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# *AEGLE MARMELOS* A POTENTIAL MEDICINAL TREE: A REVIEW

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**Abstract:** India is the leading originator of herbal therapeutic plants. It is said to be the "Botanical Garden of the World". *Aegle Marmelos* is endemic to India. It is a religious plant used in the prayer of lord shiva. Fresh leaves are used by people who worship. *Aegle Marmelos*, a monotypic genus in the Rutaceae family, found in Asian countries like Bangladesh, Indonesia, China, etc., contains medicinal and nutraceutical characteristics that have been utilized for treating many ailments in conventional medicine. The plant's medicinal and pharmacological characteristics have been thoroughly explored using modern scientific techniques. Bioactive substances have been identified from various portions of the plant. *Aegle Marmelos* is also called the Wooden apple plant, Bilwa, and Bael. The plant has multiple biologically active and medicinally beneficial bioactive components in its flowers, wood, leaves, fruits, bark, and roots. *Aegle Marmelos* carry numerous phytochemicals like as alkaloids (aeglin, aegelenine), tannins(skimmianine), coumarins (marmelosin, marmesin, imperatorin), seed oils, carotenoids, and others. The phytochemicals found in this plant exhibit both biological and pharmacological effects against long-term illness including cardiovascular disease, immunosuppressive disease, cancer, and gastrointestinal disorders. The pharmacological characteristics of this plant extract are diverse, including antifertility, antioxidant, anxiolytic, antidepressant, antidiabetic, antihistaminic, analgesic, anticonvulsant, anti-inflammatory, antidiarrheal, antimicrobial antihyperglycemic, antidiarrheal, antimicrobial and immunomodulatory activities. This review explores the conventional applications, phytoconstituent, and intrinsic properties of *Aegle Marmelos*, highlighting its potential as a medicinal plant for study and drug development.

***Index Terms*** **- Botanical garden, *Aegle Marmelos*, Phytochemistry, Traditional uses, Pharmacological activities.**

## I. Introduction

Indian plant-based medicine has one of the world's most varied traditions. Plant-derived compounds are investigated by researchers for their potential to heal various disorders. According to a literature study, plant components can heal many ailments (Monika, S. *et al*., 2023). Globally, medicinal plant significantly impacts the lives of underprivileged people (Shinwari, Z. K., *et al*., 2011). It also has a great importance in the environment. It acts as a climatic purifier; Around the world, about 80% of countries use traditional medicine, which frequently uses plant extracts (Li, R. J. *et al*., 2017). India has one of the most varied traditions of plant-based medicine worldwide. Rural populations in India have access to over 25k effective herbal medicinal plant-based medicines used as proven medicine. Early drug research relied heavily on plant sources, particularly those with ethnopharmacological use (Suntar, I., 2020). *Aegle Marmelos*, a plant of the Rutaceae

family, is highly valued in traditional medicinal systems, notably Ayurveda. This plant known as "Bael" or "Indian Quince," is considered sacred in Hindu culture. *Aegle Marmelos* is a medium-sized and slow-growing tree that reaches a height of 12 to 15 meters. This resilient plant thrives in well-drained soils, including dry and desert climates. The tree has tiny spines on its branches, and its fruits are valued for their medicinal and nutritional benefits. These fruits have a hard, woody shell and fibrous, golden flesh with a marmalade-like flavoring and flowery perfume. They can be big, round, or oval in shape (Ramakrishna, S. *et al*., 2024). It has been in use by numerous ethnic groups in the Indian subcontinent for approximately 5000 years. Many ailments are treated with the Indian traditional medical system known as Ayurveda (Rahman, S. *et al*., 2014). Ayurvedic medicine has traditionally used *Aegle Marmelos* to treat a variety of diseases, including boils, diarrhea, earaches, colds, and fever. These plants are also used for the treatment of several medicinal intrinsic activities such as having antifertility, anticancer, antibacterial, antifungal, antidiabetic, antioxidant, hepatoprotective, hemolytic, larvicidal, and anti-inflammatory properties, *Aegle Marmelos* is also used for treating dysentery and diarrhea. Its leaves are utilized to induce infertility and abortion in women (Sekar, D. K. *et al*., 2011). This plant's bark, roots, leaves, flowers, and fruits are used in different formulations owing to its therapeutic characteristics. The plant has been used in traditional medicine for so many years, with different portions providing diverse medicinal advantages. *Aegle Marmelos* is highly appreciated for both its medicinal and nutritional properties. The fruit has a variety of nutrients, including proteins, lipids, minerals, fiber, carbs, calcium, phosphorus, and potassium, making it a nutritious addition to any diet. Its nutrient-dense profile enhances its therapeutic potential by providing necessary nutrients for good health and well-being (Venthodika, A. *et al*., 2021). The plant is thought to have fewer negative effects than manufactured medications, making it a promising option for further study. Researchers and healthcare practitioners are interested in this feature due to its historic usage and therapeutic potential (Rahman, S. *et al*., 2014).

For the present study, we searched several research databases, including SciFinder, Web of Science, Scopus, PubMed, and Google Scholar. *Aegle Marmelos*, biological effects, Phytomolecules, and pharmacological activities were the search terms.

fig 1: *aegle marmelos* "bael" (a) tree, (b) leaf, (c) fruit, (d) seed, (e) bark.

**1.1 Taxonomical classification (**Bhar, K. *et al*., 2019).

Kingdom: Plantae

Subkingdom: Tracheobionta

Division: Magnoliophyta

Sub-division: Spermatophyta

Class: Magnoliophyta

Subclass: Rosidae

Family: Rutaceae

Order: Sapindales

Group: Aegle

Type/Species: *Aegle Marmelos*

table 1: different names of *aegle marmelos*

| | |
|---|---|
| English | Bengal quince, Wood/stone apple, Indian quince. |
| Hindi | Shri phal. |
| Sanskrit | Shreephal, Bilva, and Bilwa. |
| Urdu | Bel. |
| Telugu | Maredu. |
| Tamil | Vilva Pazham and Vilva Maram. |
| Marathi | Kaveeth. |
| Bengali | Bel, Shreefal. |
| Malay | Pokok Maja Batu. |
| French | Oranger de Malabar. |
| Nepali | Bel and Gudu. |
| Japanese | Modjo. |
| Latin | *Aegle Marmelos.* |

| | |
|---|---|
| Khmer | Banu. |
| Thai | Mapin, Matum, and Tum. |
| Indonesian | Mojo tree. |
| Vietnamese | Mbau Nau and Trai Mam. |

**1.2 Botanical Description** (Singh, R. *et al*., 2019)

The *Aegle Marmelos* tree, which grows slowly, can reach a height of 12 to 15 meters and is of medium size. The short, thick, and soft stem has spreading, sporadically spiky branches and flaking bark the branches at the base droop. There are multiple stiff, straight spines on young suckers. The long, axial spikes on this tree are pointed. The leaflets measure 4 to 10 cm in length and 2 to 5 cm in width, with an oval or lancet shape. Three to five leaflets make up each leaf. The lateral leaflets do not have a petiole; the terminal booklet does. The fruits have a 5 to 20 cm diameter and are oblong, round, or oval in shape. They can be grey-green until fully ripe, at which point they turn yellowish. They may have a thin, hard, wooden shell or a soft rind. There are lots of compressed, rectangular, mucous testa seeds.

