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# Unlocking the Medicinal Potential of Aegle marmelos: A Review of its Phytochemical and Pharmacological Properties

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**ABSTRACT:-**

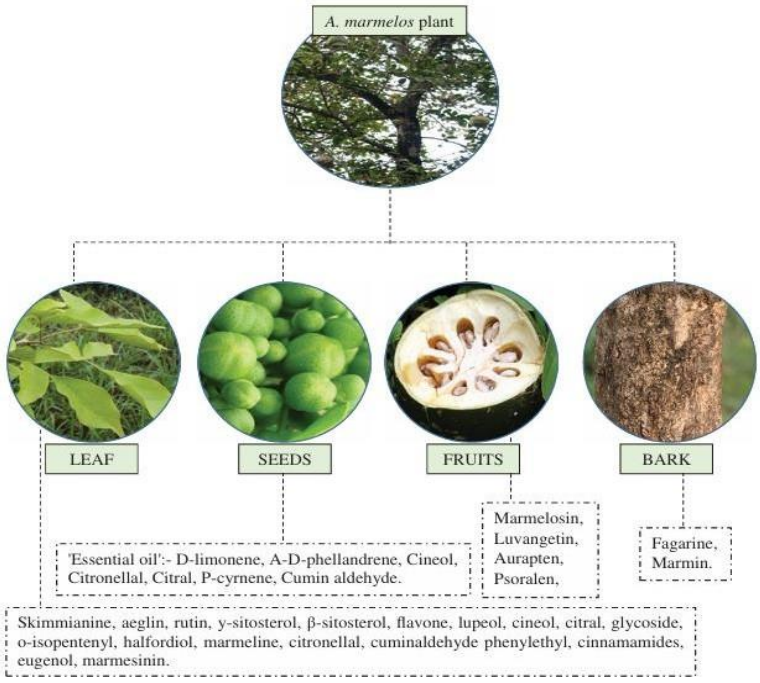
The Rutaceae family includes the fruit tree Aegle marmelos L., also known as bael, which is grown extensively worldwide. Because of its nutrient-dense fruits, extensive traditional medical use, and pharmacological qualities, this plant is becoming more and more well-known.Fibers, carotenoids, phenolics, terpenoids, coumarins, flavonoids, and alkaloids are components that contribute to the preventive and health-promoting properties of bael fruit.Numerous in vitro and in vivo investigations have evaluated these substances' potential for treatment. Fruit exhibits a variety of potential health advantages, including peroxidation, bactericidal, inhibitory, and radioprotective properties.anti-inflammatory colitis, lipid, antidiarrheal, gastroprotective, antiviral, antidiabetic, cardioprotective, antioxidant, and hepatoprotective properties,which characteristics enable it to contribute to the prevention and management of numerous illnesses.Thus, it is valuable to examine its medicinal qualities in order to provide scientists, both ancient and modern, with a general understanding of its status. This review also discusses how the aforementioned plant might be used in pharmaceutical field because of its broad range of pharmacological actions.

**Keywords:-** Aegle marmelos , antifertility activity, carotenoids, Phytochemistry, Pharmacological properties,

## INTRODUCTION:-

The natural world has a great supply of cures for human ailments. Around 80% of people worldwide rely entirely or in part on traditional medication to address its basic medical demands [1,2].A World Health Organization survey from 1993 states that practitioners of traditional medicine treat roughly 90% of patients in Bangladesh, 85% in Burma, and 80% in India [3]. For thousands of years, herbal remedies have been utilized as the main treatment in traditional medical systems, and they have greatly aided in preserving human health [4].Secondary metabolites, which might be used to make medications, and therapeutic essential oils are abundant in medicinal plants.significance. In addition to being affordable, efficient, and readily available, the safety of medicinal plants is one of the key benefits cited for their therapeutic applications in treating a variety of illnesses [5].Indigenous Indian medical systems have made extensive use of Aegle marmelos (L.) Correa (A. marmelos), also referred to as Bael and a member of the Rutaceae family, because of its numerous therapeutic benefits. Although A. marmelos is indigenous to Northern India, it is also widely distributed throughout the Indian Peninsula, as well as in Bangladesh, Thailand, Ceylon, Burma, and Indo-China [6]. It is an armed, medium- to large-sized, deciduous, glabrous tree with globular fruits, small flowers, and alternate trifoliate leaves that are 2.5 cm long and axillary [7].Numerous disorders can benefit from bael's abundance of phytochemicals, which include alkaloids, tannins, essential oils, gums, resins, coumarin, and polysaccharides.

