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Dive to pharmacological insights into *Aegle folia*: A comphrehensive review and therapeutic evaluation

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Abstract
Aegle folia (Bael) is widely used in traditional medicine for its therapeutic applications. Despite its extensive usage in Ayurveda, Unani, and Siddha systems, its integration into homoeopathic materia medica remains underexplored. This review evaluates the pharmacological effects and homeopathic potential of *Aegle marmelos* (*Aegle folia*).
Objective: To examine the pharmacological research on Aegle folia and assess its potential therapeutic relevance in homeopathy.
Methods: Following the PRISMA 2020 guidelines, an extensive search was carried out in databases such as Scopus, PubMed, Web of Science, and Google Scholar. Studies published from 2005 onward that explored the therapeutic roles and pharmacological characteristics of Aegle folia were included.
Results: The review highlights that Aegle folia exhibits a broad range of pharmacological effects, including antidiabetic, hepatoprotective, neuroprotective, antioxidant, and antiseptic activities, along with other health-promoting benefits. Bioactive constituents such as flavonoids, coumarins, alkaloids, and polyphenols contribute to these actions. Its traditional use aligns with several homeopathic indications, yet lacks systematic provings and standardization.
Conclusion: *Aegle folia* hold promise for integration into homoeopathy. However, further clinical validation and standardized provings are required to define its role in the Materia medica. Interdisciplinary studies combining pharmacology and homeopathy are recommended.

Keywords: *Aegle folia*, homoeopathy, integrative medicine, materia medica, pharmacological evaluation

Introductions
The medicinal plant Aegle folia, additionally referred to as Aegle marmelos or Bael, belongs to the Rutaceae family it is classified under order Sapindales Growing upto an average height of 12 to 15 meters, the medium-sized deciduous tree is fragrant, pale greenish-white flowers. The fruit is a pyriform or hard-shelled berry with a wood outer layer with an orange, mucilaginous pulp which is packed with seeds. The tropical and subtropical areas of India, Sri Lanka, Bangladesh, Myanmar, Thailand, and Southeast Asia are habitat to a large number of Aegle folia. Although highly drought-resistant, it grows in a variety of soil types and grows in dry, deciduous forests. Various regions and languages have different names for the tree Aegle folia is a plant that is highly valued in botanical studies and traditional medicine. In Hindu culture, it is frequently grown close to temples as a leaf offering to Lord Shiva. In rural India, it is used in agroforestry to give the community as food, shade, and health benefits "Bilva" is its Ayurvedic name, and it belongs to the "Dashamoola" group. Diabetes, respiratory illnesses, inflammatory conditions, and digestive disorders are all treated with Aegle folia.
Irritable bowel disorder, diarrhea, and dysentery are treated with the unripe fruit.
The unripe fruit is used for diarrhea, dysentery, and irritable bowel syndrome, while the ripe fruit is a natural coolant and laxative [6]. The leaves are used for diabetes management due to their hypoglycemic properties, while the roots and bark possess anti-inflammatory, febrifuge, and cardioprotective properties [7]. Bilva is also used in Ayurvedic Rasayana therapy for its rejuvenating effects. Modern pharmacological studies confirm its antibacterial, antifungal, anti-diabetic, hepatoprotective, and antioxidant properties. Modern formulations, including Bael fruit syrups, powders, and capsules, are now available for digestive health and immune support. *Aegle folia* is a lesser-known remedy in homoeopathy known for its deep action on the gastrointestinal system, liver, and metabolic processes [8].

It is primarily used for digestive disorders, fevers, and conditions involving inflammatory or infectious processes. Key Homoeopathic Indications of *Aegle folia* include treating chronic diarrhea, dysentery, irritable bowel syndrome, liver infections, malarial or enteric fevers, respiratory conditions, and diabetes and metabolic disorders [9].