**1.3 The place of occurrence and habitat**

*Aegle Marmelos* is native to India and is also referred to as wood apple, bael, and Bengal quince. *Aegle Marmelos* can be farmed anywhere in the world and grows well in a variety of habitats. This subtropical plant can grow as high as 1200 meters above sea level. It usually grows on plains and hillsides in dry forests. It is native to India and came from Central and Eastern India's Ghats. (Samba Murty, A. V. S. S. *et al.*, 1987). Bael grows in the Himalayan foothills, and many other states of India like Uttar Pradesh (u.p), Uttarakhand (u.k), Chhattisgarh, Jharkhand, Madhya Pradesh, and across the eastern seaboard (Purohit, S. S. *et al*., 2004). Numerous countries in Southeast Asia. It includes countries such as Bangladesh, Bhutan, India, Pakistan, Sri Lanka, Nepal, Myanmar, Vietnam, Cambodia, Thailand, Malaysia, Java, the Philippines, and Afghanistan are home to bael trees. plants play a crucial role in the ecosystem by purifying the air and releasing more oxygen than other plants. They operate as a sink for chemical pollutants, absorbing harmful gasses and neutralizing them (Prabodh, C. S. *et al*., 2007). In addition to its nutritional properties, bael has antiviral, antihelminthic, antifertility, antidiabetic, anti-inflammatory, antiparasitical, antipyretic, antiscorbic, digestive, aphrodisiac, aromatic, astringent, febrifuge, hemostatic, and antidiarrheal intrinsic activity.

**II. Morphology of different parts of *Aegle Marmelos*** (Mali, S. S. *et al*., 2020).

**Leaves**

One, two, or three leaves can be found on the deciduous, alternating plant. They possess 3 to 5 oval-shaped, pointed leaflets with loose teeth, ranging from two to five centimeters in width and four to ten centimeters in length. The terminal leaflet features a long petiole. A foul odor is released when mature leaves are bruised.

**Flowers**

April and May see flowering, which follows the emergence of new leaves. Along the young branchlets, The fragrant blossoms form clusters of four to seven. They feature 50 or more greenish-yellow filaments and four recurved, fleshy petals that are green on the outside but yellowish on the inside.

**Fruits**

Fruits range in shape from spherical to pyriform, oval to oblong, and have a diameter of 5 to 20 cm. It has a soft rind or a lean, solid, woody cover that is gray-green when fully grown and then turns golden. It is tied with tiny, fragrant oil glands. A central point core and eight to twenty triangular divisions with lean, dark citrus walls make up the interior. The pulp has a pasty texture, pale orange color, sweet taste, resinous texture, and slight astringency. Fruit matures between 10 and 11 months, from spring month, and then blooms. For every

100 grams of edible piece, the fruit has nutrition 61.5% water, 1.8 grams of amino acids, 0.39 grams of lipid, 1.7 grams of minerals, 31.8 grams of carbohydrates, 55 mg of carotene, 0.13% of thiamine, 1.19% of riboflavin, 1.1 mg of niacin, and 8.0 mg of L-ascorbic acid. Riboflavin can be found in abundance in bael fruit.

**Seeds**

Ten to fifteen flattened oblong seeds are present in the pulp. A bag of translucent mucilage that solidifies when dried surrounds the tiny, roughly 1 cm long seeds, which also have fuzzy hairs.

**III. Major uses** (Purohit, S. S. *et al*., 2004)

- The board is golden to smoky white, firm, glossy, and scented. The wood is ideal for building houses, carts, agricultural tools, and cow barns.
- The leaves and twigs are used as fodder, and the twigs can be chew sticks or brushes.
- The fruit shell is used to smell hair oil in Siam. Marmelle oil is an essential oil derived from crop rinds after distillation.
- The nutritious fruit pulp is used to make Sharbat and has detergent characteristics, making it a suitable replacement for laundry soap.

**IV. Ethnopharmacological relevance of *Aegle Marmelos***

The ethnic group helped preserve traditional knowledge of this herb, which was utilized to treat many diseases. In traditional medicine, ripe and unripe fruits have been used to treat dysentery and chronic diarrhea. To treat chronic dysentery, fresh fruit pulp juice should be consumed twice daily (Vyas, D. S. *et al*., 1979). The green fruit is sun-dried and used as a powder to treat diarrhea and dysentery (Lamba, B. *et al*., 1969). Ripe fruit sharbat is a remedy for constipation that is prepared with pulp, milk, and sugar. (Tiwari, N. N. *et al*.,1990). To treat intestinal parasites such as Entamoeba histolytica, ingest a fine powder of unripe fruit with water (Trivedi, V. P. *et al*., 1978). Considering ancient times, this tree's trifoliate leaves, or bilva-patra, have been proposed to Lord Shiva. These plant leaves are so important that they are still used today to treat backaches, diabetes, abscesses, and eye conditions. Ripe fruit juice can effectively cure rectal irritation (Dhankhar, S. *et al*., 2011). To treat an abscess, apply a paste of bael leaves to the affected area and cover it with a bandage. Poultice produced from leaves is used to treat ophthalmia and eye problems. Bael tea, which is made from leaves, has health benefits and can help children with chronic intestinal illnesses, cough, gastrointestinal problems, and flatulence. (Veerappan, A. K. S. *et al*., 2000). Leaves are useful for abscesses and backaches (George, K. V. *et al*.,2003). Decoction of leaves can reduce fever and remove mucus secretions from bronchial passages (Kurian, J. C., 2012). For a few days, consuming a smaller quantity of ground leaves in the early morning with a glass of water can help control diabetes. (Gaur, R. D. *et al*., 1988). To treat peptic ulcers, soak the leaves in water overnight and consume the filtered water in the morning for many weeks (Goel, R. K. *et al*., 1997). To relieve sneezing, coughing, and respiratory spasms, combine the leaf juice with warm water and a pinch of pepper and consume (Reddy, K. N. *et al*., 2006). Leaf extract is used to treat injuries from animal bites (George, K. V. *et al*., 2003). A decoction of the leaves might help treat jaundice (Devadi, G. 2002). Jharkhand tribes use one tablespoon of bael leaf juice every day to treat diabetes (Tomar, J. B. *et al*., 2012). Equivalent amounts of haldi, pyaz, and bael root are applied to relieve earaches. Mix 1:2 mustard oil with dry fruit powder and apply topically to heal burns. (Parmar, C. *et al*., 1982). In Rajaji National Park, Uttarakhand, we conducted an ethnobotanical study of the Gujjar people, and we found that *Aegle Marmelos* is used to treat diabetes, fever, diarrhea, and jaundice. Taking leaf juice on an empty stomach in the morning can assist with diabetes while combining it with honey can reduce fevers. For three days, consuming one teaspoon of powdered and dried bael leaves will increase appetite. Jaundice can be treated with bael leaf extract and honey for a week. Drink a cup of buttermilk and a measuring spoon of pulverized *Aegle Marmelos* leaves with a dash of piper nigrum to treat jaundice. Three times a day, the therapy needs to be adhered to. Fruit juices are effective in the treatment of dysentery and diarrhea (Panda, S. *et al*., 2006). We gathered information on the medicinal concoctions made from bael that are utilized by Ayurvedic and traditional herbal healers in Uttarakhand. Bael roots are found in dasamula (ten roots), which may aid in reviving appetite. Fever and cold are treated with a twice-daily infusion of betel root. A root and bark infusion can treat heart palpitations and

intermittent fever. The fruit powder of rife bael has anti-proliferative and anti-cancer qualities. Pregnancy-related vomiting can be relieved by combining unmatured fruit mash with boiling rice water two times a day; urinogenital diseases can be treated by combining it with sugar and milk twice a day. (Singh, R. *et al*., 2019).

table 2 ethnomedicinal values of *aegle marmelos* (prabodh, c. s. *et al*., 2007)

| Plant part | Ethnomedicinal value |
|---|---|
| Leaf | Ancess, back pain, eye issues, stomach problems, nausea, cuts, wounds, ulcers, heart weakness, cholera, diarrhea, cardiotonic, low blood sugar, neurological conditions, acute bronchitis, etc. |
| Fruit | diarrhea, gastrointestinal issues, difficulty in defecation, laxative, tonic, dysentery, brain and heart tonic, ulcer, antiviral, intestinal parasites, gonorrhea, and seizures. |
| Flower | Expectorant, epilepsy. |
| Seed | Febrifuge. |
| Bark | GIT disorder, periodic fevers, cardiac disorder, anti-fertility. |
| Root | Dog bite, stomach issues, cardiac conditions, sporadic fevers, antiamoebic medication, low blood sugar, and rheumatism. |

