IJPSR (2022), Volume 13, Issue 11 (Review Article)

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 28 February 2022; received in revised form, 01 June 2022; accepted, 18 June 2022; published 01 November 2022

BAEL (*AEGLE MARMELOS*) AN ASTONISHING HERB OF INDIA: A REVIEW

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Keywords:

Bael, *Aegle marmelos*, Pharmacological Activities, Antibacterial, Antioxidant

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ABSTRACT: *Aegle marmelos* (L.) is an important plant with various medicinal values. It is commonly known as Bael (or Bel), belonging to the family Rutaceae. Bilwa is used to cure a variety of diseases. All the parts of this plant-like fruit, leaves, bark, stem and roots are used in different diseases, a variety of alkaloids are found in it. Compounds purified from the fruit have been proven to have biological potential against several diseases like diabetes, gastric ulcer and have lipid regulating properties. This review emphasizes the prospective applications of *Aegle marmelos* (L.) in the pharmaceutical field due to its extensive pharmacological applications.

INTRODUCTION: In present times we all know that herbal or natural products are more used than the allopathic medicines and it's all because the awareness among peoples regarding natural medicines, natural products. Natural products are obtained from the trees with various medicinal properties, which attracts major attention from various communities of India. This system of medicines have various plus points like they are non toxic, free from pollution and the major advantage is that all products don't have any side effects [1]. Plants have been extensively used as a natural source of drugs from the time when humans understood them. In various ancient books like Rigveda and the Yajurveda, there is a brief description of medicinal plants and their usage in saving life.

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.13(11).4363-72

This article can be accessed online on www.ijpsr.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.13(11).4363-72

Humans use various plants and their chemical compounds or plant-derived products science thousands of years to cure and treat various diseases. Various herbs are used in the traditional system of Medicines like Ayurveda, Sidha, Unani, and Tibetan medicines. Literature like Rigveda, the Yajurveda, Atharvaveda, Charak, Samhita, and Sushrut Samhita describes a range of plants used to heal various health problems and diseases [2]. Only 350 species of the 6000 plants specified in ancient medical systems are used, the majority of which are herbs, *Aegle marmelos* (L.) Corr, is very important in everyday life [1]. A variety knows it of names in India, including bilva, bel, sadaphal and shriphal [3].

Bael, botanically known as *Aegle marmelos*, is mentioned in several Shiva reloads, and the location is known as Bilkeshwar temple. Bilva is a medium-sized tree with fragrant white blossoms. Its leaves begin to fallacious and Ayurvedic texts of India towards the conclusion of the spring season. Bilva is another name for this plant. Its leaves are employed in Lord Shiva's devotion. Prbatiji is said to have worshipped under the Bilva tree in Haridwar for three thousand years before marrying

Ling and the tree has fresh leaves and blooms in the summer [4]. *A. marmelos* is one of India's, Burma's and Ceylon's most significant medicinal herbs [5].

It grows wild in Central and Southern India and is cultivated in Northern India. The genus *Aegle* has three species found in tropical Asia and Africa. The Rutaceae family includes *A. marmelos*. The novelty of Bael fruit is that it is utilized in its raw condition, that is, before it has matured off the tree. According to the Shiva Purana, a person who serves and feeds milk, ghee, and grains to a hungry devotee of Lord Shiva on the roots of its tree would never be poor. These plants have been widely examined using modern scientific techniques and have been reported for a variety of therapeutic qualities, including anticancer, antibacterial, antifungal, antidiabetic, antioxidant, hepatoprotective, haemolytic, larvicidal and anti-inflammatory action [6].

A. marmelos is a tree that grows slowly, medium in size tree with a short trunk, thick, soft and flaking bark. The spines are rigid and straight.[7] This plant is used in traditional medicine for a variety of diseases, including intermittent fever, digestive problems, fertility control, postpartum therapy, and seafood poisoning [8].