This study explores the pharmacological effects, therapeutic qualities, and clinical significance of *Aegle folia* in conventional and contemporary medical systems. It reviews its phytochemical profile and identifies bioactive substances that give it therapeutic properties. The study evaluates its therapeutic indications and potential uses in homoeopathic practice, supporting its effectiveness in treating various medical disorders. The paper identifies research gaps and recommends future directions to confirm its therapeutic advantages, potentially stimulating further research and standardizing *Aegle folia* in integrative medicine.

Methodology

Study Design

Scoping review following PRISMA guidelines [10, 11].

Sources of Information and Search Tools

Electronic databases that include PubMed, Scopus, Web of Science, Google Scholar, ScienceDirect, SpringerLink, and the Cochrane Library's database were used in an extensive search

Search teams

The search technique will include Boolean operators and keywords:

- ("*Aegle marmelos*" OR "Bael" OR "Bilva") AND ("therapeutic" OR "medicinal" OR
- "pharmacological")
- ("*Aegle marmelos*" AND "homoeopathy" OR "materia medica" OR "provings")
- ("*Aegle marmelos*" AND "Ayurveda" OR "Unani" OR "Siddha" OR "ethnobotany")
- ("*Aegle folia*" OR "Bael" OR "Bilva") AND ("therapeutic" OR "medicinal" OR "pharmacological")
- ("*Aegle folia*" AND "homoeopathy" OR "materia medica" OR "provings")
- ("*Aegle folia*" AND "Ayurveda" OR "Unani" OR "Siddha" OR "ethnobotany")

Inclusion Criteria

- Peer-reviewed articles published in English.
- Studies focusing on the therapeutic properties, pharmacology, phytochemistry, or ethnobotanical use of *Aegle folia*.
- Experimental, clinical, and *in vivo*/*in vitro* studies on the medicinal effects of *Aegle folia*.

Exclusion Criteria

- Studies with incomplete or irrelevant data on *Aegle folia*.
- Articles published in non-English languages (unless translation is available).
- Duplicates, opinion papers, and anecdotal reports without scientific validation.
- Studies focusing on non-medicinal uses (e.g., agricultural, industrial applications).
- Review article
- Publish before 2005

Data Extraction and Management

Data will be extracted using a standardized data collection form, including:

- **Study details:** Authors, publication year.
- **Study type:** Clinical trial, *in vivo*, *in vitro*, ethnobotanical survey, homeopathic proving.
- **Therapeutic applications:** Disease conditions targeted.
- **Phytochemical composition:** Identified bioactive compounds.
- **Pharmacological actions:** Antimicrobial, anti-inflammatory, hepatoprotective, anti-diabetic, etc.
- **Outcomes and limitations:** Key findings of the study.

Results

A total of 425 records were identified from PubMed (405) and Google Scholar (20). After removing two duplicates, 423 records remained for screening. Of these, 266 were excluded due to irrelevance (158) or unconventional format (108). Subsequently, 157 full-text articles were assessed, resulting in the inclusion of 134 studies in this review.

Discussion

This systematic review, encompassing 134 studies, highlights the remarkable pharmacological diversity of *Aegle folia* and underscores its potential therapeutic applications across a wide range of diseases. The findings reveal consistent evidence that the plant's phytoconstituents exert significant effects on gastrointestinal, metabolic, neurological, cardiovascular, antimicrobial, and oncological health [2, 4, 6]. Importantly, the review traces the progression of *Aegle folia* research from traditional medicine to modern experimental and clinical validation, establishing its growing relevance in integrative medicine and homeopathy [7, 8].

One of the most well-established areas of *Aegle folia* research relates to gastrointestinal health. The plant is widely used in Ayurveda to treat ulcers, diarrhea, and dysentery; studies on both humans and animals have confirmed these uses [2, 4].