**[ FIG 0.1 PhytochemicalspresentindifferentpartsofAeglemarmelos[Colourfigurecanbeviewedatwileyonlinelibrary.com] [8]**



## Biological profile:-

***Synonyms:-***

Hindi (Bel, Bael, Sripal); Sanskrit (Bilva, Sriphal, Shivadruma, Shivapala); Telugu (Maredu); Bengali (Bel); Gujrati (Bil); Kannada (Bilpatra, Kumbala, Malura); Thai (Matum and Mapin); and Cambodia (Phneou or pnoi); Java; French (Oranger du Malabar); Portuguese (Marmelos); Vietnamese (Baunau); Malayan (Majapahit). are some of the synonyms for Bael.[9]

***Ecology :-***

Bangladesh, Egypt, Malaysia, Myanmar, and other nations are home to the Indian species known as bael. Three of the most populated nations in the world include Pakistan, Sri Lanka, and Thailand. The tree grows in the wild. Dry woodlands in the central and southern regions can be located on plains and hills. Bangladesh, Pakistan, India, and Burma are all located in the same area.[9]

***Parts of plant:- Leaves***

The deciduous, alternate leaves are borne alone or in pairs or threes and consist of three to five oval, pointed, shallowly toothed leaflets that are 4–10 cm long and 2–5 cm wide. Long petioles and ripe leaves have a definite smell. It gives out a foul odor when damaged.[10]

**[fig 0.2 leave of beal ] [11]**

***Flower***

Soon after the new leaf appears, in April and May, flowers begin to bloom. Along the immature branchlets, fragrant flowers with four recurved, fleshy petals that are green in color bloom in clusters of four to seven.
There are at least fifty golden stamens that are greenish on the outside and yellowish on the inside.[10]

**[fig 0.3 Flower Of Bale ] [12]**

***Fruit***

Fruits The fruit has a thin, hard, woody shell or a more rectangular shell and is round, pyriform, oval, or oblong in shape with a diameter of 5 to 20 cm.
ggray-gree until the fruit is completely ripe or has a less tender rind.
It becomes yellow when it is completely ripe. It has tiny, aromatic oil glands scattered throughout. Both a soft and a hard central core are present inside.

8–20 hardly noticeable triangular segments with thin, slender, rich orange walls that are packed with delicate, fragrant orange Pulp has a slightly astringent, sweet, resinous texture. FruitIt takes 10–11 months from bloom to ripening.[13]

***Fruits include***

1.8 grams of protein, 0.39 grams of fat, 1.7 grams of sugar, and 61.5 grams of water.
55 milligrams of carotene, 31.8 grams of carbs, minerals, and 0.13 Vitamin A in milligrams. Eight milligrams of niacin, 1.1 milligrams of niacin, 1.19 milligrams of riboflavin,
and thiamine.
One hundred grams of edible vitamin C. The nutritional content of the bael fruit is high. nutrient-dense and highest in riboflavin.[13]

.

**[Fig o.4 Bael Fruit ] [14]**

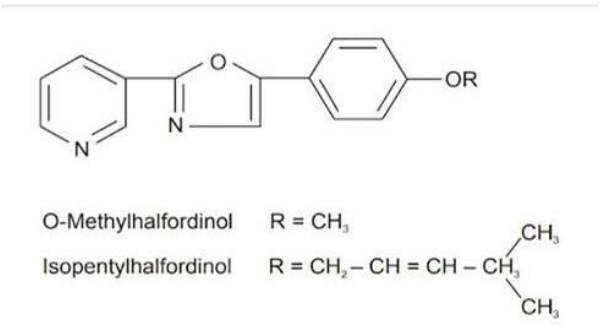
***Chemical composition***

Among the various chemical components that have been isolated and identified from the Tree parts that can be eaten include bark, roots, wood, leaves, and fruits. [15]

