

A review on phytochemical and pharmacological properties of *Aegle marmelos*

¹Miss.Nikita Rajendra Naik, ²Miss.Purva Paprikar

¹Student, ²Lecturer

Shastry Institute of Pharmacy, Erandol , Jalgaon India- 425109
Dr. Babasaheb Ambedkar Technological University, Lonere , Maharashtra 402103

Abstract- The *A. marmelos* is also known as Bael, wooden apple, belo and bilwa. The important phytochemicals isolated From various parts of the plant are alkaloids, cardiac glycoside, saponin, Steroids, coumarines terpenoids, phenylpropanoids, tannins, polysaccharides And flavonoids. *A. marmelos* is Belonging to Rutaceae family, the family of flowering plants. *A. marmelos* is known for various Medicinal properties in traditional medicinal system and use to cure a variety of diseases. In last Few decades, *A. marmelos* is extensively studied for its medicinal properties by advanced Scientific techniques and a variety of bioactive compounds have been isolated from the different Part of plant and were analysed pharmacologically. The medicinal properties of this plant Represent it as a valuable source of medicinal compound. This report is a summarized Information concerning the morphology, distribution, phytochemistry, traditional uses and Biological activities of the *A. marmelos*. The different parts of the plant extract possess pharmacological Activities like anticonvulsant, antioxidant, antihyperglycemic, anxiolytic, antidepressant, Antihistaminic, antimicrobial, hepato protective, analgesic, immuno modulatory, cardio protective And antithyroid activity. The present review article is focused to explore the different Pharmacological activity of *A. marmelos*.

Keywords: Rutaceae , *Aegle marmelos* , Pharmacological activity.

INTRODUCTION

This review article comprehensively explores the phytochemical and pharmacological properties of *Aegle marmelos*, commonly known as bael or bael fruit. *Aegle marmelos* has been a subject of increasing interest due to its diverse medicinal potential. The review systematically examines the plant's phytochemical composition, highlighting the presence of bioactive compounds such as flavonoids, alkaloids, tannins, and essential oils. It delves into the extraction methods employed to isolate these compounds, providing insights into the variations observed in different plant parts. *A. marmelos* is a native plant of India. *A. marmelos* belongs to Rutaceae family and commonly known as wood apple. In India, *A. marmelos* is grown as a temple garden plant and the leaves are used to pray Lord Shiva.

A. marmelos is an important medicinal plant with several ethnomedicinal applications in traditional and folk medicinal systems. Traditionally, *A. marmelos* is used in the treatment of diarrhea and dysentery. Leaves of this plant used to cause infertility/abortion in women. Recently, the plant is screened for its medicinal properties by scientific techniques and reported for various medicinal properties. The pharmacological properties of *Aegle marmelos* are elucidated, encompassing its antioxidant activity, antimicrobial effects against bacteria and fungi, anti-diabetic potential through modulation of insulin sensitivity, and anti-diarrheal activity, potentially attributed to its impact on gut motility and inflammation. The review consolidates findings from various studies, shedding light on the mechanisms underlying these pharmacological actions. The present review aims to document the morphology, distribution, phytochemistry and medicinal properties of *A. marmelos* and its future prospects for the further scientific investigation for the development of effective therapeutic compounds.



TRADITIONAL USES

Throughout history, *Aegle marmelos*, commonly known as Bael, has been an integral component of traditional medicine across diverse cultures. The review explores the plant's traditional uses, revealing a tapestry of medicinal applications deeply interwoven with cultural practices. *A. marmelos* is extensively described in the Vedic literature for the treatment of various diseases. *A. marmelos* is traditionally used to treat jaundice, constipation, chronic diarrhea, dysentery, stomachache, stomachic, fever, asthma, inflammations, febrile delirium, acute bronchitis, snakebite, abdominal discomfort, acidity, burning sensation, epilepsy, indigestion, leprosy, myalgia, smallpox, spermatorrhoea, leucoderma, eye disorders, ulcers, mental illnesses, nausea, sores, swelling, thirst, thyroid disorders, tumors, ulcers and upper respiratory tract infection. Moreover, the traditional uses extend beyond physical health, encompassing spiritual and cultural dimensions. The plant holds significance in religious rituals and ceremonies, further emphasizing its cultural importance. By delving into these traditional applications, the review aims to illuminate the historical context and cultural relevance of *Aegle marmelos*, providing a holistic perspective on its multifaceted role in traditional medicine.

