INTI JOURNAL | Vol.2026, Issue 3, No.10
eISSN:2600-7320

The Multifaceted Therapeutic Wonders of *Aegle marmelos*: A Comprehensive Review

Arya K.R. [1*], Aathila Thamanna[2], K.H. Aksharra[3], Shani S.[4], Dinesh S.[5], B. David Jayaseelan[6]

[1,2,3,4,5,6]Department of Microbiology, Nehru Arts and Science College, TM Palayam, Coimbatore, Tamil Nadu, 641105, India

***Email:** aryakrkunnath@gmail.com[1]

Abstract

Plants play a vital role in keeping the environment healthy and serving as the cornerstone of sustenance and medicine. *Aegle marmelos*, commonly known as bael, is a medicinal tree belonging to the Rutaceae family that is widely distributed across the Indian subcontinent. Various parts of the plant, including roots, leaves, seeds, flowers, and fruits, contain diverse bioactive chemical constituents such as alkaloids, terpenoids, tannins, coumarins, flavonoids, and phenylpropanoids. This review synthesizes current knowledge on the phytochemical composition and pharmacological properties of *A. marmelos*, including its antioxidant, anti-inflammatory, anti-diabetic, antimicrobial, antiviral, antidiarrheal, and wound-healing properties. The summary highlights the plant's therapeutic potential as a renewable source for pharmaceutical agent discovery and aims to guide young researchers in future pharmacological applications.

Keywords

Aegle marmelos, phytochemical components, pharmacological activities, therapeutic uses, biofertilizer

Introduction

Plants have been the cornerstone of sustenance and medicine for humans, animals, and birds since the dawn of life. The utilization of various plant parts, such as roots, stems, leaves, flowers, and fruits, has been a vital aspect of survival. Ancient civilizations, including those documented in the Rigveda, Yajurveda, Atharvaveda, Charak Samhita, and Sushrut Samhita, recognized the medicinal properties of plants. In recent decades, scientific studies have validated the medicinal properties of plants. Research has identified numerous active chemical compounds responsible for their therapeutic effects, including anticancer, antibacterial, antifungal, antidiabetic, antioxidant, hepatoprotective, hemolytic, larvicidal, and anti-inflammatory properties (Bhar et al., 2019). The significance of plants in medicine is undeniable, and continued research and exploration of plant-

Submission: 30 June 2026; **Acceptance:** 28 July 2026; **Available online:** October 2026

Copyright: © 2026. All the authors listed in this paper. The distribution, reproduction, and any other usage of the content of this paper is permitted, with credit given to all the author(s) and copyright owner(s) in accordance to common academic practice. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license, as stated in the website: https://creativecommons.org/licenses/by/4.0/

based medicines hold promise for discovering new treatments and improving human health (Bhar et al., 2019).

Aegle marmelos, commonly known as bael or Bengal quince, is a species of tree belonging to the citrus family Rutaceae (Choudhary et al., 2021), which is native to the Indian subcontinent and Southeast Asia. It is present in India, Pakistan, Bangladesh, Sri Lanka, and Nepal as a naturalized species. The tree is considered to be sacred by Hindus and Buddhists.

Taxonomy

Kingdom: Plantae
Order: Sapindales
Family: Rutaceae
Subfamily: Aurantioideae
Genus: *Aegle*
Species: *A. marmelos*

Botanical Description and Uses

Table 1. Botanical description and uses of Aegle marmelos

Parts	Description	Uses
Bark	Thick bark that secretes a sticky gum when thrashed. The gum is sweet initially but becomes bitter, solidifying into long strands upon exposure to air.	Traditional bark infusions are used for cough and fever; component of Chyavanprash. Root bark serves as fish poison and fever treatment. Bark decoctions and leaf extracts treat fevers.
Leaves	Alternate serrated leaflets on trifoliate leaves (3 to 5 leaflets, 4–10 cm long, 2.5–5 cm wide). Dark green when mature.	Treats fever, seminal weakness, nausea, vomiting, swellings, diarrhea, dyspepsia, wounds, bronchitis, cholera, beriberi, and stomach problems.
Seed	Flat, oblong, ~1 cm long with woolly hair structure. Surrounded by a clear, sticky mucus sac that solidifies when dry.	Exhibits antibacterial properties; inhibits pathogens such as Escherichia coli, Staphylococcus aureus, and Vibrio cholerae.
Flower	Hypogynous, bisexual, ebracteate, actinomorphic, strongly scented, greenish-white. Blossom in May–June on lateral panicles in leaf axils.	Distilled flowers act as local anesthetics, antidiabetic, diaphoretic, expectorant, and anti-dysenteric agents; acts as a stomach and intestinal tonic.