Preclinical investigations have demonstrated that methanolic extracts significantly reduce gastric lesions, restore gut microbiota, and alleviate dysenteric symptoms [6]. Clinical studies further validated its benefits in irritable bowel syndrome by reducing abdominal discomfort and improving digestion [4]. More recent studies have expanded its scope, showing hepatoprotective effects, normalization of liver enzymes, and regulatory roles in gut motility [12, 13].

Collectively, these findings not only confirm the plant's traditional uses but also expand its therapeutic potential to include functional dyspepsia and broader hepatogastrointestinal disorders [4, 12].

The plant's role in diabetes and metabolic health is another domain where evidence has been steadily accumulating. Early studies demonstrated its hypoglycemic activity, with extracts lowering fasting blood glucose levels in experimental models [12, 15]. Later work showed that *Aegle folia* enhances insulin sensitivity, protects pancreatic beta-cells, and improves overall glycemic control [12, 15]. Clinical investigations reported improved outcomes among diabetic patients, including better lipid regulation and reductions in

oxidative stress markers [12]. These findings position *Aegle folia* as an important botanical candidate for addressing the growing global burden of diabetes and associated metabolic disorders [12, 15].

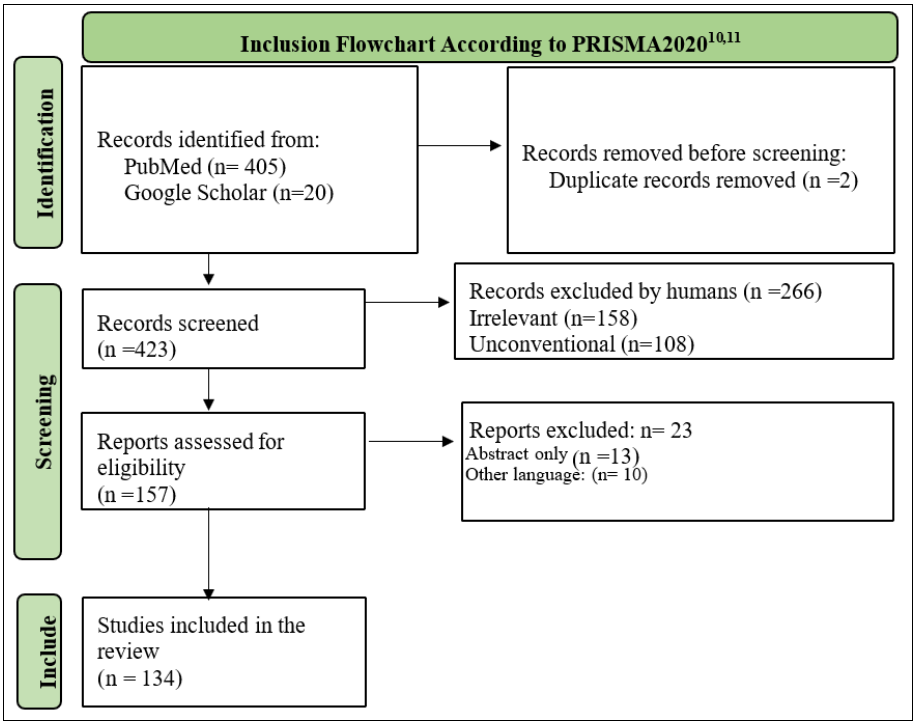

Chart 1: PRISMA flow chart

Neuroprotective and cognitive health effects represent a more recent but rapidly expanding field of research. Initial studies identified its antioxidant activity in neuronal cells, reducing oxidative stress markers and hinting at potential neuroprotection [13, 14]. Although direct evidence remains limited, findings from antioxidant and anti-inflammatory studies suggest that *Aegle folia* may regulate neuroinflammation and promote neuronal regeneration, thereby offering promise in the management of neurodegenerative diseases [13, 14].

