

Nutritional and Functional Properties of Tamarind (Tamarindus Indica) Leaves: A Comprehensive Review

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ABSTRACT

For centuries, plant-based materials have served as traditional remedies for promoting health and treating various ailments. *Tamarindus indica* is one such well-known medicinal plant. Belonging to the family Leguminosae (subfamily Caesalpiniaceae), tamarind is an evergreen tree originally native to Africa but now widely cultivated in tropical and subtropical regions worldwide. Ayurvedic texts describe its pharmacological properties as the basis for its therapeutic value. Besides its medicinal importance, tamarind is also commonly used as a flavoring agent in foods and beverages. The fruit of tamarind is a rich source of polyphenols, flavonoids, essential amino acids, vitamins, and other phytochemicals, contributing to its moderate antioxidant potential. Due to its affordability and availability, tamarind is considered beneficial in managing several diseases. The seeds exhibit antidiabetic, hepatoprotective, and antsnake venom activities, while other parts of the plant—including fruit pulp, leaves, and stem bark—possess antioxidant, analgesic, antiemetic, antibacterial, hypolipidemic, and liver-regenerative properties. Along with the fruit, the leaves and seeds also hold nutritional and commercial value. This review aims to highlight the phytochemical profile, traditional applications, pharmacological properties, and medicinal importance of tamarind, as well as its use in household preparations.

Keywords: *Tamarindus indica*, tamarind, antioxidant activity, flavonoids

INTRODUCTION

Inflammation is a key biological response that helps protect the body following infection or tissue injury by preventing further damage at the affected site. While acute inflammation is vital for immune defense, persistent or chronic inflammation has been strongly associated with numerous non-infectious disorders, such as arthritis. Although synthetic drugs are commonly used to manage inflammation, some of these agents inhibit kinase enzyme activity, which may in turn weaken the body's immune protection against infections.¹ Consequently, the reliance on medicinal plants for the treatment and management of inflammation and pain—an age-old practice—continues to gain worldwide recognition. The role of

these plants in preventing and managing inflammatory diseases is therefore highly significant.² Humans and plants have shared a close bond since ancient times. The use of plants as medicine can be traced back to the early stages of human civilization. India, in particular, possesses a long-standing heritage of traditional medicine and extensive knowledge of plant-based healthcare. Across the world, especially in countries like China and India, plants have served as the foundation of advanced traditional medical systems practiced for thousands of years.³ Historical evidence of plant use in healing is also documented in the Rig Veda, one of the oldest Hindu scriptures, dating from around 3500 B.C. to 1800

B.C.⁴

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Fig 1: Tamarind Leaves

Synonyms: Imli ke patte

Family: Fabaceae (Leguminosae)

• Chemical Constituents of Tamarind Leaves:

Tamarind leaves are rich in nutritional and phytochemical compounds, including:

Organic Acids: Tartaric acid, malic acid, citric acid, succinic acid

Flavonoids: Apigenin, Luteolin, Orientin, Isoorientin, Vitexin, Isovitexin

Phenolic Compounds: Caffeic acid, Ferulic acid, Chlorogenic acid, Ellagic acid

Tannins & Saponins Alkaloids Glycosides Terpenoids

Vitamins: Vitamin C, Vitamin A, and some B-complex vitamins

Minerals: Calcium, Magnesium, Potassium, Phosphorus, Iron

Origin and History:

The geographical origin of *Tamarindus indica* has long been debated among scholars. Some researchers propose that the species originated in the Far East or Africa (Coates-Palgrave, 1988) [13], while others specifically identify Ethiopia as its native region (Troup, 1921) [72]. However, it is now widely accepted that tamarind is native to Africa and was later introduced to Asia and Central America. The name “tamarind” comes from the Persian phrase “tamar-ihind,” which translates to “date of India.” Ancient Indian literature, such as the *Brahma Samhita* (dated between 1200 and 200 BCE) (El-Siddig, 2006) [16], also mentions tamarind. This reference has led some historians and botanists, including Morton and Dowling (1987) [46], to argue for a possible Indian origin.⁵ It is believed that tamarind was introduced to Asia around the first millennium BCE, and by 400 BCE, its cultivation was already established in Egypt. The Arab and Persian traders likely played a key role in spreading the plant from the Indian subcontinent to Southeast Asia.⁶