## V. Nutritional content

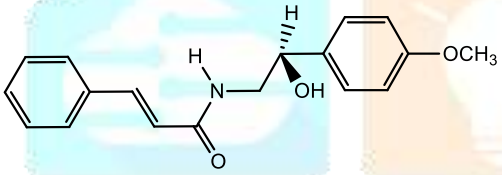
The *Aegle Marmelos* "Bael" plant is important and has a rich nutritional value due to its high protein, carbs, vitamins, and minerals. The *Aegle Marmelos* "Bael" plant contains nutrients like calcium, iron, phosphorus, and micronutrients carotene, thiamin, riboflavin, and niacin. Vitamins, chemicals (tannins, alkaloids, polyphenols, terpenes), fiber, protein, and oil are all found in plants and have many health benefits. Pulp from Bael is a great way to get vitamin C or ascorbic acid. (Sarkar, A. *et al*., 2021). Fruit pulp is dried and combined with thirty percent sugar for use in soft squash or cold beverages. *Aegle Marmelos* fruit pulp is mixed with sugar, glucose, hydrogenated fat, and low-fat milk fine particles to make candy. Bael fruit can eradicate colon worms and cure persistent diarrhea. (Apou, A. C. *et al*., 2019). While infusing flowers with sugar and milk creates a refreshing drink, the fresh juice of leaves or flowers can decrease hunger. Fruit juice is improved in taste by the addition of sugar and milk. Fruits like squash, nectar, jellies, marmalades, and confections are made from the mash of the *Aegle Marmelos* fruit. Mucilage from unmatured Bael fruit seeds has adhesive properties. The thick, gum-like substance used to make Feronia gum comes from the trunks and branches of Bael trees. (Ullikashi, K. Y. *et al*., 2017). Bael dry powder is combined with mustard. Oil in (1:2) is used to cure burns and administered externally. This is often used for treating diarrhea and dysentery. *Aegle Marmelos* fruit is often used to heal stomach ulcers and constipation and manage heat stress. Plant Fruit juice from the Bael plant is frequently used to cleanse the blood and remove toxins from the kidneys and liver. It also improves defense against toxins and regulates the immune system. *Aegle Marmelos* contains nutrients that are good for the liver, such as riboflavin, thiamine, and β-carotene. Another use for bael fruit is as a heart tonic. (Upadhyay, R. K. 2015).

## VI. Phytochemistry of *Aegle Marmelos*

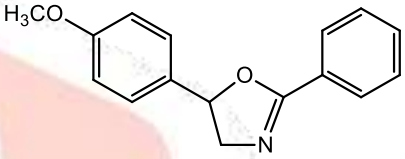
Plant components include a variety of phytocompounds, including alkaloids, cardiac glycosides, carotenoids, coumarins, flavonoids, inulin, lignins, phenolics, phlobatannins, saponins, steroids, tannins, terpenoids (Bramhachari, P. V. *et al*., 2010). The majority of such compounds have positive health impacts and have various pharmacological actions. The other ingredients in the crude extracts are also responsible for the phytotherapeutic effects of the various plant parts, in addition to the single compound (Kumar, K. S. *et al*., 2012).

table 3 chemical constituent of *aegle marmelos*

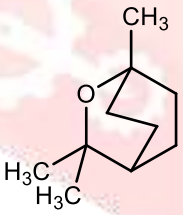
| S.no. | Plant Parts | Chemical constituent | Ref. |
|---|---|---|---|
| 1 | Leaves | Citral, cineol glycoside, Rutin, Flavone, O-Halfordiol, Marmeline, Lupeol, Citronellal, Marmesinin, Aeglin, Isopentenyl, Cuminaldehyde, Phenylethyl cinnamamides, Skimmianine, Eugenol, alpha and beta-sitosterol. | Shoeb, A. *et al.*,1973. |
| 2 | Fruit | Tannin, Aurapten, Imperatorin, Psoralen, Luvangetin. | Kim, H. J. *et al.*, 2021. |
| 3 | Bark | Fagarine, Marmin | Maity, P. *et al.*, 2009. |
| 4 | Seed | Cumin aldehyde, A-D-phellandrene, Citral, Cineol, P-cymene, citronellal, D-limonene**.** | Pathirana, C. K. *et al.*, 2020. |