PHYTOCHEMICAL STUDIES

The phytochemical composition of *Aegle marmelos* is rich and includes various bioactive compounds such as alkaloids, flavonoids, tannins, terpenoids, coumarins, and essential oils. These constituents contribute to the plant's diverse medicinal properties, showcasing its potential for applications in traditional medicine and pharmaceutical research. The review of its phytochemical profile underscores the plant's significance as a source of biologically active compounds with potential therapeutic benefits. *A. marmelos* is extensively described in the Vedic literature for the treatment of various diseases. *A. marmelos* is traditionally used to treat jaundice, constipation, chronic diarrhea, dysentery, stomachache, stomachic, fever, asthma, inflammations, febrile delirium, acute bronchitis, snakebite, abdominal discomfort, acidity, burning sensation, epilepsy, indigestion, leprosy, myalgia, smallpox, spermatorrhoea, leucoderma, eye disorders, ulcers, mental illnesses, nausea, sores, swelling, thirst, thyroid disorders, tumors, ulcers and upper respiratory tract infections.

Aegle marmelos, commonly known as Bael, is a plant with a rich phytochemical composition that has been used in traditional medicine for various health benefits. Some of the key phytochemicals found in *Aegle marmelos* include :-

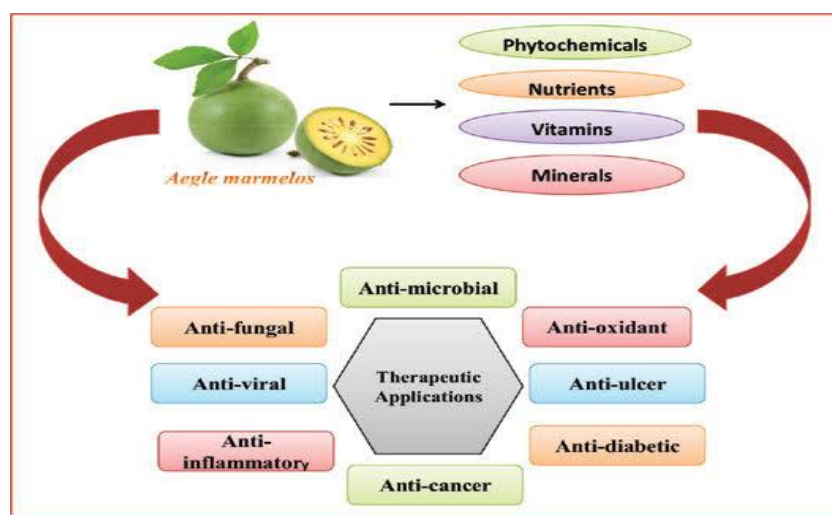
1. Alkaloids: *Aegle marmelos* contains various alkaloids, such as aegeline, fragrine, and Aegelenine.
2. Coumarins: These compounds include marmin, marmelide, psoralen, and imperatorin
3. Terpenoids: *Aegle marmelos* contains terpenoids like cineol and caryophyllene
4. Carotenoids: The fruit pulp is rich in carotenoids, which are essential for vision, immune system, and cardiovascular health
5. Phenolics: *Aegle marmelos* contains phenolic compounds, which have antioxidant and anti-inflammatory properties.
6. Pectins: The plant contains pectins, which are polysaccharides found in the cell walls of plants and have various health benefits.
7. Tannins: *Aegle marmelos* contains tannins, which are polyphenolic compounds that have astringent effect and can be used as a tanning agent.
8. Flavonoids: These compounds have antioxidant and anti-inflammatory properties and can be found in various plant species.