It is included in British pharmacopeia as it has efficacy in treating diarrhea and dysentery [9]. According to Chopra "No medication has been longer and better known nor enjoyed by the people of India than the Bael fruit." Vedas (Ayurvedic practitioners) employed Indian Bael as a component in respective herbal formulations for boil, dysentery, earaches, discharge from the ears and fever or cold in a Himalayan area (State of Uttaranchal, Indian Republic) from 2001 to 2002, according to a survey.

Traditional medicine has employed ripe and unripe fruits, roots, leaves, and branches. The ripe fruit has been utilized in Ayurveda for chronic diarrhea and dysentery, as a heart and brain tonic, and as adjuvant therapy for dysentery [5]. Diarrhea, dysentery, dyspepsia, stomach discomfort, seminal weakness, uropathy, vomiting, diabetes, snake bite, seafood poisoning, and certain antiviral activity are all treated using extracts from various sections of the plant [10]. An attempt is made to analyze the antibacterial activity of leaf, bark, and fruit extracts in light of the traditional usage of *A. marmelos* in medicine. The leaves have been used as a febrifuge and a poultice for treating eye problems and ulcers, as well as fresh leaf administration for heart weakness, dropsy, and beriberi [11].

Plant Profile:

Botanical Name: *Aegle marmelos*

Common Name-: Bael

Biological Source: Bael consists of the unripe or half-ripe fruits or their slices or irregular pieces of *Aegle marmelos* Corr., belonging to the family Rutaceae [12].

Classification:

Kingdom: Plantae

Subkingdom: Tracheobionta

Division: Magnoliophyta

Class: Magnoliopsida

Subclass: Rosidae

Order: Sapindales

Family: Rutaceae

Genus: Aegle

Species: marmelos

Plant Names in Different Language [4]:

Hindi: (Baelputri, bela, sriphal, kooralam).

Sanskrit: (Bilwa, sriphal).

German: (Belbaum, Schleimapfelbaum).

English: (Bael fruit, Indian bael, holy fruit, golden apple).

Urdu: (bel).

Gujrati: (Billi).

Arab: (Bull, Quiththa el hindi).

Indonesian: (maja batuh, maja).

Japanese: (modjo).

Vietnames: (tar imam, mbau nau) [4].

Morphology of the Plant: *A. marmelos* tree is 25 and 30 feet tall. The spines of young suckers are rigid and straight. This tree has sharp, one-inch long axial spikes [4, 13].

Leaves: The leaves are alternating, pale green, and trifoliate; the terminal leaflet is 5.7 cm long, 2.8 cm wide, and has a long petiole; the two lateral leaflets are virtually sessile, 4.1 cm long, 2.2 cm wide, and oblong to lanceolate with reticulate pinnate venation; and the petiole is 3.2 cm long [4].

Leaflets: The leaflets are oval or lance-shaped, with a length of 4-10 cm and a width of 2-5 cm. It has 3 to 5 leaflets in its leaves. The lateral leaflets lack petioles, but the terminal leaflet possesses a lengthy one. The petiole measures 1 to 2.5 inches in length. When mature leaves are injured, they exude an odd odor.

Flowers: Flowers appear in clusters of four to seven along juvenile branchlets, with four re-curved, fleshy petals. The blooms are greenish-white in hue and have an unusual scent. The months of May and June are when the flowers bloom [14].

Fruit: The fruit is spherical or oval in form and is 2 to 4 inches in diameter. Nature's shell is thin, rigid, and woody. When unripe, it is greenish, but as it ripens, it turns yellowish. The fruit's pulp is divided into 8 to 15 segments. Yellow, soft, pasty, sweet, resinous, and fragrant, the pulp is yellow, soft, pasty, sweet, resinous, and aromatic.

Seeds: They are individually contained in an adhesive sac. The seeds are completely encased in the pulp. The seeds are hard, flattened-oblong, and covered with fuzzy hairs [4, 13].

Stamens: Several elongate, apiculate filaments, free or fascicled, are inserted around a small disc. Ovules numerous, 2-seriate; ovary ovoid, cells 10-20; style terminal, short, deciduous; stigma capitate; ovules numerous, 2-seriate [4].

