excision wounds was studied in the Wistar rat male model. The cream was put on top of the wound until it heals completely, then record the results on 0, 4, 8, 12, 16 and 20 days after the wound. Results indicated a quicker rate of healing and revealed a greater incidence of wounds when compared to the control sample. The enhancement of the tensile strength within the plant extract 102's healing process was depicted in the incision model.

Antifungal Activity:

Leaf extract from *A. marmelos* exhibited strong Antifungal properties as well. The ethanolic extract from the root demonstrated Antifungal effect on both A. fumigates and T. mentagrophytes. The Bael plant's essential oil that was extracted from its leaves demonstrated Antifungal Activity against Trichophyton mentagrophytes, T. rubrum, Aspergillus Nigeria, M. cookie, A. flavus, Histoplasma capsulatum, and Microsporum gypseum.

Antiallergic Activity:

Allergy sufferers can use its pulp as a herbal soap substitute because it has a detergent-like property.

Analgesic and Antipyretic:

Bael extract has been demonstrated to have antipyretic and analgesic properties, as evidenced by its notable suppression of carrageenan-induced paw edema, cotton pellet granuloma, and paw itching in rats and mice. It is not as safe to use other synthetic antipyretic medications as it is to use herbal ones. Bael is beneficial in treating fever and pain because of this antipyretic lower body temperature in feverish people but do not result in hypothermia in otherwise normal people. When an infection occurs, pyrogens such as interferon, TNFa, and ILs are produced, which causes fever which raised the hypothalamus's temperature threshold and caused PGE2 production.

Antidandruff Activity:

The Bael fruit is rind is used as a dandruff remedy. Soaking the rind in ginger or coconut oil is another way to treat excessive hair loss and flaky scalp skin.

Anti-oxidative Activity:

Oxidative stress is created by the body's regular metabolic processes as well as by a variety of chemical and environmental factors. These factors lead to the production of different reactive free radicals, which alter DNA and lipids. A compound's ability to reduce can be a strong predictor of its possible antioxidant activity. Antioxidants can function in one of two ways. One is by oxidizing itself or by encircling the material's active ingredients in a layer of defense. Using the DPPH radical scavenging method, nitric oxide scavenging assay, reducing power assay, H202 radical scavenging assay, ABTS radical scavenging assay, and superoxide radical scavenging assay81, the antioxidant activity of the methanolic and ethanolic extract of the fruit pulp of *A. marmelo*s plant was evaluated in a rat model. The plant's methanolic and ethanolic extract, which demonstrated strong antioxidant activity, were found to block free radicals. Unripe fruit has higher inhibitory action than ripe fruit.

Antidepressant and anxiolytic activity:

The Methanolic extract of the leaves of Bael plant showed antidepressants and calming effects in contrast to the mice model.

Adverse effect:

Bael`s non-toxic behaviour has been confirmed by clinical trials, ensuring that the pharmaceutical application is incredibly safe and free of side effects.

Marketed formulation:

Table 6 Uses of different portion of Bael patra in Marketed formulation.

Tree part	Product Name	Method of preparation	
Unripe Pulp	Dehydrated bael, Bael preserve	Dehydration Preservation with syrup	
Bael peel and Pomace	Cattle feed	Dehydration and grinding	
Bael Fruit Pulp	Bael slab Fruit beverages Bael tea Bael wine Bael panjiri	Drying Extracted juice and enhanced with pectin, whey protein, and carboxymethyl cellulose Juice extraction Yeast fermentation Dehydration and Grinding.	
Bael fruit seed	Seed cake oil Seed oil	Pyrolysis Ultrasonic extraction	

	Oil	Microwave extraction	

Home Made Remedies:

Not quite ripe,it has been discovered that Bael fruit pulp, when combined with sugar or honey, works incredibly well for treating dysentery, diarrhea, and other gastrointestinal issues. Because of its laxative properties, Bael leaf decoction with black pepper also aids in the management of constipation by loosening the stools.

Conclusion:

It is clear from the literature review that the A. maemelos plant has many therapeutic uses and is regarded as the most important medicinal herb. It is used to cure a variety of aliments in Ayurveda, Siddha, and other medicinal systems. The Bael tree serves as an indicator plant to locate subterranean water, according to folklore. The plant`s fruit juice has a variety of therapeutic qualities that supports overall health and lower the risk of illness. The phytochemical constituents extracted from the Bael plant have been shown in reported studies to have a variety of pharmacological and therapeutic activities, including antifungal, anticancer, anti-oxidant, radioprotective, hepatoprotective, anti-diabetic, anti-stress, antiulcer, anti-inflammatory, antimicrobial, wound healing, and anti-asthmatic properties. The plant`s fruit is edible, very nourishing, and has anti-oxidant qualities. Although the plants medicinal usefulness, has been extensively researched, more investigation is still needed to uncover the plant`s other phytoconstituents and investigation its as yet-undiscovered pharmacological and therapeutic qualities.

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