Table 1: Geographic Origin and Spread of *Tamarindus indica*

Region	Role in Tamarind History	References
Africa (Ethiopia)	Accepted native origin	Troup (1921) ^[72] , Coates-Palgrave (1988) ^[13]
India & South Asia	Early adoption, cultural references (<i>Brahma Samhita</i>)	El-Siddig (2006) ^[16] , Morton & Dowling (1987) ^[46]
Middle East	Trade route for tamarind to Asia	Historical trade records
Central America	Introduced via Spanish/Portuguese explorers	Post-Columbian period
Egypt (400 BCE)	Evidence of early cultivation	Historical accounts

Production

India and Thailand are the leading producers of tamarind in Asia, followed by Indonesia, Sri Lanka,

and Bangladesh. In the Americas, Mexico and Costa Rica are major producers. Although native to Africa, tamarind is not widely cultivated there, with limited production in countries like Zambia, Kenya, and Senegal. India is the only country cultivating tamarind on a large commercial scale, mainly in Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Odisha, Karnataka, Kerala, Bihar, and West Bengal. Tamil Nadu leads in production, followed by Kerala and Maharashtra. India produces and markets about 5.5 million tonnes annually, exporting around 70,000 tonnes, mainly to West Asia, Europe, and North America. Thailand ranks second globally, producing about 140,000 tonnes per year and is known for its sweet tamarind variety, while most global production (around 95%) is of the sour type.⁷ Tamarind plays an important role in the economy of tropical countries,

particularly India, where it serves as a major source of income for rural communities. The fruit is valued for its diverse uses in food, medicine, and industry. Its pulp is commonly used in traditional dishes, beverages, and sauces, while also finding applications in confectionery, pharmaceuticals, and cosmetics.⁸ Tamarind is available in two main varieties—sour and sweet—the former dominating global production, especially in India, and the latter produced mainly in Thailand for export. The tree is hardy and drought-resistant, thriving even in poor soils, which makes it suitable for cultivation in arid and semi-arid regions. Due to increasing international demand, tamarind and its processed products such as pulp, powder, and concentrate are widely exported from India to the Middle East, Europe, and North America. The growing use

Table 2: Global Tamarind Production by Country

Country/Region	Production Type	Estimated Output (Tonnes)	Remarks
India	Commercial crop (sour)	~5.5 million (marketed)	Largest global producer; major export contributor
Thailand	Commercial crop (sweet)	~140,000	Leading producer of sweet tamarind
Mexico & Costa Rica	Regional cultivation	N/A	Primary producers in the Americas
Indonesia, Sri Lanka, Bangladesh	Minor production	N/A	Limited scale
African countries (e.g., Kenya, Zambia, Tanzania)	Native but not commercialized	Limited	Mostly used locally, not commercially farmed

of sugar instead of salt in processing has further improved the fruit's quality, flavor, and shelf life, boosting its global market appeal.⁹

Pharmacological Activities:

1) Antidiabetic and Hypolipidemic Activity

Tamarind pulp and fruit extracts exhibit hypolipidemic and antioxidant effects in rats on cholesterol-rich diets. Ethanolic extract (50 mg/kg) of the fruit pulp significantly reduced body weight, serum cholesterol, and triglycerides while increasing HDL in obese rats. Tamarind helps regulate metabolic disorders such as hyperglycemia, hyperlipidemia, and obesity associated with diabetes and cardiovascular diseases.¹⁰ Its aqueous methanolic leaf extract effectively lowered blood glucose in alloxan-induced diabetic rats, likely by reducing free radicals and enhancing insulin secretion. Additionally, tamarind seed extract obtained via subcritical water extraction improved testosterone levels and protected against