Origin of the Plant: *A. marmelos* is a species that grows in the subtropics. It grows up to an altitude of 1,200 m in the Punjab, where the temperature in the shade may reach 48.89°C in the summer and -6.67°C in the winter, and protracted droughts are common. Although *A. marmelos* prefers rich, well-drained soil, it has thrived and produced fruit on the oolitic limestone of southern Florida.

It may also thrive in marshy, alkaline, or stony soils with pH levels ranging from 5 to 8. Flowering occurs in India in April and May, just after the new leaves develop, and fruition happens in May and June [5, 15].

Geographical Source of the Plant: *A. marmelos* is a subtropical plant that may reach a height of 1,200 meters above sea level. It thrives in dry woodlands on steep and plain terrain. *A. marmelos* grows in India, Ceylon, China, Nepal, Sri Lanka, Myanmar, Pakistan, Bangladesh etc. In India, it may be found in Sub-Himalayan plains stretching from Jhelum to West Bengal, as well as in central and southern India. It can be found in practically all of India's states [13].

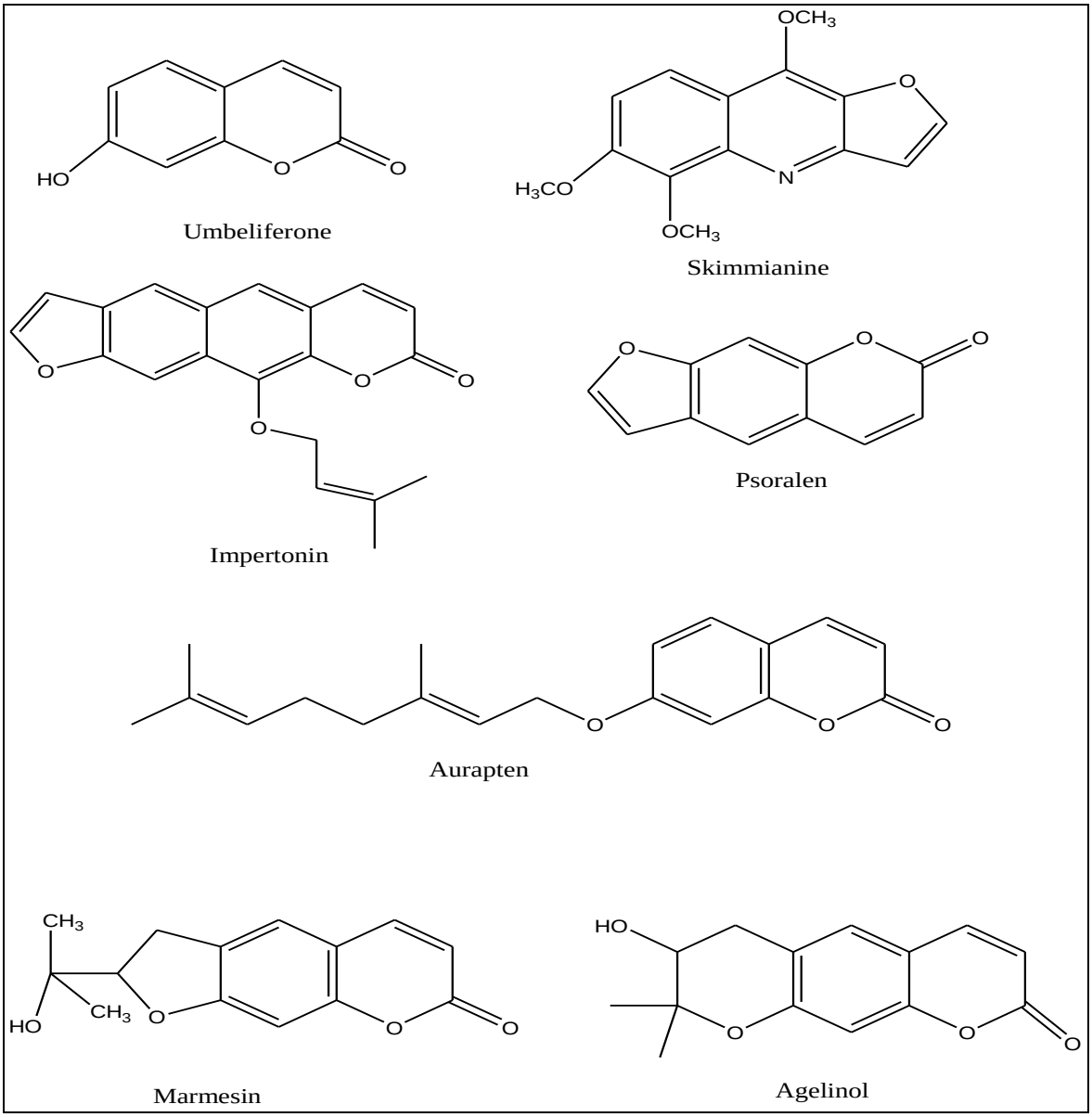
Chemical Constituents of Plant:

Leaves: Alkaloids, mermesinin, rutin, phenylethyl cinnamides, anhydromarmeline and aegelinosides [16, 17, 18, 19] sterols and essential oils are found in leaves [20].

Stem Barks and Roots: As aegelinol, it contains a coumarin. Psoralen, xanthotoxin, coumarins, tembamide, mermin, and skimmianine are all found in the roots [21].

Alkaloids: Alkaloids are the most diverse group of secondary plant compounds. New alkaloids have been discovered in the leaves of *Aegle marmelos*. *viz.*, ethyl cinnamamide, O-3, 3-(di methylallyl) halfordinol, N-2- methoxy-2-[4-(3',3'-dimethylallyloxy) phenyl] ethyl cinnamamide *etc* [22].

Coumarins: The bark, leaves, fruit, and root of the plant included marmin, marmesin, umbelliferine, umbeliferone, skimmianine, Scoporone, scopoletin, psoralen, marmelide, xanthotoxol and impertonin [11, 23]. Marmelosin, skimmianine, and umbelliferone are the therapeutically active principle constituents of *A. marmelos* [24].



Nutritional Value: A physicochemical analysis of *A. marmelos* reveals that it also has a high nutritional value. The pulp of *A. marmelos* is high in glucose and sugar and is also used to make an energy drink with milk.

Proteins, lipids, fibre, calcium, minerals, iron, vitamin A, vitamin B1, vitamin C, and riboflavin are among the other nutrients found in *A. marmelos* [24, 25]. The leaves and shoot are used as a green vegetable in Indonesia [25, 26].

Traditional Uses of *Aegle marmelos:* A. *marmelos* is extensively described in the Vedic literature for the treatment of various diseases.

Seed: Seed oil has antibacterial properties and inhibits the growth of *Vibrio cholerae*, *Staphylococcus aureus* and *Escherichia coli*, among other microorganisms [27].

Root: Root bark is used as a cure for palpitation of heat and melancholia, intermittent fever, and fish poison. The bark juice mixed with a little cumin in milk is used as a treatment for seminal fluid deficiency. Root alcoholic extract with hypoglycemic properties [28]. It's also used to treat dog bites, stomach problems, heart problems, intermittent fevers, antiamoebic, hypoglycemia, and rheumatoid arthritis [29].

Leaves: Abscess, backache, abdominal disorders, vomiting, cut and wounds, dropsy, beriberi, heart weakness, cholera, diarrhea, cardiotonic, blood sugar, animal injuries, neurological disorders, hair tonic, acute bronchitis, child delivery are all

conditions where leaves are employed [30]. Veterinary treatment for wounds, worms and fodder for sheep, goats and cattle, as well as stimulation of membrane contraction in anaesthetized cats [31].

Flower: The medicine was created by distilling flowers and was used as a stomach and intestinal tonic, anti-dysenteric, antidiabetic, diaphoretic and local anesthetic. It's also used as an expectorant and for epilepsy [32].

Fruit: Fruits are also used as a laxative, tonic, digestive, stomachic, dysentery, brain and heart tonic, ulcer, antiviral, intestinal parasites, gonorrhea and epileptic treatment [33]. Fruit is eaten during convalescence after diarrhea [34].