***Coumarins***

Alloimperatorin, alloimperatorin, alloimperatorin, alloimperatorin, alloimperatorin, imperatorin, marmin, marmelosin, marmesin, and alloimperatorin Psoralen, scopoletin, methyl ether, xanthotoxol, umbelliferone, and scopoparone Marmenol is also referred as as

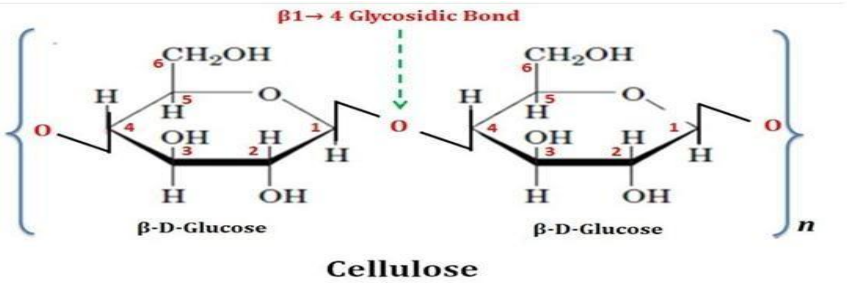
7-geranyloxycoumarin, or marmelide27, is a 7-methoxy-7-methyl-3-octaenyloxy [7-(2, 6-dihydroxy-2, 6-dihydroxy-2, 6 dihydroxy-2, 6-dihydroxy-2, 6-dihydroxy-2]. [15]




***Alkaloids***

Dictamine, fragrine (C13H11O3 N), marmeline, aegelin, and aegelenine Opentenylhalfordinol27, N-2-[4-(3', 3'-Dimethylallyloxy), O Methylhalfordinine
[phenyl] N-2-hydroxy-2-[4-(3', 3'-dimethylallyloxy) Phenyl] ethyl cinnamide N-2-hydroxy-2-(4-hydroxyphenyl), N-4 Methoxystyryl Cinnamide, and Ethyl Cinnamide Ethyl Cinnamide 29, 30, N-2ethoxy-2-(4-methoxy phenyl) ethyl, O- (3, 3-dimethylallyl) halofordinol N-2-methoxy-2-[4-(3', 3'-dimethylallyloxy) phenyl] cinnamide N-2-methoxy-2-(4-methoxyphenyl)-ethylcinnamide and ethylcinnamide 3. [15]

***Polysaccharides***



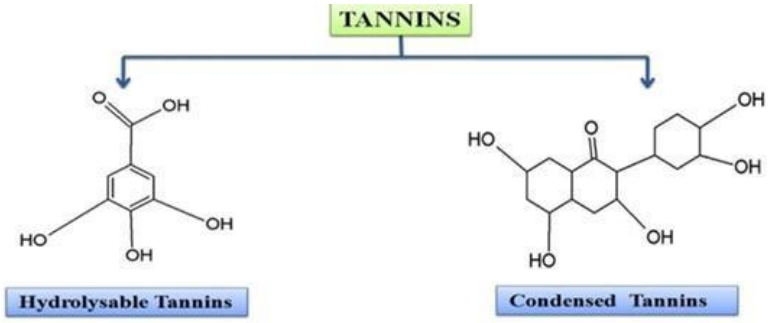

**[fig 0.5 Cellulose Chemical Structure ] [16]**

Hydrolysis yields galactose, arabinose, uronic acid, and L-rhamanose.

**Seed oil**

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

**Tannin**




**[fig 0.6 Chemical Structure Of Tannins ] [17]**

January was the month with the highest tannin concentration in Bael fruit. The pulp of wild fruits contains up to 9% tannin, but the pulp of domesticated fruits contains less. Leaves also contain tannin in the form of skimmianine.

**Pharmacological properties :-**

- Antidiarrhoeal activity
- Antimicrobial and antiviral activity
- Radioprotective effects
- Anticancer activity
- Antigenotoxic activity
- Ulcer healing potential
- Antipyretic potential
- Diuretic activity
- Antifertility activity
- Toxicological studies

**1. Antidiarrhoeal activity ;-**

Mazumder et al. investigated the chloroform extract of A. marmelos root's antidiarrheal potential both in vitro and in vivo. According to an in vitro investigation, the extract was similar to that of ciprofloxacin and mostly effective against Vibrio cholerae strains, with Escherichia coli (E. coli) and Shigella spp. coming in second and third, respectively [18].