Table 1…Continued

Fruit	Round or oval (5–7 cm diameter, ~77.2 g, capacity 73 mL, sphericity 93.72 ± 2.78%), yellowish-green with a firm, woody exocarp.	Astringent; treats stomach issues, diarrhea, gonorrhea, epilepsy, and ulcers. Demonstrates antidiabetic, anticancer, antioxidant, and antibacterial effects.

(Source: Khedkar & Gore, 2025)

Nutritive and Therapeutic Value

According to research published in Food Science and Nutrition, a 100-gram serving of bael fruit contains approximately 137–139 calories, 1.8 g protein, 0.3 g fat, 31.8–32 g carbohydrates, 2.9 g fiber, and 1.7 g minerals. It is a source of essential nutrients, including calcium, phosphorus, potassium, and vitamins B1, B2, and C, as well as various phytochemicals such as alkaloids, flavonoids, and tannins.

Table 2. Nutritive value of Aegle marmelos

Components	**Value (%)**
Water	64.5
Protein	1.8
Fat	0.2
Mineral	1.5
Fiber	2.2
Carbohydrates	30.6
Calcium	0.09
Phosphorus	0.05
Potassium	0.6
Iron	0.3
Vitamin A	186 IU
Vitamin B1	0.01
Nicotinic acid	0.9
Riboflavin	0.01
Calorific value	129 kcal

(Source: Neeraja et al., 2017)

Almost all parts of *Aegle marmelos* are used in therapeutics due to their richness in bioactive phytochemicals. Extracts possess antimicrobial, antibacterial, antifungal, antiviral, anti-

inflammatory, larvicidal, antioxidant, antidiabetic, anti-ulcer, anticancer, wound-healing, hepatoprotective, cardioprotective, and radioprotective effects.

Chemical Composition

The leaves of *A. marmelos* contain O-isopentenyl halfordiol, γ-sitosterol, lupeol, aegelin, rutin, marmesinin, β-sitosterol, marmeline, and phenylethyl cinnamamides (Yadav & Chanotia, 2009). Organic extracts of the leaves confirm the presence of alkaloids, cardiac glycosides, terpenoids, saponins, tannins, flavonoids, and steroids. Fruit pulp contains steroids, terpenoids, flavonoids, phenolic compounds, lignin, fats, oils, inulin, proteins, carbohydrates, and alkaloids (Rajan et al., 2011). Bioactive compounds like γ-sitosterol, aegelin, and lupeol contribute to its ability to control diabetes, treat ulcers, and protect against oxidative damage (Patel et al., 2012).

Therapeutic Effects

Antioxidant Activity: Antioxidants prevent cell oxidation. Ethanol, methanol, and aqueous extracts of *A. marmelos* effectively fight oxidation (Reddy & Urooj, 2013). Bael extract demonstrates antioxidant and hypoglycemic effects in alloxan-induced diabetic male albino rats, significantly elevating oxidative stress markers such as erythrocyte GSH and plasma GST (Upadhya et al., 2004). Leaf extracts decrease hepatic lipid peroxidation while increasing levels of glutathione, superoxide dismutase, and catalase, alongside displaying antiproliferative potential (Chockalingam et al., 2012).

Anti-Inflammatory Activity: Inflammation is the immune response to pathogens or foreign objects, commonly treated using non-steroidal anti-inflammatory drugs (NSAIDs) (Jose & Antony, 2003). Root bark aqueous extract significantly reduces acute inflammation, showing a 46% decrease in carrageenan-induced paw edema (Benni et al., 2011). Dried flower water extracts reduce inflammation by inhibiting nitric oxide production, stabilizing cell membranes, and acting as antioxidants (Kumari et al., 2014). Leaf extracts also exhibit strong anti-inflammatory activity superior to aspirin in paw edema models (Ghangale et al., 2008).