Pharmacological Activities of *Aegle marmelos:*

Antidiarrheal Activity: The unripe fruit of *Aegle marmelos* is a powerful antidiarrheal and dysentery treatment that humans have used for centuries. *Aegle marmelos* has been shown to have antidiarrheal properties in several studies [35].

Antifertility Activity: The leaves of *Aegle marmelos* are the most efficient in fertility treatment. The weights of the testis, epididymes, seminal vesicle, testicular sperm count, epididymal sperm count, and motility all decreased significantly [36].

Anthelmintic Activity: The fruit of the *Aegle marmelos* is very useful in cases of paralysis and death [37].

Toxicology: The leaves of *Aegle marmelos* are particularly useful in Short-term toxicity was not observed after chronic ingestion of leaf powder. It has a large medication safety margin [38, 39].

Immunomodulatory: In rats, the leaves of *Aegle marmelos* induce both cell-mediated and antibody-mediated immune responses [40], with a high dosage being more efficient in humoral immunity [41].

Antioxidant Activity: Antioxidant activity against a range of free radicals has been widely documented for *A. marmelos*. The fruit of *A. marmelos* has been shown to have antioxidant properties. Natural sources, such as plants, can provide antioxidant chemicals. Flavones, isoflavones, flavonoids, anthocyanin, coumarin lignans, catechins and isocatechins are all antioxidants found in these plants. Antioxidants are substances that have free radical scavenging action and can protect cells from oxidative stress caused by free radicals [42].

Antidiabetic Activity: In alloxan diabetic rats, the leaves of *A. marmelos* were found to have anti-diabetic action. A methanolic extract of *A. marmelos* leaves lowers blood sugar levels [26, 43]. In the Ayurvedic system of medicine, leaf extract has been used to treat diabetes. It improves the body's ability to use exogenous glucose loads by stimulating glucose absorption with insulin [24].

Anticancer Activity: Leticia V. and Costa L. (2005) examined the anticancer possibility of Bangladeshi traditional medicine, utilizing brine shrimp lethality assays, sea urchin eggs assays, and MTT assays using tumor cell lines to test extracts of *Aegle marmelos*. On all of the tests utilized, the extract of *Aegle marmelos* was established to be unsafe [44]. Similarly, Gagetia G.C. *et al.* (2005) found that hydroalcoholic extract of bael leaves in an animal model of Ehrlich ascites carcinoma has an anticancer effect [45].

Antiulcer Activity: According to Goel R.K. (1997) Pyranocoumarin extracted from the seeds of *Aegle marmelos* Correa provided considerable protection against pylorus-ligated and aspirin-induced ulcers. -induced stomach ulcers in rats and guinea pigs, as well as cold restraint stress-induced ulcers in rats and guinea pigs [46,47].

Antimicrobial Activity: Antimicrobial activity was stronger against gram-negative germs than against gram-positive pathogens [48]. Cuminaldehyde and Eugenol, two leaf components, may be responsible for antibacterial action [49].

Anti-inflammatory Activity: The unripe fruit pulp of *A. marmelos* has been shown to have anti-inflammatory properties. Inflammation was generated in Sprague Dawley rats by injecting 0.1 ml of 1% carrageenan into the sub planer side of the left hind paw. The carrageenan-induced inflammation in the inflamed rats was dramatically decreased after extract administration [50].

Antifungal Activity: *A. marmelos* leaf extract also showed potent antifungal activity [51].

Antipyretic and Analgesic Activity: In one investigation, *A. marmelos* extract was shown to have antipyretic, anti-inflammatory, and analgesic properties in experimental mice. *A. marmelos* was screened for analgesic activity by an Acetic acid-induced writhing test in Swiss mice. The results indicated that methanol extract significantly reduced the writhing induced by acetic acid [52, 53].

Cardioprotective Activity: *A. marmelos* has also been used as a cardio protective in several trials. The preventive effect was determined by administering leaf extract to experimental animals suffering from isoprenaline-induced myocardial infarction [52-54].