In cardiovascular and inflammatory health, *Aegle folia* has demonstrated multiple benefits. Experimental studies have shown improvements in endothelial function, while findings also confirm cholesterol-lowering properties and modulation of inflammatory cytokines [16]. Its strong antioxidant profile contributes to reductions in oxidative stress, thereby supporting cardioprotection [12, 16]. Evidence of reduced inflammatory markers highlights its potential as an adjunct therapy in managing chronic inflammatory and ischemic heart conditions [16].

Aegle folia has significant immunomodulatory and microbiological benefits Apart from it has fungal impacts against Candida albicans, studies have demonstrated that it has bacterial activity against Escherichia coli, Staphylococcus aureus, and other pathogens [13, 17].

Beyond direct antimicrobial activity, the plant has demonstrated immunomodulatory potential, with evidence suggesting enhancement of host defense mechanisms and boosting of immune responses [17]. These properties make *Aegle folia* an attractive candidate for managing infections and supporting overall immune health, particularly in an era where antimicrobial resistance is an increasing concern [13, 17].

Emerging research has also highlighted the anticancer potential of *Aegle folia*. Early studies demonstrated cytotoxic effects on cancer cell lines, while later work revealed its ability to induce apoptosis in liver and other cancer models [13]. More recent investigations have shown inhibition of tumor growth, reductions in cancer progression, and enhancement of chemotherapy efficacy [13]. These findings point toward a dual role of the plant as both a direct anticancer agent and a supportive therapy in integrative oncology, although clinical validation remains limited at this stage [13].

Despite these promising findings, the translation of *Aegle folia* into modern clinical practice faces important challenges. Standardization of extracts and dosage remains inconsistent across studies, making it difficult to establish uniform therapeutic guidelines [2, 4]. Most of the available evidence is derived from preclinical research, with relatively few large-scale, well-controlled clinical trials [10, 11]. Regulatory hurdles and lack of validated formulations further limit its integration into mainstream medicine [10, 11]. Additionally, the molecular mechanisms underlying its therapeutic effects are still only partially understood, requiring more advanced pharmacological and biochemical investigations [12].

Future research directions should therefore emphasize well-designed randomized controlled trials to confirm safety and efficacy in human populations [10, 11]. Standardization of bioactive compound extraction, quantification of purity, and development of reproducible formulations are essential for clinical translation [12, 13]. Investigations into synergistic effects with conventional drugs could help establish *Aegle folia* as a supportive therapy, while exploration of novel delivery systems could improve its bioavailability and therapeutic impact [13]. By bridging these knowledge gaps, the plant has the potential to evolve from a traditional remedy into a scientifically validated component of integrative medicine [7, 8].

In summary, *Aegle folia* is a multifaceted medicinal plant with therapeutic relevance across gastrointestinal, metabolic, neurological, cardiovascular, antimicrobial, and oncological domains [2, 4, 6, 12, 16]. Its journey from traditional medicine to contemporary pharmacological validation highlights its versatility and future promise. While challenges related to standardization, regulation, and clinical validation persist, the breadth of evidence supports its continued investigation [10, 11]. Addressing these limitations through rigorous scientific inquiry could firmly establish *Aegle folia* as a cornerstone of integrative and complementary medicine, bridging the gap between ancient wisdom and modern therapeutics [7, 8].

Conclusion

Aegle folia, a plant with numerous therapeutic applications, has been confirmed in a systematic review of 134 studies. Its bioactive compounds, including flavonoids, alkaloids, polyphenols, and coumarins, have potent anti-inflammatory, anti-diabetic, antioxidant, and cytotoxic properties. *Aegle folia* is a promising yet unexplored remedy in homoeopathic materia medica, but its integration into modern practice requires a more detailed and evidence-based approach. Collaboration between pharmacologists, homoeopaths, and bioinformatics researchers is essential to bridge the gap between ethnomedicine and modern homoeopathy. Advanced analytical techniques will enhance the standardization, efficacy, and therapeutic predictability of *Aegle folia*.

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Conflict of interest

The author declares no conflict of interest.

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