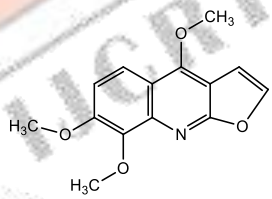

Aegeline



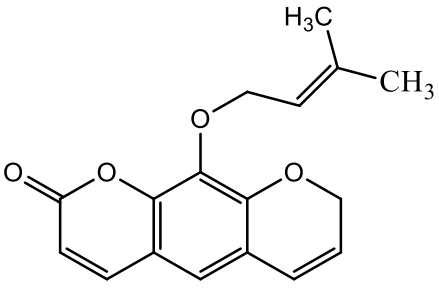

Aeglemarmelosin



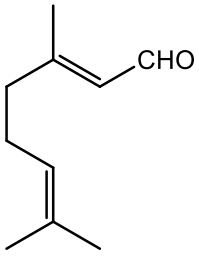

Cineol



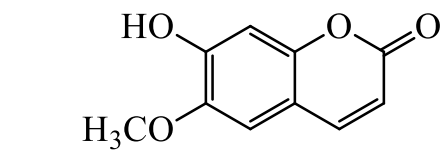

Skimmianine



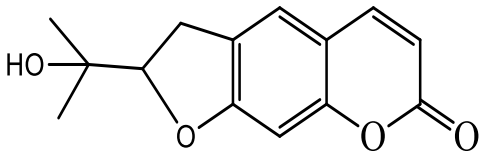

Imperatorin



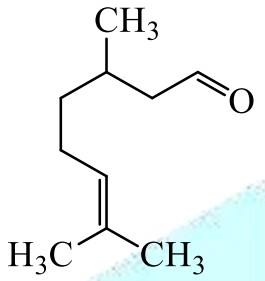

Citral



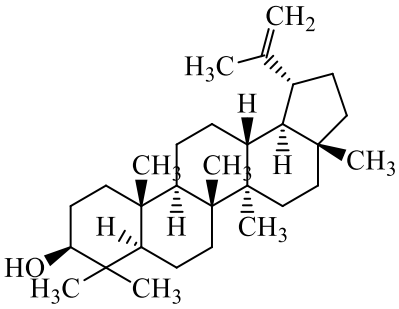
Scopoletin



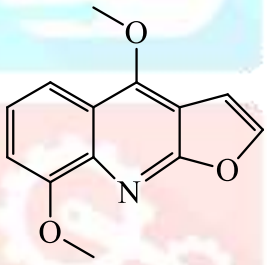
Marmisin



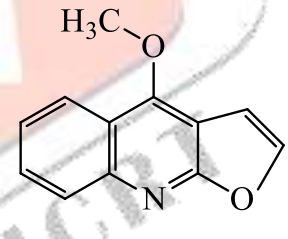
Citronella



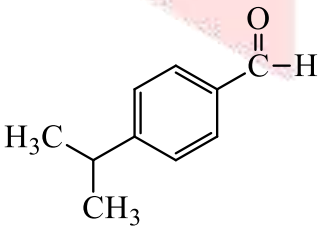
Lupeol



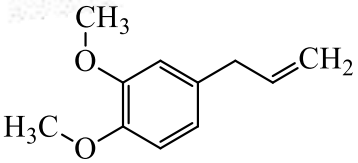
Fagarine



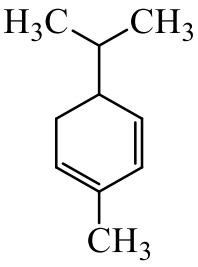
Dictamine



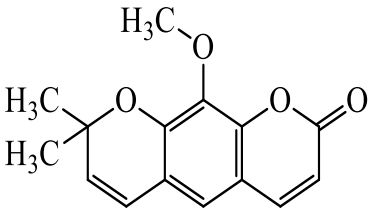
Cuminaldehyde



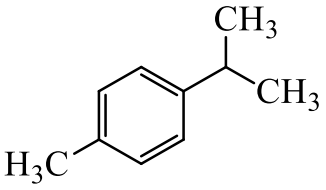
Eugenol



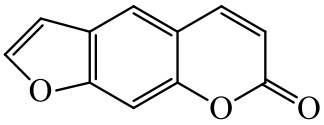
α-Phellandrene



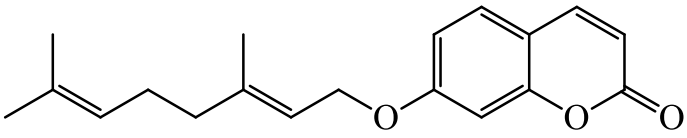
Luvangetin



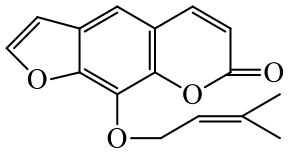
P-cymene



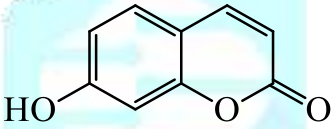
Psoralen



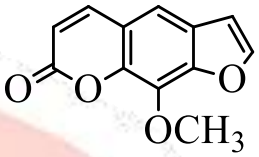
Aurapten



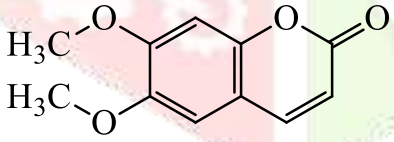
Marmelide



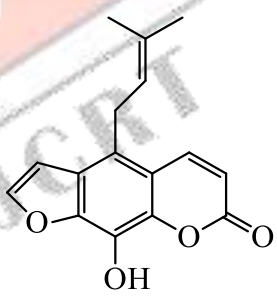
Umbelliferone



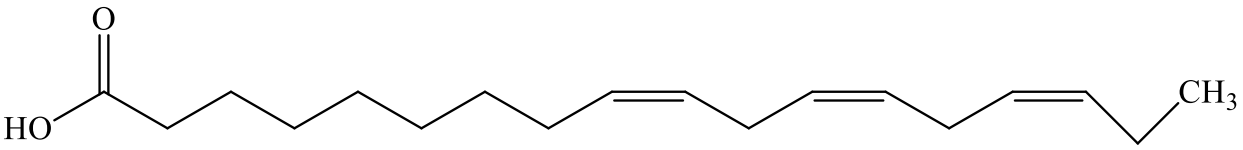
Xanthotoxin



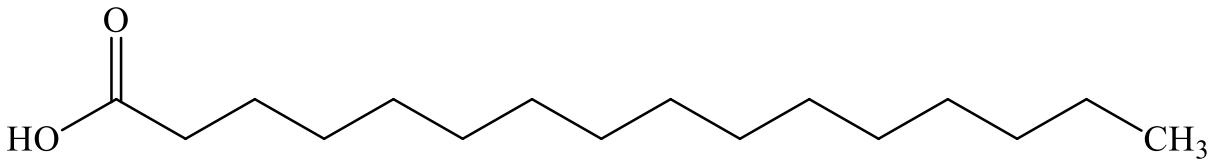
Scoparone



Alloimperatorin



Linolenic acid




Palmitic acid

fig 2: phytoconstituents present in *aegle marmelos* (chaudhary, y. *et al*., 2017)

### 6.1 Active constituents

*Aegle Marmelos* contains various phytochemicals, including terpenoids, coumarins, alkaloids, fatty acids, and amino acids. The plant's active elements contribute to its pharmacological and therapeutic qualities (Ramakrishna, S. *et al*., 2024).

### Terpenoids

*Aegle Marmelos* contains various terpenoid chemicals, including cineol, caryophyllene, and other mono- and sesquiterpenes. It is well known that these terpenoids have antioxidant, antibacterial, and anti-inflammatory properties.

### Coumarins

*Aegle Marmelos* contains a lot of coumarins, including marmin, marmelide, psoralen, and imperatorin. Coumarins have several biological effects, including anti-inflammatory, antioxidant, antibacterial, and anticancer characteristics.

### Alkaloids

*Aegle Marmelos* contains the alkaloids Angeline, fragrine, and aegelenine. These alkaloids have been researched for their possible medicinal benefits, including anticancer, antidiabetic, and antibacterial properties.

### Fatty acids

*Aegle Marmelos* contains a range of triglycerides, such as linoleic, oleic, palmitic, and stearic acid. These lipid acids enhance the nutritional importance of the plant and may have therapeutic advantages.

### Amino acids

*Aegle Marmelos* has yielded several amino acids, such as glycine, aspartic acid, and glutamic acid. Amino acids are significant for the composition of proteins and participate in numerous biological procedures (Dhankhar, S. *et al*., 2011).

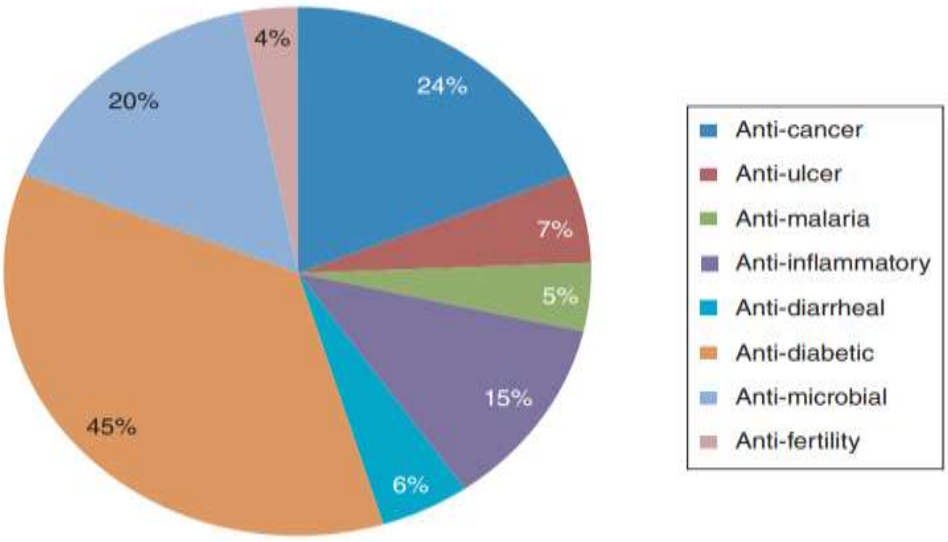



fig 3: *aegle marmelos* reported a percentage of biological activities (monika, s. *et al*., 2023).

## VII. Phytochemical screening

The phytochemical evaluation identified medicinally active ingredients such as alkaloids, carbohydrates, steroids, protein, amino acids, anthraquinone glycoside, tannins, reducing sugar, gums, volatile oil, flavonoids, amino acids, cysteine, and phenolic compounds. More information on this study is presented in Table 3 (Nag, S. *et al*., 2015).

table 4 phytochemical evaluation of the ethanolic extract of *aegle marmelos*

| TEST | OBSERVATION | CONCLUDE |
|---|---|---|
| Carbohydrate tests | | |
| ➢ Molisch test | Violet-colored ring | Present |
| ➢ Fillings test | Brick Red ppt | Reducing Sugars Present |
| Alkaloid tests | | |
| ➢ Mayers Test | Cream colored ppt | Present |
| ➢ Wagners Test | Reddish Brown ppt | Present |
| Anthraquinone Glycoside tests | | |
| ➢ Borntragers test | Ammonical layer turn Pink | Present |
| Protein tests | | |
| ➢ Protein test | Purple Color | Present |
| ➢ Cysteine test | Lead sulphate black ppt | Present |
| ➢ Ninhydrin test | Purple Color | Present |
| Tannins and phenols test | White color | Present |
| fixed oils and fats test | Filter paper becomes permanently discolored with oil | Present |
| gums and mucilage test | Red Color | Present |
| Flavanoids test | Yellow Color | Present |

## VIII. Pharmacological Activities

*Aegle Marmelos* has a wide spectrum of pharmacological actions due to its complex phytochemical makeup. This plant has been shown to have the following important pharmacological activities.