Antidandruff Activity: The rind of the *A. marmelos* fruit is utilized in dandruff treatment. Excess hair loss and flaky scalp skin can also be treated by soaking the rind in coconut oil or ginger oil.

Hepatoprotective Activity: Singanan *et al.* investigated the hepatoprotective effects of *A. marmelos* leaves in albino rats with alcohol-induced liver damage. The findings revealed that the leaves of *A. marmelos* have a strong hepatoprotective effect [55].

Antiallergic Activity: As its pulp contains a detergent characteristic, it can be used as a herbal soap replacement for allergy sufferers [56].

Antipyretic Activity: Modern medication is not as safe as natural therapy. *A. marmelos* has an antipyretic effect and is used to treat fever and pain [57, 58].

Anti-inflammatory Activity: Different Bael leaf organic extracts have anti-inflammatory, Analgesic, and antipyretic effects that are both acute and subacute [59]. Because Lupeol and Skimmianine have exhibited the same potentialities in pure form, their activities might be due to their existence in the leaves [60].

Anti-constipating Effect: Most readily accessible ripe fruits are used as natural laxatives. The fruits of *A. marmelos* are commonly used to cleanse and tone the gut. After two to three months of regular consumption of this fruit, the intestines are cleared of old stored fecal matter. It is commonly consumed as 'Sherbat,' which is formed from the pulp of ripe fruit [61].

Antiarthritic Activity: Arthritis and gout are treated with raw bael fruit. When combined with heated mustard oil, its pulp can be administered to inflamed joints to relieve pain [62].

Antiepileptic Activity: The leaves of *Aegle marmelos* were shown to exhibit antiepileptic action. When taken orally with honey, a cooked mixture of all of these botanicals in water demonstrated great effectiveness in treating epilepsy [62].

Insect Controlling Properties: *A. marmelos* essential oil was found to have insecticidal efficacy against four stored grain insect pests: *Callosobruchus chinensis* (L.), *Rhyzopertha dominica* (F.), *Sitophilus oryzae* (L.) and *Tribolium castaneum* [63].

Anti-viral Activity: The total phenolic content, total flavonoid content, antioxidants, and antibiofilms of methanolic extracts of *Aegle marmelos* (Bael) leaves and fruit, as well as its in ovo antiviral ability against Newcastle disease virus [64].

Anti-anemic Activity: In rats, the hydro-alcholic leaf extract of Aegle marmelos has anti-anemic action when used to treat phenyhydrazine-induced anaemia. The leaf of the *Aegle marmelos* plant has an anti-anemic effect, which might be owing to its high iron concentration [65].

Radioprotective Effect: The micronucleus assay was used to assess the radioprotective activity of a hydroalcoholic extract of *Aegle marmelos* in cultured human peripheral blood lymphocytes. The results show that AME at 5 mg/ml protected HPBLs against radiation-induced DNA damage and genomic instability and that its radioprotective action may be due to scavenging of radiation-induced free radicals and enhanced oxidant state [66]. In another study, the hydroalcoholic extract of the fruit is administered to mice exposed to gamma radiation to investigate the radioprotective effect of bael. The extract is given intraperitoneally for 5 days at varying quantities of 5, 10, 15, 20, or 40

mg/kg. After that, they are subjected to Cobalt (Co) gamma-rays at a dose of 10 Gy. The majority of the survivors are discovered around day 10 or 30. A 20 mg/kg concentration was shown to provide the best impact. Bael extract has been proven to have a radioprotective effect after 30 days of therapy [67, 68, 69].

Anti-asthmatic Activity: Bael leaf decoction is useful for decreasing phlegm in colds and asthma. The tracheal chain of the guinea pig ileum demonstrates an antagonistic influence on contraction induced by histamine [70, 71]. The presence of aegeline in bael leaf aids in the inhibition of histamine release from mast cells [72]. Histamine release is influenced by intracellular Ca signaling events and mast cell type. Another research shows that skimmianine, found in bael roots, aids in the release of histamine from rat mast cells [73].