The phytochemistry of *Aegle marmelos* has been extensively studied, and the plant has been found to contain a variety of biologically active compounds. However, most compounds still need to be thoroughly assessed to investigate novel lead molecules, and the mechanisms of a few bioactive chemicals have been discovered so far. Comprehensive research

is necessary to Ascertain the mechanisms of action, the bioactivity of numerous phytochemicals, and the Effectiveness of Aegle marmelos for medicinal purposes.

PHARMACOLOGICAL STUDIES

The pharmacological studies conducted on Aegle marmelos, commonly known as Bael, unveil a Multifaceted spectrum of medicinal properties. Extensive research has been dedicated to Unraveling the diverse pharmacological aspects of this botanical entity, examining its potential Therapeutic applications across various health domains. This review synthesizes these Pharmacological studies, offering a nuanced analysis of Aegle marmelos' therapeutic potential. By scrutinizing the underlying mechanisms of action and summarizing key findings, this article Aims to provide a comprehensive overview of the pharmacological profile of Aegle marmelos, Shedding light on its promise as a source of novel therapeutic agents.



ANTI-ULCER ACTIVITY

Antiulcer activity refers to the ability of a substance or drug to prevent or treat ulcers in the Gastrointestinal tract. Ulcers are open sores that can develop in the lining of the stomach, small Intestine, or other parts of the digestive system. These can be caused by factors like excessive Stomach acid production, Helicobacter pylori infection, or certain medications. Methanolic extract of unripe fruit of Aegle Marmelos reduced gastric ulceration and Prevent the oxidative stress caused by Helicobacter pylori-Lipopolysaccharide in Rats . Gastro-Protective effect of extract was due to the Presence of luvangetin which lowers Oxidative stress in the gastro duodenal Mucosa . Some Other study suggested that ripe fruit of A.Marmelos protect gastric mucosa in NSAID Induced ulceration in rats by its antisecretory And Cytoprotective property . Methanolic and aqueous fruit seed Extract of A. marmelos exhibited Antiulcer Activity due to presence of quercetin Compound .Aegle marmelos exhibits notable Gastroprotective effects, making it a potential candidate for managing and preventing Ulcers.Aegle marmelos has been reported to enhance mucosal defense mechanisms, promoting The integrity of the stomach lining. This multifaceted approach underscores its potential as a Natural remedy for ulcers.

ANTI-DIABETIC ACTIVITY

Aegle Marmelos has been use to control diabetes in traditional medicinal system. Many in vivo Scientific studies have been conducted in animal models to evaluate the ant-diabetic activity of Different organic extracts and fresh juice of A. marmelos. Antidiabetic potential of the leaves and Callus of A. marmelos was reported in streptozotocin Induced diabetic rabbits. All the extracts Reduced the blood sugar level in streptozotocin diabetic rabbits, however, among the various Extracts, the methanol extracts of the leaf and callus brought About the maximum antidiabetic Effect.

ANTIOXIDANT ACTIVITY

Antioxidant activity of the fruit of A. marmelos was reported. Antioxidant activity and free Radical scavenging activity of the ripe and unripe fruit of Aegle marmelos was compared. Results Indicate that the enzymatic antioxidants increased in ripe fruit when compared to unripe fruit Extract (except glutathione peroxidase). The percentage of free radical inhibition was also high in Unripe fruit than that of the ripe fruit .Methanol and aqueous extract of A. marmelos fruit pulp was screened for antioxidant activity by DPPH radical scavenging method, reducing power assay, nitric oxide scavenging assay, superoxide radical scavenging assay, ABTS radical scavenging assay and H₂O₂ radical Scavenging

assay. Both aqueous and alcoholic extract exhibited good antioxidant activity. The antioxidant activity of the fruit of *A. marmelos* was reported. The aqueous extract of *A. marmelos* fruit was screened for antioxidant.