### 8.1 Antispermatogenic activity

*Aegle Marmelos* bark extract has significant levels of marmin and fagarine, which reduces male fertility (Srivastava, A. K. *et al*., 2022). Ethanolic extract of *Aegle Marmelos* bark has been shown to improve sperm motility. Increasing the concentration of extracts has been shown to impair sperm motility. *Aegle Marmelos* leaf alkaloids dramatically cause reversible infertility in male albino rats in graded dose-dependently (Kumar, B. S. *et al.,* 2011). *Aegle Marmelos* extract effectively suppresses conception and quickly restores fertility following treatment termination, making it an ideal choice for male contraception (Srivastava, A. K. *et al*., 2022). Male lab rats' reproductive organs were treated with triple-graded dosages of an *Aegle Marmelos* leaf extract with 50% ethanol: 100, 200, and 300 mg/kg/day for 60 days. After consuming the extract, all important accessory sex organs decreased (Chauhan, A. *et al*., 2007). The treated animals' cauda epididymis generated significantly fewer sperm, with worse motility and density. *Aegle Marmelos* at 300 mg reduced male rat fertility to zero. Male Albino rats showed antifertility effects from water extracts of *Aegle Marmelos*. Methanolic, ethanolic, and Aqueous extracts of leaves were given according to body weight at a dose of 250 mg/kg. *Aegle Marmelos* leaves were given to rats for 45 days, resulting in a decrease in the testis weight, epididymis, and seminal vesicles. The extract decreases the testicular sperm concentration, epididymal sperm density, motility, and atypical sperm count (Sathiyaraj, K. *et al*., 2010).

### 8.2 Anticancer activity

The cytotoxicity of *Aegle Marmelos* acetate and methanol extracts on human laryngeal carcinoma cells (HEp-2), M.D. Anderson and MB stand for Metastasis Breast cancer (MDA-MB-231) breast cancer cells, and Vero E6 cells were examined. The methanol extract of *Aegle Marmelos* had an IC50 of 47.08 g/ml, whereas the acetone extract had an IC50 of 79.62 g/ml, indicating increased sensitivity in HEp-2 cells. Both methanol and acetone extract of *Aegle Marmelos* is toxic to cancer cells, however, Vero cells can survive for 24 hours (Seemaisamy, R. *et al*., 2019). In vitro, anticancer activity was analyzed using MTT tests on the MCF-7 breast cancer cell line at varied doses. Fruit extracts include flavonoids, which can function as a reducing agent and help produce gold nanoparticles (Vijayakumar, S. 2019). *Aegle Marmelos* fruit pulp aqueous extract effectively killed MCF7 cells at 100 grams per milliliter and had an inhibitory concentrate (IC50) of 47.92 grams per milliliter concentrations (Vardhini, S. P. *et al*., 2018).In the living organism (in-vivo) research, experimental lab animals with Ehrlich ascites tumors were injected intraperitoneally with a dose of 400 mg/kg body weight, *Aegle Marmelos* hydro-ethanolic extract. This dramatically enhanced the median survival period up to 4 weeks following tumor implantation evaluated in the saline-administered control group (Jagetia, G. C. *et al*., 2005). In a rat model, *Aegle Marmelos* fruit pulp ethanolic extract inhibited breast cancer development. *Aegle Marmelos* treatment group showed a significant decline in substantial reductions in breast carcinoma size ($p < 0.05$) and blood biomarkers ($p < 0.0001$) (Akhouri, V. *et al*., 2020).

### 8.3 Antidiabetic activity

*Aegle Marmelos* fruit aqueous extract reduces blood glucose levels in experimental animals in a chemically-induced diabetic rat model. It stimulates anti-diabetic production by partially regenerating β-cells in pancreatic islets (Kamalakkannan, N. *et al*., 2005). *Aegle Marmelos* concentrate at a dosage of 250 mg/kg per body weight is more potent than glycenamide. The fruit having coumarins may stimulate β-cells in the islets of Langerhans to produce more insulin, which could explain its antidiabetic properties. Additionally, the water extract of *Aegle Marmelos* seeds helps reduce blood sugar levels in individuals with severe diabetes (Kamalakkannan, N. *et al*., 2003). Mice treated with fruit extract showed superior results than those managed with glibenclamide antidiabetic agent. The outside-the-body (in-vitro) investigation found that lectin extract had a significant antidiabetic impact on glucose absorption in yeast cells (kumer Saha, R. *et al*., 2016). *Aegle Marmelos* fruit extract with an inhibitory concentration (IC50) of 3.36 micrograms per milliliter beat metformin in improving blood sugar absorption by yeast cells. The investigation revealed that *Aegle Marmelos* "bael" fruit extract has

lowering blood sugar characteristics because of its antioxidant activity and active components (Abdallah, I. Z. *et al*., 2017). *Aegle Marmelos* aqueous seed extract lowers blood glucose levels in normal and acutely diabetic rats while enhancing sugar capacity in sub and moderately-diabetic experimental animals. This extract helps stimulate the release of insulin from the pancreas effectively (Kesari, A. N. *et al*., 2006). *Aegle Marmelos* leaves alcoholic extract reduces the alpha-amylase and alpha-glycosidase with IC50 standards of 46.21 and 42.07 micrograms per milliliter, separately. In HepG2 cells, *Aegle Marmelos* significantly decreased raised reactive oxygen species (ROS) levels caused by high glucose grades and increased sugar intake ($p < 0.05$) (Ahmad, W., *et al*., 2021).

### 8.4 Anti-inflammatory activity

A study using a rat paw edema model showed that *Aegle Marmelos* aqueous extract showed anti-inflammatory properties (Dhuley, J. N. 2003). The extracts of *Aegle Marmelos* "bael" leaves were tested for anti-inflammatory properties. *Aegle Marmelos* leaves alcoholic extract significantly reduced histamine-induced strength and had a good relaxing result in isolated ileum of guinea pig and breathing chains. This suggests that the extract may reduce H1-receptor activation (Arul, V. *et al*., 2004).

### 8.5 Antidiarrheal activity

*Aegle Marmelos* is known for its antidiarrheal properties and is frequently helpful in treating long-lasting bowel upset and bloody diarrhea. In vitro, the dried fruit mash of *Aegle Marmelos* showed antidiarrheal activity. *Aegle Marmelos* ethanolic extract was efficient as opposed to Shigella bacillus, Sonnies bacillus, and Flexneri bacillus, but moderately effective anti-dysentery bacillus (Maheshwari, V. L. *et al*., 2009).

### 8.6 Antioxidant activity

*Aegle Marmelos* is known to have antioxidant properties against various free radicals. We investigated the antioxidant and free radical destroyer abilities of mature and unmatured *Aegle Marmelos* fruit. Matured fruit contains more enzymatic antioxidants than unripe fruit extract (excluding glutathione peroxidase). Unmatured fruit showed increased levels of free radical scavenging compared to mature fruit (Sharmila, S. *et al*., 2011). *Aegle Marmelos* fruit is antioxidant-rich. *Aegle Marmelos* fruit aqueous extract exhibited antioxidant biological activity by 2,2-diphenyl-1-picrylhydrazyl (DPPH) reactive oxygen species destroyer (Gheisari, H. R. *et al*., 2011).

### 8.7 Antibacterial activity

*Aegle Marmelos* leaf extracts were investigated for antibacterial activity against a variety of pathogens, including Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Salmonella typhi, Proteus vulgaris, Pseudomonas aeruginosa, and Klebsiella pneumoniae. The chloroform, methanol, and ethanol extracts showed controlled bactericidal activity., whereas the water extract had minimal. Antimicrobial action was stronger against gram-negative germs than gram-positive ones (Gavimath, C. C. *et al*., 2008). *Aegle Marmelos* Aqueous, petroleum ether, and ethanol extract leaves showed effective antibacterial action against salmonella typhi, proteus vulgaris, Escherichia coli, Streptococcus pneumoniae, and Klebsiella pneumoniae (Sivaraj, R. *et al*., 2011). The ethanolic extract of the root exhibits antibacterial properties against a variety of bacteria, including Bacillus subtilis, Vibrio cholerae, Salmonella typhimurium, Klebsiella pneumoniae, Pseudomonas aeruginosa, Staphylococcus aureus, and E. coli (Pitre, S. *et al*., 1987).