high-fat diet-induced hormonal imbalances, supporting endocrine health.¹¹

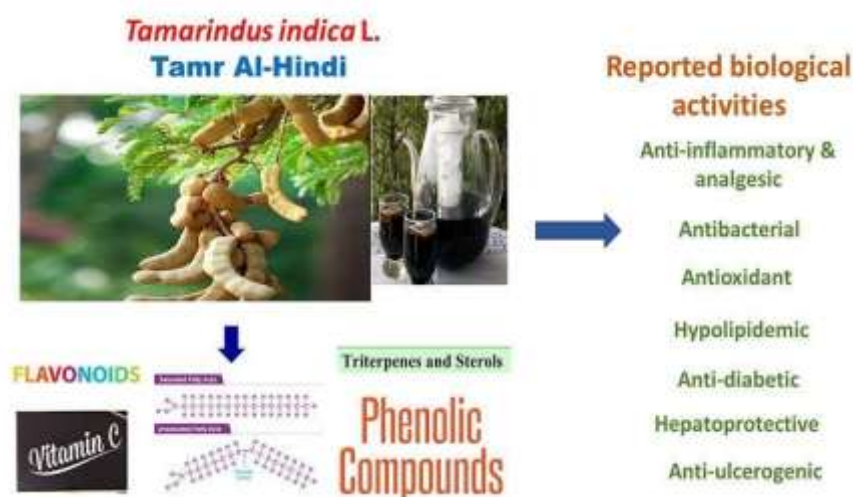
2) Antioxidant activity

Hydro-alcoholic and aqueous extracts of tamarind leaves exhibit antioxidant properties, including Fe^{3+} -reducing ability and scavenging of $\text{NO}^\bullet$, $\text{OH}^\bullet$, and $\text{DPPH}^\bullet$ radicals. Among its compounds, caffeic acid (from seed extract) shows the strongest antioxidant effect, helping protect cells from lipid peroxidation associated with aging and conditions like cancer, cardiovascular disease, diabetes, and inflammatory disorders.¹² Tamarind seed coat is rich in antioxidants, phenolics, tannins, and flavonoids, and its extracts demonstrate activities such as reducing lipid peroxidation, stimulating collagen, inhibiting tyrosinase, and providing antimicrobial, anti-inflammatory, antidiabetic, and antihyperlipidemic effects. Studies on tamarind leaf extract in erythrocytes indicate that, despite containing saponins, the extract protects cells, likely due to its flavonoids and antioxidant mechanisms.¹³

3) Hepatoprotective Activity

Tamarind shows significant hepatoprotective effects in various studies. In rats, aqueous extracts of fruits, leaves (350 mg/kg), and unroasted seeds (700 mg/kg) reduced liver damage caused by paracetamol, lowering serum ALP, AST, bilirubin, liver weight, and necrosis. Hydroalcoholic and aqueous seed extracts improved liver function markers (SGOT, SGPT, ALP, bilirubin), increased antioxidant

enzymes (GSH, CAT, SOD), and reduced lipid peroxidation. Ethanolic flower extracts protected against isoniazid- and rifampicin-induced liver toxicity. Additionally, tamarind seed trypsin inhibitor (TTI) nano-encapsulated in chitosan and whey protein (ECW) improved liver health in rats on a high-glycemic diet, reducing blood glucose, liver enzymes, APRI and FIB-4 scores, and improving hepatic morphology.¹⁴



4) Anti-Inflammatory Activity

Tamarind leaves, bark, and pod husks exhibit anti-inflammatory and wound-healing properties. Leaf juice with ginger treats bronchitis, while bark preparations help with eye inflammation.¹⁵ Tamarind leaves reduce carrageenan-induced paw edema, stabilize membranes, and inhibit neutrophils and TNF- α . Seed extracts (ethyl acetate, petroleum ether, methanolic, and ethanolic) in rats increased pain latency, reduced paw edema, and lowered pro-inflammatory mediators, protecting cartilage and bone. Tamarind seed trypsin inhibitor also decreased TNF- α levels in treated animals.¹⁶

5) Antimicrobial Activity

The methanolic leaf extract of tamarind was evaluated for antibacterial activity against melioidosis, a serious infection prevalent among paddy farmers in Southeast Asia. In vitro tests against *Burkholderia pseudomallei* showed inhibition, with both the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) at 125 μ g/ml. These findings suggest the potential of tamarind for further animal studies targeting melioidosis. Tamarind extracts were

also tested against various Gram-positive, Gram-negative bacteria, and fungi. Their antimicrobial activity remained stable across temperatures of 4°C, 30°C, 60°C, and 100°C, but decreased under alkaline conditions.¹⁷ The MIC and MBC values of ethanolic stem and leaf extracts were as follows:

Escherichia coli: 15 mg/ml (stem), 18 mg/ml (leaf)
Pseudomonas aeruginosa: 14 mg/ml (stem), 20 mg/ml (leaf)
Salmonella typhi: 10 mg/ml (stem), 15 mg/ml (leaf)
Staphylococcus aureus: 20 mg/ml (both stem and leaf)
Bacillus subtilis: 8 mg/ml (stem), 18 mg/ml (leaf)

These results indicate that tamarind extracts are effective against both Gram-negative and Gram-positive bacteria, with *Bacillus subtilis* being the most sensitive and *Staphylococcus aureus* the least.¹⁸

6) Analgesic Activity

Tamarind bark extracts were tested for pain-relieving (analgesic) effects using models like the hot plate test and acetic acid-induced writhing test. The petroleum ether extract at 50 mg/kg (i.p.) showed notable analgesic activity, comparable to the standard drug

pentazocine (10 mg/kg, i.p.), likely due to sterols and triterpenes responsible for anti-inflammatory and analgesic effects. The aqueous fruit extract (60–600 mg/kg) significantly reduced writhing in a dose-independent manner, achieving 51.8–74.1% analgesia.¹⁹ It also increased latency in the hot plate test in a dose-dependent manner and inhibited pain in both early and late phases of the formalin test. Pre-treatment with 5 mg/kg naloxone, an opioid receptor blocker, significantly altered these effects, indicating that the aqueous tamarind fruit extract exerts antinociceptive activity at both peripheral and central levels through opioid pathway activation.²⁰

7) Wound Healing Activity

Polysaccharides from tamarind seeds (xyloglucans) may aid corneal wound healing by affecting the integrin recognition system in human conjunctival cells. Tamarind—especially bark and leaves—is widely used to treat cuts, wounds, and abscesses, either alone or with other plants. Other parts like fruit, leaf powder, pod husks, or gum are also applied for wound care. Tamarind leaf decoctions are traditionally used to clean wounds, ulcers, and sores, including those from Guinea worm infections. Tamarind seeds enhance wound closure and antioxidant activity, showing significant wound-healing effects.²¹

8) Fever and malaria

Tamarind fruits are traditionally used as a febrifuge in Madagascar and the Sudan, and in Benin and Sudan, they were specifically employed to treat malaria. In Ghana, Benin, and Nigeria, tamarind leaves were also used for malaria treatment. The fruit pulp served as both a febrifuge and a laxative across the Sahel and Sudan regions. Across the savannah belt from Senegal to Ethiopia, identical remedies using tamarind pulp were recorded for malaria, fever, and constipation, often prepared by mixing the pulp with water and sometimes boiling it.²² In a study on antimalarial activity against *Plasmodium falciparum*, tamarind pulp extracts were obtained using various solvents. Chloroform extracts showed the strongest activity, containing mainly aliphatic hydrocarbons, acid alcohols, esters, sitosterol, and aromatics, suggesting that antispasmodic effects may result from one or a combination of these compounds.²³

9) Effect on Cardiovascular System and Blood

The impact of crude tamarind pulp extract on lipid levels and atherosclerotic lesions was examined in hypercholesterolemic hamsters, showing its strong potential to lower atherosclerosis risk in humans. In Bangladesh, studies on tamarind fruits assessed their effects on human lipid profiles, blood pressure, and body weight. Additionally, research on hamsters indicated that hydroalcoholic tamarind pulp extract affects inflammatory mediator systems.²⁴

CONCLUSION

This review provides comprehensive insights into the bioactive compounds, traditional medicinal uses, and pharmacological potential of tamarind. Various parts of the plant—including leaves, seeds, bark, fruit pulp, and flowers—contain numerous bioactive constituents that offer nutritional benefits and potential applications in both the pharmaceutical and textile industries. The fruit's unique sweet-and-sour flavor contributes to its widespread use in cooking. It can be challenging to prioritize its uses, whether as a food ingredient or a natural remedy, highlighting its therapeutic significance. This review aims to consolidate existing knowledge and encourage further research on tamarind's health benefits.

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