Additionally, it was discovered that rats' intestinal propulsion was reduced by a methanol extract of A. marmelos fruits [19].

The development and activity of certain enterotoxins as well as the bacterial colonization of the gut epithelium were impacted by the unripe fruit pulp of A. marmelos. These imply the variety of potential ways in which A acts. marmelos in contagious types of diarrhea, confirming its reference in ancient Indian writings and the local communities' ongoing use of herb for the therapy for diarrheal illnesses [20].

**2. Antipyretic potential :-**

Shukla et al. assessed A. memmelo's antipyretic ability in albino rats that had pyrexia brought on by Brewer's yeast. They show that the 200-mg dose of ethanolic extract

mg/kg body weight and 400 mg/kg body weight, respectively, resulted in a dose-dependent, significant ($P<0.001$) decrease in high body temperature. The extracts' antipyretic properties were on par with paracetamol's (100 mg/kg body weight) [21,22].

3. **Diuretic activity :-**

Singh et al. investigated the diuretic activity of various organic extracts and their fractions of

A. marmelos fruit in experimental models. The extracts were administered to experimental rats intraperitonealy at doses of 300, 400 and 500 mg/kg. They evaluated diuretic effect by measuring urine volume and sodium content in urine. They found that ethanolic extract produce significant increase in excretion of sodium at the higher dose (500 mg/kg). Petroleum ether, chloroform and ethyl acetate fractions are also effective[23].

4. **Toxicological studies :-**

A. marmelos is generally regarded as safe, and not much research has been done on how harmful it is. Veerappan and colleagues investigated the harmful effects of A. marmelos leaves. They observed that after receiving 50 mg/kg body weight of A. marmelos extracts intraperitoneally for 14 days in a row, there were no appreciable alterations in the histological

analyses of the heart, liver, kidney, testis, spleen, and brain. There were no obvious clinical abnormalities or histological alterations found.

Additionally, these researchers discovered that administering A. marmelos leaf extracts intraperitoneally at concentrations of 50, 70, 90, and 100 mg/kg body

weight to Wistar rats, both male and female, for 14 days in a row did not cause any short-term toxicity [24]. Furthermore, in the ames assay, it has been observed that the aqueous extract of A. marmelos fruit is not mutagenic to Salmonella typhimurium strain TA 100 [25]. However, there were no published animal studies.

Pharmacological investigations on animal models further confirmed that, up to a maximum dosage of 250 mg/kg body weight, doses of A. marmelos fruit extract administered over a 30-day period had no negative effects [26].

4. **Antimicrobial :-**

Someone has found A. Marmelos. It has historically been used to treat a wide range of conditions. To avoid a variety of infectious diseases Microorganisms that cause disease are known as pathogenic microorganisms. examined the antimicrobial properties of

Inhibition zones of 11 mm and 9 mm were employed for marmelos leaves and fruit extract. Roultella plantikola is a parasitic fungus that was observed using leaf and fruit extracts. The plant extract had the strongest inhibition zone (18 mm) activity against fungus, meaning that the minimum Chrysogenum Penicillium A fungal infection called Candida albicans (7mm) is brought on by Candida albicans.[27]

5.**Antiviral activity** :- The ethanolic Bael fruit extract has demonstrated to be effective. Antiviral efficacy against the Ranikhet virus Disease. Marmilide is a compound found in bael fruit.The most powerful antiviral agent available Interferes with the replication process's early stages Iteration. [28]

5. **Antigenotoxic activity :-**

E. coli PQ37 and peripheral human blood lymphocytes can be used to determine the antigenotoxic activity of A. marmelos fruit extract. Aflatoxin B1 triggers the SOS reaction in the chromotest (E. coli PQ37) and $H_2O_2$ (hydrogen peroxide), and acetone and methyl alcohol stop it. The SOS response is a reaction to DNA damage that involves mutagenesis induction, DNA repair, and cell cycle arrest. The methanol extract of A. marmelos fruit inhibits the genotoxicity of hydrogen peroxide and aflatoxin B1 by 70.48% and 84.65%, respectively .The fruit extract's antigenotoxic properties and capacity to preserve DNA from the S9 are due to the presence of several polyphenolic components. reactive oxygen species and dependent mutagens. A. marmelos fruit extract contains polyphenols that can decrease the activity of enzymes involved in the metabolism of aflatoxin B1.[29]