### 8.8 Antiulcer activity

*Aegle Marmelos* is reported to have gastroprotective properties. Unripe bael fruit extract significantly reduced absolute ethanol-induced gastrointestinal mucosal injury in mice. The fruit contains luvangetin, which contributes to its action. Gastric ulcers are frequently caused by oxidative stress. Luvangetin may decrease oxidative stress-producing chemicals in the gastrointestinal system, avoiding ulcer development (Pallab, M. *et al*., 2009).

### 8.9 Hepatoprotective activity

*Aegle Marmelos* leaves demonstrated hepatoprotective effectiveness against liver damage by alcohol in Albino rats. The rats were administered 30% ethanol solution for 40 days and treated with *Aegle Marmelos* leaves for 21 days. The thiobarbituric acid reactive material assay (TBARS) values for the healthy, alcohol-intoxicated, and herbal drug-treated groups were 123.35, 235.68, and 141.85 g/g tissue, separately. *Aegle Marmelos* leaves have shown strong hepatoprotective properties (Singanan, V. *et al*., 2007).

### 8.10 Anti-hyperlipidemic

*Aegle Marmelos* fruit and seed aqueous extract by oral administered in diabetes-induced rats at a dose of 250 mg/kg body weight led to a valuable reduction in blood lipid levels Triglyceride hydrolysis may stimulate fat mobilization from deposits, contributing to the observed impact. The extract also improves glucose utilization (Kesari, A. N. *et al*., 2006).

### 8.11 Antifungal activity

At a concentration of 500 ppm, the essential oil derived from the leaves completely prevented fungal spore germination in Microsporum alternatum, Alternaria brassicae, Alternaria carthami, Collectotrichum capsici, Curvularia lunata, Fusarium oxysporum cicer, Fusarium odum, and Ustilago cynodontis. Lower doses of the fungicide exhibited delayed and consistent inhibition (Rana, B. K. *et al*., 1997).

*Aegle Marmelos* leaf extracts were examined for their antifungal effectiveness against dermatophytic fungi such as Trichophyton mentagrophytes, Trichophyton rubrum, Microsporum canis, Microsporum gypseum, and Epidermophyton floccosum. lowest inhibitory and fungicidal concentrations were determined, demonstrating that the leaf extracts effectively inhibit the development of all tested ringworm fungi (Balakumar, S. *et al*., 2011).

### 8.12 Antimalarial activity

*Aegle Marmelos* leaves and seeds alcoholic extracts were studied for their effectiveness against the NK65 strain of Plasmodium berghei, both in vivo and in vitro. The seeds exhibited schizontocidal effects in both systems, on the other hand, the leaves demonstrated biological activity outside the living system (Misra, P. et al., 1991).

### 8.13 Antiviral activity

*Aegle Marmelos* shows antiviral activity during the initial stages of viral replication with minimal harm to the host cells, unlike modern virucidal drugs for example ribavirin, which typically target later stages of viral multiplication and may cause notable adverse effects (Singh, R. *et al*., 2019). The 50% ethanolic extract derived from the fruits demonstrates significant antiviral effects specifically targeting the Ranikhet disease virus. This suggests that the extract contains compounds capable of inhibiting the replication or spread of the virus. Such findings highlight the potential of these fruit extracts in developing treatments or preventive measures against Ranikhet disease, a viral infection affecting poultry. Further studies would be necessary to identify the specific active compounds and understand their mechanisms of action to antagonize the virus replication (Dhar, M. L. *et al*., 1968).

### 8.14 Cytoprotective activity

*Aegle Marmelos* leaves have been demonstrated to protect freshwater fish, Cyprinus carpio, from heavy metal exposure. After being exposed to heavy metals, Cyprinus carpio was treated with *Aegle Marmelos* leaf powder. The therapy improved cytoprotection by stabilizing the plasma membrane and regulating the antioxidant enzyme system (Vinodhini, R. *et al*., 2009).

### 8.15 Toxicity study

*Aegle Marmelos* fruit pulp ethanolic extract acute oral toxicity was tested on Swiss albino mice at doses of 550 and 1250 mg/kg per body weight. The results showed that the extract is causing no harm to laboratory

animals and proved safe at these doses. The lab animals showed no behavioral and biological activity changes that were consistent for 2 weeks of monitoring (Rakulini, R., *et al.*, 2019). The outcomes revealed that the examination of the extract's lethal dose 50 is significantly outstanding. The oral acute toxicity screening found no toxic symptoms, behavioral abnormalities, or fatality at 1250 mg/kg dosages. *Aegle Marmelos* ethanolic fruit pulp extract was found to be not harmful to mice at concentrations below the lethal dose (LD50) (Monika, S. *et al*., 2023).

## IX. Conclusion

*Aegle Marmelos*, a venerated plant in traditional medicine systems, especially Ayurveda, has received attention for its various pharmacological activity and possible therapeutic uses. This study covers the plant's traditional usage, phytochemistry, and pharmacological properties, emphasizing its potential as a therapeutic resource. *Aegle Marmelos* fruit, leaves, bark, seeds, and roots have been widely researched for their chemical composition and biological functions. The plant's phytochemical composition, including terpenoids, coumarins, alkaloids, fatty acids, and amino acids, contributes to its diverse pharmacological characteristics. Further investigation is necessary to completely know the safety parameters, effectiveness, and pharmacokinetics of *Aegle Marmelos* extracts and isolated components. Research on the plant can verify its conventional usage while also uncovering novel applications in healthcare. *Aegle Marmelos* is a promising candidate for drug discovery and development due to its broad pharmacological actions and phytochemical profile, which provide a wide range of therapeutic possibilities. Continued research efforts in his field will surely contribute to the improvement of human health and well-being.

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## REFERENCES

**[1]** Abdallah, I. Z., Salem, I., El-Salam, A. and Nayrouz, A. S. (2017). Evaluation of antidiabetic and antioxidant activity of *Aegle Marmelos* L. Correa fruit extract in diabetic rats. The Egyptian Journal of Hospital Medicine, 67(2): 731-741.

**[2]** Ahmad, W., Amir, M., Ahmad, A., Ali, A., Ali, A., Wahab, S.and Alam, P. (2021). *Aegle Marmelos* leaf extract phytochemical analysis, cytotoxicity, in vitro antioxidant and antidiabetic activities. Plants, 10(12): 1-13.

**[3]** Akhouri, V., Kumari, M. and Kumar, A. (2020). Therapeutic effect of *Aegle Marmelos* fruit extract against DMBA induced breast cancer in rats. Scientific reports, 10(1): 1-12.

**[4]** Apou, A.C., Farzana, T., Suzauddula, M. and Hossain, M. (2019). The Physicochemical Characteristics and Quality Evaluation of Bael Fruit (Limoniaacidissima L.) Pulp Powder for the Product of Functional Food. Daffodil Int. Univ. J. Allied Health Sci, 6: 82-88.

**[5]** Arul, V., Miyazaki, S. and Dhananjayan, R. (2004). Mechanisms of the contractile effect of the alcoholic extract of *Aegle Marmelos* Corr. on isolated guinea pig ileum and tracheal chain. Phytomedicine, 11(7-8): 679-683.

**[6]** Balakumar, S., Rajan, S., Thirunalasundari, T. and Jeeva, S. (2011). Antifungal activity of *Aegle Marmelos* (L.) Correa (Rutaceae) leaf extract on dermatophytes. Asian Pacific Journal of Tropical Biomedicine, 1(4): 309-312.

**[7]** Bhar, K., Mondal, S. and Suresh, P. (2019). An eye-catching review of *Aegle Marmelos* L. (Golden Apple). Pharmacognosy Journal, 11(2): 207-224.