ANTIMICROBIAL ACTIVITY

Aegle Marmelos has been traditionally used for the treatment of various infectious diseases and has been extensively reported to inhibit the broad range of pathogenic microorganisms. Many *in vitro* studies proved the antimicrobial potential of *A. marmelos* extracts towards the pathogenic microorganisms including bacteria and fungi. The antimicrobial activity of the leaves of *A. Marmelos* was performed by agar well diffusion method. The aqueous, petroleum ether and Ethanol extract of the leaves of *Aegle marmelos* exhibited efficient antimicrobial activity against *Escherichia coli*, *Streptococcus pneumoniae*, *Salmonella typhi*, *Klebsiella pneumoniae* and *Proteus vulgaris*. The ethanolic extract shows activity against *Penicillium chrysogenum* and the Petroleum ether and aqueous extract shows activity against *Fusarium oxysporum*. The antimicrobial activity of the leaves of *Aegle marmelos* was reported. The antimicrobial activity was checked by disc diffusion method. The petroleum ether extract of leaves was checked against multi-resistant strains of *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli*, *Salmonella typhi*, *Proteus vulgaris*, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*. The antimicrobial activity against gram-negative strains was higher than that of gram-positive strains.

ANTI-INFLAMMATORY ACTIVITY

Aegle marmelos, commonly known as Bael, has been found to exhibit anti-inflammatory properties in various studies. A study evaluated the acute anti-inflammatory activity of dried flower extracts of *Aegle marmelos* in rats using the carrageenan-induced paw edema model. The results showed a significant reduction in inflammation. Unripe fruit pulp of *A. marmelos* was reported to possess anti-inflammatory activity. Inflammation was induced by injecting 0.1 ml of 1% λ carrageenan into the subplantar side of left hind paw of Sprague Dawley rats. Extract treatment of the inflamed rats significantly reduced the λ carrageenan-induced inflammation. It has been recognized for its notable anti-inflammatory properties. Studies have demonstrated that various parts of the plant, including leaves, bark, and fruits, possess bioactive compounds with anti-inflammatory effects. The anti-inflammatory activity of *Aegle marmelos* is often attributed to its ability to inhibit proinflammatory mediators, such as cytokines and prostaglandins. *Aegle marmelos* extracts may be beneficial in alleviating inflammatory conditions, making it a subject of interest in the development of natural anti-inflammatory agents. While more studies are needed to elucidate specific mechanisms and establish standardized protocols, current evidence supports the traditional use of *Aegle marmelos* as an anti-inflammatory botanical remedy.

ANTICANCER ACTIVITY

Research proved that extracts from *Aegle Marmelos* are able to inhibit the *in vitro* proliferation of human tumor cells, Erythroleukemic HEL, melanoma colo38, MDAMB- 231 and breast cancer MCF7 cell lines. The ethanolic leaf extract of *A. marmelos* showed greater antiproliferative activity against colon, breast carcinoma and leukaemia cell line. Anticancer activity was due to leaves and fruit of bael which contain lupeol, Eugenol, citral, and marmelin skimmianine. It has been observed that ethanolic leaves extract of *A. Marmelos* showed antiproliferative activity against ascites tumor in Swiss albino mice. It was reported that the hydromethanolic *A. Marmelos* bark extract has antitumor and antioxidant potential against 7, 12-Dimethylbenzanthracene (DMBA) induced skin papillomagenesis in Swiss albino mice. The presence of phytochemicals such as alkaloids, flavonoids, and terpenoids in *Aegle marmelos* has been associated with anti-cancer activities. The different parts of the plant exhibit cytotoxic effects on various cancer cell lines, including those associated with breast, lung, and cervical cancers. These cytotoxic effects are often attributed to the induction of apoptosis, a programmed cell death mechanism crucial for inhibiting the uncontrolled growth of cancer cells. *Aegle marmelos* extracts have shown potential in mitigating cancer progression by modulating key signaling pathways involved in cell proliferation and survival. Additionally, the plant's antioxidant properties contribute to combating oxidative stress, which is implicated in cancer development.

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