Anti-Diabetic Activity: Methanolic fruit and leaf extracts reduced blood glucose in alloxan-induced diabetic rats (Sabu & Kuttan, 2004; Saha et al., 2015). Whole plant extracts lowered fasting glucose, improved lipid profiles, and exerted protective effects on kidneys in streptozotocin-induced diabetic rats (Jagetia, 2024). Bioactive flavonoids and lectins contribute to these antidiabetic and antimicrobial mechanisms (Saha et al., 2015; Nigam & Nambiar, 2015).

Anti-Microbial Activity: Methanolic leaf and flower extracts inhibit Gram-positive and Gram-negative bacteria, including *Escherichia coli*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus* (Suresh & Karthikeyan, 2009). Crude extracts show antibacterial activity against S. aureus and antifungal action against *Candida albicans* (Senthilkumaran et al., 2014). Fruit and leaf extracts display broad-spectrum antimicrobial activity with notable inhibition zones against *Raoultella planticola* and *Penicillium chrysogenum* (Meena et al., 2016). Allylphenols contribute to these antimicrobial properties (Senthilkumaran et al., 2014). Methanolic fruit extracts also inhibit *Candida albicans* and *Aspergillus niger* (Parihar et al., 2013).

Anti-Viral Activity: Seselin isolated from *A. marmelos* leaves exhibits antiviral effects against Bombyx mori nucleopolyhedrovirus (Somu et al., 2019). Plant extracts show in vitro antiviral

activity against human coxsackieviruses B1–B6, with marmelide acting as a potent virucidal agent (Badam et al., 2002). Leaf and fruit extracts demonstrate in ovo antiviral activity against Newcastle disease virus, with in silico docking confirming interaction with the viral HN protein (Andleeb et al., 2021).

Anti-Diarrheal Activity: Hot aqueous decoctions of unripe fruit pulp inhibit colonization, adherence, and invasion of enteropathogenic *E. coli*, enteroinvasive *E. coli*, and *Shigella flexneri* in HEp-2 cells (Brijesh et al., 2009). Aqueous-ethanolic extracts containing tannins, alkaloids, and saponins reduce gut motility and fluid secretion, producing a 67.44% (400 mg/kg) and 70.93% (800 mg/kg) reduction in diarrheal episodes in mice (Mehesare et al., 2019). Root extracts actively inhibit Vibrio cholerae, E. coli, and Shigella spp. at levels comparable to ciprofloxacin (Mazumder et al., 2006).

Wound Healing Properties: Topical application of 5% w/w and 10% w/w ointments derived from methanolic and ethanolic seed extracts demonstrated significant in vivo wound healing in rats (Sharma & Dubey, 2011). Root extracts showed similar dermal wound-healing properties (Jaswanth et al., 2001).

Conclusion

Aegle marmelos is a therapeutic and nutraceutical plant species with extensive traditional usage in indigenous medicine. Scientific evaluations have validated its diverse bioactive compounds and pharmacological properties, including antibacterial, antifungal, antiviral, antidiabetic, antidiarrheal, wound-healing, and antioxidant effects. *A. marmelos* remains a valuable natural source for future pharmaceutical discovery and drug development.

Acknowledgements

The authors express sincere gratitude to the faculty members and the Department of Microbiology, Nehru Arts and Science College, Coimbatore, for their continuous support and academic guidance. There is no external grant or funding body to be acknowledged for preparing this review.