**[8]** Bramhachari, P. V., Reddy, Y. H. K., Kotresha, D. and Varaprasad, B. (2010). Phytochemical examination, antioxidant and radical scavenging activity of *Aegle Marmelos* (L.) Correa extracts. Journal of Pharmacy Research, 3(12): 3023-3025.

**[9]** Chauhan, A., Agarwal, M., Kushwaha, S. and Mutreja, A. (2007). Suppression of fertility in male albino rats following the administration of 50% ethanolic extract of *Aegle Marmelos*. Contraception, 76(6): 474-481.

**[10]** Choudhary, Y., Saxena, A., Kumar, Y., Kumar, S. and Pratap, V. (2017). Phytochemistry, pharmacological and traditional uses of *Aegle Marmelos*. Pharmaceutical and Biosciences Journal, 27-33.

**[11]** Devadi, G. (2002). Importance of Bael and its use in health care. Kalyan Aarogaya Ank, 2: 401-402.

**[12]** Dhankhar, S., Ruhil, S., Balhara, M., Dhankhar, S. and Chhillar, A. K. (2011). *Aegle Marmelos* (Linn.) Correa: A potential source of Phytomedicine. J Med Plant Res, 5(9): 1497-1507.

**[13]** Dhar, M. L. and Dhar, M. M. (1968). Screening of Indian plants for biological activity. Indian Journal of Experimental Biology.; 6: 232-647.

**[14]** Dhuley, J. N. (2003). Investigation on the gastroprotective and antidiarrhoeal properties of *Aegle Marmelos* unripe fruit extract. Hindustan antibiotics bulletin, 45(1-4): 41-46.

**[15]** Gaur, R. D., Tiwari, J.K., (1988). Indigenous medicinal plant of Garhwal Himalaya (India): An Ethhnobotanical Study, In Medicinal and Poisonous Plant of Tropics, AJM Leeuwenberg (Ed), International Book Distributors, Dehradun. 139-143.

**[16]** Gavimath, C. C., Ramachandra, Y. L., Rai, S. P., Sudeep, H. V., Ganapathy, P. S. and Kavitha, B. T. (2008). Antibacterial activity of *Aegle Marmelos* Correa leaves extract. Asian journal of Bio science, 3(2): 333-336.

**[17]** George, K. V., Mohanan, N. and Nair, S. S. (2003). Ethnobotanical investigations on *Aegle Marmelos* (Linn.) Corr. 29- 35.

**[18]** Gheisari, H. R., Amiri, F. and Zolghadri, Y. (2011). Antioxidant and antimicrobial activity of Iranian Bael (*Aegle Marmelos*) fruit against some food pathogens. Int. J. Curr. Pharm. Res, 3(3): 85-88.

**[19]** Goel, R. K., Maiti, R. N., Manickam, M. and Ray, A. B. (1997). Antiulcer activity of naturally occurring pyrano-coumarin and isocoumarins and their effect on prostanoid synthesis using human colonic mucosa. Indian Journal of Experimental Biology, 35(10): 1080-1083.

**[20]** Jagetia, G. C., Venkatesh, P. and Baliga, M. S. (2005). *Aegle Marmelos* (L.) C ORREA Inhibits the Proliferation of Transplanted Ehrlich Ascites Carcinoma in Mice. Biological and Pharmaceutical Bulletin, 28(1): 58-64.

**[21]** Kamalakkannan, N. and Prince, P. S. M. (2005). The effect of *Aegle Marmelos* fruit extract in streptozotocin diabetes: a histopathological study. Journal of herbal pharmacotherapy, 5(3): 87-96.

**[22]** Kesari, A. N., Gupta, R. K., Singh, S. K., Diwakar, S. and Watal, G. (2006). Hypoglycemic and antihyperglycemic activity of *Aegle Marmelos* seed extract in normal and diabetic rats. Journal of ethnopharmacology, 107(3): 374-379.

**[23]** Kim, H.J., Seo, Y.J., Htwe, K.M. and Yoon, K.D., (2021). Chemical Constituents from *Aegle Marmelos* Fruits. Natural Product Sciences, 27(4): 240-249.

**[24]** Kumar, B. S., Rao, K. M., Madhusudhan, K., Reddy, M. K. and Prasad, M. S. K. (2011). Isolation and evaluation of antifertility activity of total alkaloids from leaves of *Aegle Marmelos* in male albino rats (rattus norvegicus). International Journal of Applied Biology and Pharmaceutical Technology 2(3): 178–183.

**[25]** Kumar, K. S., Umadevi, M., Bhowmik, D., Singh, D. M. and Dutta, A. S. (2012). Recent trends in medicinal uses and health benefits of Indian traditional herbs *Aegle Marmelos*. The Pharma Innovation, 1(4): 57-65.

**[26]** kumer Saha, R., Nesa, A., Nahar, K. and Akter, M. (2016). Anti-diabetic Activities of the Fruit Aegle mamelos. Journal of Molecular Biomarkers & Diagnosis, 7(2): 1-5

**[27]** Kurian, J. C. (2012). Ethno-medicinal plants of India, Thailand and Vietnam. Journal of Biodiversity, 3(1): 61-75.

**[28]** Lamba, B. and Bhargava, K. P. (1969). Activity of some synthetic and natural products against experimental ankylostomiasis. Indian J. Pharmacol, 1(6): 204-222.

**[29]** Li, R. J., Gao, C. Y., Guo, C., Zhou, M. M., Luo, J. and Kong, L. Y. (2017). The anti-inflammatory activities of two major withanolides from Physalis minima via acting on NF-κ B, STAT3, and HO-1 in LPS-stimulated RAW264. 7 Cells. Inflammation, 40: 401-413.

**[30]** Maheshwari, V. L., Joshi, P. V. and Patil, R. H. (2009). In vitro anti diarrhoeal activity and toxicity profile of *Aegle Marmelos* Correa ex. Roxb. dried fruit pulp", Natural Product Rad, 8(5): 498-502.

**[31]** Maity, P., Hansda, D., Bandyopadhyay, U. and Mishra, D.K., (2009). Biological activities of crude extracts and chemical constituents of Bael, *Aegle Marmelos* (L.) Corr. Indian Journal of Experimental Biology,47: 849-861.

**[32]** Mali, S. S., Dhumal, R. L., Havaldar, V. D., Shinde, S. S., Jadhav, N. Y. and Gaikwad, B. S. (2020). A systematic review on *Aegle Marmelos* (Bael). Research Journal of Pharmacognosy and Phytochemistry, 12(1): 31-36.

**[33]** Misra, P., Pal, N. L., Guru, P. Y., Katiyar, J. C. and Tandon, J. S. (1991). Antimalarial activity of traditional plants against erythrocytic stages of Plasmodium berghei. International Journal of Pharmacognosy, 29(1): 19-23.

**[34]** Monika, S., Thirumal, M., & Kumar, P. R. (2023). Phytochemical and biological review of *Aegle Marmelos* Linn. Future science OA, 9(3): 1-15.

**[35]** Nag, S., Mandal, R. and Dastidar, D.G., (2015). A Study on Antimicrobial Activity and Phytochemical Screening of Methanolic Extract from Barks of *Aegle Marmelos* (L.). Eurp. J. Biotechnol. Biosci, 3(4): 28-32.

**[36]** Pallab, M., Dhananjay, H., Uday, B. and Mishra, D. K. (2009). Biological activities of crude extracts and chemical constituents of *Aegle Marmelos* (L.) Corr. Indian Journal of Experimental Biology, 47(11): 849-861.

**[37]** Panda, S. and Kar, A. (2006). Evaluation of the antithyroid, antioxidative and antihyperglycemic activity of scopoletin from *Aegle Marmelos* leaves in hyperthyroid rats. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives, 20(12): 1103-1105.

**[38]** Parmar, C. and Kaushal, M. K. (1982). Wild fruits of the Sub-Himalayan region. Wild fruits of the Sub-Himalayan region. Kalyani Publishers, New Delhi, 1-5.

**[39]** Pathirana, C.K., Madhujith, T. and Eeswara, J., (2020). Bael (*Aegle Marmelos* L. Corrêa), a medicinal tree with immense economic potential. Advances in Agriculture, 1-13.