Cytoprotective Effect: In research involving Cyprinus carpio, the freshwater fish was held in sub-lethal metal ion concentrations for 1, 8, 16 and 32 days. After 32 days, fish are given bael powder at a dose of 500 mg/kg. Bael's cytoprotective impact is demonstrated by plasma membrane stability and antioxidant enzyme system regulation [74]. Bael may efficiently protect RBCs from oxidants, indicating that it has cytoprotective properties [75].

Anti-ocular Hypertension Activity: Rabbits have been shown to have acted in decreasing intraocular pressure [76]. This is comparable to timolol. The chloroform extract of bael leaf has been used to treat cataracts by boosting glutathione, catalase, and superoxide dismutase, decreasing lens aldose reductase (AR), and lowering osmotic stress at doses of 150 and 300 mg/kg body weight [77, 78].

Anti Spermatogenic Activity: For sperm to mature, they must travel through the epididymis caput, corpus, and cauda [79]. Sperm motility may be reduced by bael leaf. The usage of the bael leaf restricts the spermatogenesis process [80]. The bael leaf extract was given to male rats at doses of 200, 400 and 600 mg/kg in an experiment. The results demonstrate a significant decrease in sperm count in rats. The concentration of sperm in the epididymis and sexual behaviour have been reported to alter [81, 82]. Leaf extract therapy reduces cell counts in the seminiferous epithelial cell cycle at stage VII. The dose level has no adverse effects on the liver or kidneys [83].

Anti-stress Activity: The anti-stress action of bael in albino rats has been studied using swimming endurance, as well as post-swimming motor function tests, forced swim tests, and cold swimming endurance tests [84].

The blood cholesterol and triglyceride levels did not rise in the forced swim model to determine the adaptogenic activity of bael. Still, there was an increase in swimming endurance time, rota rod falling time, and spontaneous motor activity. During times of stress, these markers can be diminished [85]. Bael extract can raise plasma corticosterone levels, lower glucose levels and decrease non-enzymatic antioxidants. Fruit contains vitamins C and E, which might help alleviate stress [86].

Anti-genotoxic Effects: In genetics, this is known as genotoxicity, and it occurs when various chemicals destroy genetic components such as DNA and RNA in cells. Following ROS removal, dietary components utilized in chemoprotective medicines damage DNA. Bael extract with various phytochemicals and different solvents has antigenotoxic action [87].

SOS response has been diminished in chromotest hydrogen peroxide-induced SOS and aflatoxin B1. The presence of polyphenols has been shown to protect DNA from reactive oxygen species. Another investigation indicated that bael extract at 250 mg/kg had the best effectiveness against doxorubin-induced genotoxicity [88].

Anti-microfilariae: Filariasis is a parasitic worm disease caused by filaridea worms. Microfilariae motility loss can be aided by Vitex negundo L root extract and Bael leaf extract at a dosage of 100 ng/mL [89, 90].

Contractile Activity: In the ileum and tracheal chain isolated from guinea pigs, an alcoholic bael extract at 1 mg/mL and 2 mg/mL can demonstrate contractile action. Maximum relaxation has been seen in the H1 receptor as a result of depression [91].

CONCLUSION: *Aegle marmelos* (Bael) is a plant with many therapeutic characteristics, as evidenced by the pharmacological activities described above. It has been extensively used as folk medicine to cure a variety of disorders.

The truth that the whole plant of *Aegle marmelos* has considerable therapeutic potential is simply predicted by studies. The creation of current pharmaceuticals from *A. marmelos* might be stressed to control numerous ailments, as pharmacologists look forward to developing new treatments from natural sources. To create products, a comprehensive research and development effort should be done to improve their economic and therapeutic usage.

ACKNOWLEDGEMENT: The authors are thankful to the Management of Jagannath University Bahadurgarh for providing the necessary support.

CONFLICTS OF INTEREST: The authors declare no conflict of interest

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How to cite this article:
Garg D, Pragi, Sharma A and Kumar V: Bael (*Aegle marmelos*) an astonishing herb of India: a review. Int J Pharm Sci & Res 2022; 13(11): 4363-72. doi: 10.13040/IJPSR.0975-8232.13(11).4363-72.