References

Andleeb, R., Ijaz, M. U., Ashraf, A., Bano, N., Zafar, N., Tasleem, F., Marc, R. A., Pop, O. L., & Ahmed, H. T. (2021). Biological activities of methanolic extract of Aegle marmelos against HN protein of Newcastle disease virus. *Agronomy*, *11*(9), Article 1784. https://doi.org/10.3390/agronomy11091784

Badam, L., Bedekar, S. S., Sonawane, K. B., & Joshi, S. P. (2002). In vitro antiviral activity of bael (Aegle marmelos Corr) upon human coxsackieviruses B1–B6. *Journal of Communicable Diseases*, *34*(2), 88–99. https://pubmed.ncbi.nlm.nih.gov/14768825/

Benni, J. M., Jayanthi, M. K., & Suresha, R. N. (2011). Evaluation of the anti-inflammatory activity of Aegle marmelos (Bilwa) root. *Indian Journal of Pharmacology, 43*(4), 393–397. https://doi.org/10.4103/0253-7613.83108

Bhar, K., Mondal, S., & Suresh, P. (2019). An eye-catching review of Aegle marmelos L. (Golden Apple). *Pharmacognosy Journal, 11*(2), 207–224. https://doi.org/10.5530/pj.2019.11.34

Brijesh, S., Daswani, P., & Tetali, P. (2009). Studies on the antidiarrhoeal activity of Aegle marmelos unripe fruit: Validating its traditional usage. *BMC Complementary and Alternative Medicine, 9,* Article 47. https://doi.org/10.1186/1472-6882-9-47

Chockalingam, V., Kadali, S. D. V. S., & Gnanasambantham, P. (2012). Antiproliferative and antioxidant activity of Aegle marmelos (Linn.) leaves in Dalton's Lymphoma Ascites transplanted mice. *Indian Journal of Pharmacology, 44*(2), 225–229. https://doi.org/10.4103/0253-7613.93854

Choudhary, G., Ahmad, U., & Chaudhary, S. (2021). Distinctive solvatochromic response of fluorescent carbon dots derived from different components of Aegle marmelos plant. *Engineered Science, 15*, 197–209. http://dx.doi.org/10.30919/es8e512

Ghangale, G. R., Surve, V. S., Anbarasan, K., & Gatne, M. M. (2008). Evaluation of Aegle marmelos (Bael) for anti-inflammatory activity in rats. *The Journal of Bombay Veterinary College, 16*(1), 15–16 https://www.cabidigitallibrary.org/doi/pdf/10.5555/20093278407

Jagetia, G. C. (2024). Antidiabetic effect of Bael Aegle marmelos Correa family Rutaceae. *Clinical Journal of Diabetes Care and Control, 6*(1), Article 180053. https://www.academicstrive.com/CJDCC/CJDCC180053.pdf

Jaswanth, A., Sathya, S., Ramu, S., Puratchikody, A., & Ruckmani, K. (2001). Effect of root extract of Aegle marmelos on dermal wound healing in rats. *Ancient Science of Life, 20*(4), 333–336. https://pmc.ncbi.nlm.nih.gov/articles/PMC3336404/

Jose, V. M., & Antony, T. T. (2003). Recent trends in the utilization of 'NSAIDs' in a tertiary care hospital. *Indian Journal of Pharmacology, 35*(5), 318–319. https://doi.org/10.4103/IJPHA_2003355_318

Khedkar, S., & Gore, P. (2025). A review: Therapeutic profile of Aegle marmelos (Bael). *Journal of Pharmacognosy and Phytochemistry, 14*(2), 20–24. https://doi.org/10.22271/phyto.2025.v14.i2a.15270

Kumari, K. D. K. P., Weerakoon, T. C. S., Handunnetti, S. M., Samarasinghe, K., & Suresh, T. S. (2014). Anti-inflammatory activity of dried flower extracts of Aegle marmelos in Wistar rats. *Journal of Ethnopharmacology, 151*(3), 1202–1208. https://doi.org/10.1016/j.jep.2013.12.043

Mazumder, R., Bhattacharya, S., Mazumder, A., Pattnaik, A. K., Tiwary, P. M., & Chaudhary, S. (2006). Antidiarrhoeal evaluation of Aegle marmelos (Correa) Linn. root extract. *Phytotherapy Research, 20*(1), 82–84. https://doi.org/10.1002/ptr.1804

Meena, R. K., Pareek, A., & Meena, R. R. (2016). Antimicrobial activity of Aegle marmelos (Rutaceae) plant extracts. *International Journal of MediPharm Research, 2*(1), 1–5.