**Aegle marmelos's functional uses in food products :-**

| **Product** | **Plantpart** | **Product features** |
|---|---|---|
| Preserve | Fruit | Syrup concentration maintained at desired level (70%)[30] |
| Fruitbeer | Fruit | Beer having 1.75% proteine,16brix,pH3.9and25% fruitis acceptable[31] |
| Preserve | Fruit | Syrup TSS maintained at 70%[32] |
| Candy | Fruit | Recipe is same as preserve preparation. Drying for 8–10 hr at 55–60C [33] |

| | | |
|---|---|---|
| Toffee | Fruit | For 1kg fruitpulp 750g sugar used Mix heating at80C.Thickness maintained at 0.5–0.75mm [33] |
| Slab | Fruit | Pulp treated and containing 0.5% acidity ,0.07% KMS and 35% TSS.Moisture maintained at 14.5% [33] |
| Jam | Fruit | 45% mixed fruitpulp of bael and mango used [34] |
| Juice | Fruit | RTS with 15–20% fruit portion is the acceptable treatment [35] |
| RTS | Fruit | During preparation desired level of dilution,TSS and acidity is obtained by adding citric acid,water and sugar [36] |

**Pharmaceutical product available in market :-**

There are various medicinal product of A. MARMELOS are available in the market world wilde to treat various infection as shown as above.


**[Fig 0.7 Aegle Marmelos Tincture Preparation] [37]**

Aegle marmelos Ø, commonly known as Bael mother tincture, is a homeopathic preparation derived from the plant Aegle marmelos (family Rutaceae). It is traditionally used for the treatment of gastrointestinal disorders such as diarrhea, dysentery, and chronic colitis due to its antimicrobial and anti-inflammatory properties. The product shown is manufactured by **REPL (Rajasthan Herbal & Homeopathic Pharmaceuticals Ltd., India)**, a recognized producer of homeopathic formulations. The tincture is typically administered in small doses (5–10 drops diluted in water) under physician supervision.[38]


**[Fig 0.8 Aegle Marmelos Extract Capsulin ] [39]**

Baidyanath is one of India's oldest and most reputable manufacturers of Ayurvedic medicines, herbal formulations, and natural supplements. The company produces a wide range of products including classical Ayurvedic medicines, proprietary herbal remedies, and health supplements. Their Bael Fruit capsules, made from Aegle marmelos extract, are formulated to support digestive health and act as an antimicrobial and bowel cleanser.[40]

## Future Perspectives of *Aegle marmelos* (L.)

The sacred and important plant Aegle marmelos (L.), also referred to as bael, is employed extensively in Siddha, Ayurvedic, and Unani healing systems. Modern pharmacological research has barely partially examined its medicinal potential, despite its lengthy history of use. In order to completely understand A. marmelos' pharmacological and biochemical characteristics, traditional knowledge and contemporary scientific study must be combined. To identify and describe the bioactive components that give it its diverse range of pharmacological activities, such as antidiabetic, antimicrobial, anti-inflammatory, hepatoprotective, and anticancer effects, future research should concentrate on systematic phytochemical investigations [41]. Its phytoconstituents and biological targets can be clearly linked with the use of sophisticated analytical techniques including metabolomics, proteomics, and molecular docking studies [42]

Furthermore, weakly soluble chemicals like marmelosin and aegeline may become more soluble, stable, and bioavailable by formulation creation employing nanotechnology, increasing their therapeutic efficacy [43]. To guarantee sustainable production and increase the yield of secondary metabolites, tissue culture and genetic engineering techniques can also be used[44].

## Conclusion

Bael, also known as Aegle marmelos (L.), is a highly prized medicinal herb with numerous health advantages. For generations, traditional medicine has utilized it to treat inflammation, infections, diabetes, and gastrointestinal issues. Current research has verified that it has natural chemicals with antibacterial, antidiabetic, antioxidant, and liver-protective qualities in its leaves, fruits, roots, and bark. When used regularly and appropriately, A. marmelos can improve general well-being, prevent disease, and preserve excellent health. This plant may play a significant role in the future development of safe and efficient herbal medications with additional scientific study and clinical testing.

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