**[40]** Pitre, S. and Srivastava, S. K. (1987). Pharmacological, microbiological, and phytochemical studies on roots of *Aegle Marmelos*. 194-197.

**[41]** Prabodh, C. S., Vivek, B., Nitin, B. and Archana, S. (2007). A review on Bael tree. Natural Product Radiance, 6(2): 171-178.

**[42]** Purohit, S. S. and Vyas, S. P. (2004). *Aegle Marmelos* Correa ex Roxb. (Bael), medicinal plant cultivationa scientific approach. Agrobios, Jodhpur, 498-504.

**[43]** Rahman, S. and Parvin, R. (2014). Therapeutic potential of *Aegle Marmelos* (L.)-An overview. Asian Pacific journal of tropical disease, 4(1): 71-77.

**[44]** Rakulini, R. and Kalaichelvi, S. (2019). A review of anti–diarrheal activity of *Aegle Marmelos*. Journal of Complementary and Alternative Medical Research, 7(2): 1-10.

**[45]** Ramakrishna, S. and GN, V. (2024). A Comprehensive Review on Traditional Uses, Phytochemistry, and Pharmacological Activities of *Aegle Marmelos*. Journal of Pharma Insights and Research, 2(2): 136-142.

**[46]** Rana, B. K., Singh, U. P. and Taneja, V. (1997). Antifungal activity and kinetics of inhibition by essential oil isolated from leaves of *Aegle Marmelos*. Journal of ethnopharmacology, 57(1): 29-34.

**[47]** Reddy, K. N., Reddy, C. S. and Trimurthulu, G. (2006). Ethnobotanical survey on respiratory disorders in Eastern Ghats of Andhra Pradesh, India. Ethnobotanical leaflets, 2006(1): 139-148.

**[48]** Samba Murty, A. V. S. S. and Subrahmanyam, N. S. (1989). textbook of economic botany. Wiley Eastern Limited, New Delhi.; 4: 697-698.

**[49]** Sarkar, A., Rashid, M., Musarrat, M. and Billah, M. (2021). Phytochemicals and nutritional constituent evaluation of Bael (*Aegle Marmelos*) fruit pulp at different development stage. Asian Food Science Journal, 20(1): 78-86.

**[50]** Sathiyaraj, K., Sivaraj, A., Madhumitha, G., Kumar, P. V., Saral, A. M., Devi, K. and Kumar, B. S. (2010). Antifertility effect of aqueous leaf extract of *Aegle Marmelos* on male albino rats. Int J Curr Pharmaceu Res, 2: 26-29.

**[51]** Seemaisamy, R., Faruck, L. H., Gattu, S., Neelamegam, R., Bakshi, H. A., Rashan, L. and Nagarajan, K. (2019). AntiMicrobial and AntiCancer activity of *Aegle Marmelos* and Gas Chromatography Coupled Spectrometry Analysis of their Chemical Constituents. International Journal of Pharmaceutical Sciences and Research, 10(1): 373-380.

**[52]** Sekar, D. K., Kumar, G., Karthik, L. and Rao, K. B. (2011). A review on pharmacological and phytochemical properties of *Aegle Marmelos* (L.) Corr. Serr. (Rutaceae). Asian Journal of Plant Science and Research, 1(2): 8-17.

**[53]** Sharmila, S. and Vasundra Devi, P. A. (2011). Comparison of in vitro antioxidant activity of the ethanolic extract of ripe and unripe fruit of *Aegle Marmelos*. J. Pharm. Res, 4: 720-722.

**[54]** Shinwari, Z. K. and Qaiser, M. (2011). Efforts on conservation and sustainable use of medicinal plants of Pakistan. Pak. J. Bot, 43(1): 5-10.

**[55]** Shoeb, A., Kapil, R.S. and Popli, S.P., (1973). Coumarins and alkaloids of *Aegle Marmelos*. Phytochemistry, 12(8): 2071-2072.

**[56]** Singanan, V., Singanan, M. and Begum, H. (2007). The hepatoprotective effect of bael leaves (*Aegle Marmelos*) in alcohol induced liver injury in albino rats. International Journal of Science & Technology, 2(2): 83-92.

**[57]** Singh R, Kakar S, Shah M, Jain R (2018) Some medicinal plants with anti-fertility potential: a current status. J Basic Clin Reprod Sci 7: 7–19.

**[58]** Singh, R., Singh, A. and Babu, N. (2019). Ethno-medicinal and Pharmacological activities of *Aegle Marmelos* (Linn.) Corr: A review. Pharma Innov. J, 8(6): 176-181.

**[59]** Sivaraj, R., Balakrishnan, A., Thenmozhi, M. and Venckatesh, R. (2011). Antimicrobial activity of *Aegle Marmelos*, Ruta graveolens, Opuntia dellini, Euphorbia royleena, and Euphorbia antiquorum. Journal of Pharmacy research, 4(5): 1507-1508.

**[60]** Srivastava, A. K. and Singh, V. K. (2022). Anti-Fertility Role of *Aegle Marmelos* (Bael). J. Appl. Health Sci. Med, 2: 21-25.

**[61]** Süntar, I. (2020). Importance of ethnopharmacological studies in drug discovery: role of medicinal plants. Phytochemistry Reviews, 19(5): 1199-1209.

**[62]** Tiwari, N. N. and Joshi, M. P. (1990). Medicinal plants of Nepal. III. Journal of Nepal Medical Association, 28(95): 266-279.

**[63]** Tomar, J. B., Bishnoi, S. K. and Saini, K. K. (2012). Healing the tribal way: ethno-medicinal formulations used by the tribes of Jharkhand, India, 97-105.

**[64]** Trivedi, V. P., Nesamany, S. and Sharma, V. K. (1978). Ayurvedic herbs: a clinical guide to the healing plants of traditional medicine. J. Res. Ind. Med. YOGA Homeopath, 28(13): 841-842.

**[65]** Ullikashi, K. Y., Kammar, M. R. and Lokapure, S. R. (2017). Development of value-added products from bael fruit (*Aegle Marmelos*). Int. J. Curr. Microbio. and App. Sci, 6(7): 2652-2659.

**[66]** Upadhyay, R. K. (2015). Bel plant: A source of pharmaceuticals and ethno medicines. International Journal of Green Pharmacy (IJGP), 9(4): 1-19.

**[67]** Vardhini, S. P., Sivaraj, C., Arumugam, P., Ranjan, H., Kumaran, T. and Baskar, M. (2018). Antioxidant, anticancer, antibacterial activities and GCMS analysis of aqueous extract of pulps of *Aegle Marmelos* (L.) Correa. The Journal of Phytopharmacology, 7(1): 72-78.

**[68]** Veerappan, A. K. S. and Renganathan, D. (2000). Cardiotonic effect of *Aegle Marmelos* Corr. On amphibian heart in situ preparation. In Proc. 6th Internet World Congress for Biomed. Sci, 104: 309-317.

**[69]** Venthodika, A., Chhikara, N., Mann, S., Garg, M. K., Sofi, S. A. and Panghal, A. (2021). Bioactive compounds of *Aegle Marmelos* L., medicinal values and its food applications: A critical review. Phytotherapy Research, 35(4): 1887-1907.

**[70]** Vijayakumar, S. (2019). Eco-friendly synthesis of gold nanoparticles using fruit extracts and in vitro anticancer studies. Journal of Saudi Chemical Society, 23(6): 753-761.

**[71]** Vinodhini, R. and Narayanan, M. (2009). Cytoprotective effect of Nelumbo nucifera and *Aegle Marmelos* in Common Carp (Cyprinus carpio L.) exposed to heavy metals. International journal of Integrative biology, 7(2): 124-129.

**[72]** Vyas, D. S., Sharma, V. N., Sharma, H. K. and Khanua, N. K. (1979). Effect of labetalol, an alpha-& beta-adrenoceptor blocking agent on gastric acid secretion & gastric ulcers in pylorus-ligated rats. Indian Journal of Research in Homeopathy, 14: 1093-1094.