Mehesare, S. S., Waghmare, S. P., Thorat, M. G., Hajare, S. W., Itankar, P. R., & Ali, S. S. (2019). Evaluation of antidiarrhoeal activity of extract of unripe fruit of Aegle marmelos. *Journal of Pharmacognosy and Phytochemistry, 8*(4), 2390–2392.

Neeraja, V., Bisht, V., & Johar, V. (2017). Bael (Aegle marmelos): Extraordinary species of India: A review. *International Journal of Current Microbiology and Applied Sciences, 6*(3), 1870–1887. https://doi.org/10.20546/ijcmas.2017.603.213

Nigam, V., & Nambiar, V. S. (2015). Therapeutic potential of Aegle marmelos (L.) Correa leaves as an antioxidant and anti-diabetic agent: A review. *International Journal of Pharma Sciences and Research, 6*(3), 611–621. https://www.researchgate.net/publication/275646470

Parihar, N., Parihar, N., & Kumar, S. (2013). Study of antifungal potential of Aegle marmelos: A medicinal plant. *International Journal of Plant, Animal and Environmental Sciences, 3*(1), 126–129. https://fortunejournals.org/ojs/index.php/jpaif/article/view/19699

Patel, A. R., Dipak, G., Manodeep, C., & Jagdish, V. K. (2012). Aegle marmelos (Linn.): A therapeutic boon for human health. *International Journal of Research in Ayurveda and Pharmacy, 3*(2), 269–275. https://www.ijrap.net/admin/php/uploads/765_pdf.pdf

Rajan, S., Gokila, M., Jency, P., Brindha, P., & Sujatha, R. K. (2011). Antioxidant and phytochemical properties of Aegle marmelos fruit pulp. *International Journal of Current Pharmaceutical Research, 3*(2), 65–70. https://www.researchgate.net/publication/291022694

Reddy, V. P., & Urooj, A. (2013). Antioxidant properties and stability of Aegle marmelos leaves extracts. *Journal of Food Science and Technology, 50*(1), 135–140. https://doi.org/10.1007/s13197-010-0221-z

Sabu, M. C., & Kuttan, R. (2004). Antidiabetic activity of Aegle marmelos and its relationship with its antioxidant properties. *Indian Journal of Physiology and Pharmacology, 48*(1), 81–88. https://pubmed.ncbi.nlm.nih.gov/15270373/

Saha, S. K., et al. (2015). Anti-diabetic activities of the fruit Aegle marmelos. *Journal of Molecular Biomarkers & Diagnosis, 7*(2), Article 272. https://doi.org/10.4172/2155-9929.1000272

Senthilkumaran, R., Savitha, S., & Sivakumar, T. (2014). Antimicrobial activity of Aegle marmelos. *International Journal of Advanced Research in Biological Sciences, 1*(8), 176–183.

Sharma, G. N., & Dubey, S. K. (2011). Evaluation of wound healing activity of Aegle marmelos seed. *Pharmacologyonline, 2*, 171–178. https://www.researchgate.net/publication/266006950

Somu, C., Karuppiah, H., & Sundaram, J. (2019). Antiviral activity of seselin from Aegle marmelos against nuclear polyhedrosis virus infection in the larvae of silkworm, Bombyx mori. *Journal of Ethnopharmacology, 245*, Article 112155. https://doi.org/10.1016/j.jep.2019.112155

Suresh, K., & Karthikeyan, S. B. (2009). Antimicrobial activity of Aegle marmelos against clinical pathogens. *Journal of Physiology, 2009*, 323–327. https://updatepublishing.com/journal/index.php/jp/article/view/2038

Upadhya, S., Shanbhag, K. K., Suneetha, G., Naidu, M. B., & Upadhya, S. (2004). A study of hypoglycemic and antioxidant activity of Aegle marmelos in alloxan-induced diabetic rats. *Indian Journal of Physiology and Pharmacology, 48*(4), 476–480. https://pubmed.ncbi.nlm.nih.gov/15907058/

Yadav, N. P., & Chanotia, C. S. (2009). Phytochemical and pharmacological profile of leaves of Aegle marmelos Linn. *The Pharmaceutical Reviews, 11*, 144–150. https://staff.cimap.res.in/PublicationFiles/The_Pharma_Review_742_144.pdf