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REVIEW ARTICLE

Insight into Pharmacological Actions of *Azadirachta indica* (Neem) Leaf Extract

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ABSTRACT

Azadirachta indica, commonly known as Neem, has been used for centuries for both medicinal and ritual purposes. This plant's accessibility and affordability have made it a popular choice for many individuals. Several studies have investigated the therapeutic potential of this plant, from its leaves to its bark. Neem is utilized in many traditional treatments because of its abundance of biologically active components. Nimbin, cyclic trisulfide, azadirachtin, nimbolide, nimbidin, mamoodin, and gedunin, among others, are used as spermicidal, antipyretic, hypoglycemic, antibacterial, immunomodulatory, antigastric ulcer, anti-inflammatory, antiarthritic, antifungal, diuretic, antimalarial and antitumor agents. Conventionally, diverse parts of the plant have been used by residents from various nations to treat a variety of diseases, including leprosy, eye problems, anorexia, skin ulcers, biliousness, intestinal worm elimination, epistaxis, and skin diseases such as burning consciousness, ringworms, wounds and itching. It additionally serves as a pain reliever, substitute treatment, and cure for fever and urinary problems. This study evaluated the anti-inflammatory and antioxidant properties of *Azadirachta indica.*

Keywords: *Azadirachta indica,* Phytochemical composition, Phytopharmacological effect, Antioxidant potential.

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GRAPHICAL ABSTRACT

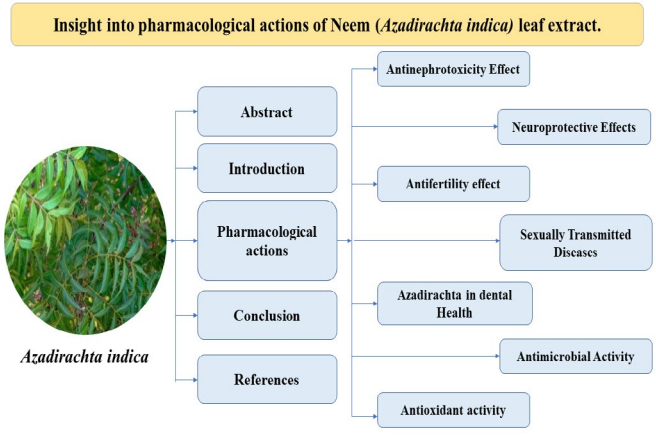

Figure 1: Insight into the pharmacological actions of *Azadirachta indica* (Neem) leaf extract.

INTRODUCTION

Background and Significance

The neem plant (*Azadirachta indica* A. Juss.) be situated a tropical immortal tree that is perennial in dry locations and innate to the Indian subcontinent.[3] *A. indica* A. Juss. The English terms are Persian liac and neem plant, Indian liac, cornucopia, bead plant, bastard tree, margosa tree, and Indian cedar. De Jussieu described this plant in 1830.[1] *A. indica*, or neem, is a versatile tree valued for its medicinal properties, ecological benefits, and use in agriculture. Its resilience and adaptability make it an important species in many regions of the world. It has been used in the practice of Ayurvedic treatment for more than 4,000 years because of its curative ability. Neem is known as 'arista' in Sanskrit, which translates to 'perfect, complete, and imperishable'. Plants, including bark, fruits, leaves, seeds, and roots, often include composites with recognized antipyretic and antiviral, antiseptic anti-

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inflammatory, antifungal, and antulcer uses. The Sanskrit name "nimba" gives rise to the phrase "nimbati swasthyam dadati," which means "to bestow excellent health."[3] *A. indica*, which is generally recognized as neem, has garnered significant attention in the realm of phytopharmacology because of its diverse therapeutic potential and extensive historical use in traditional medicine. This versatile tree, native to the Indian subcontinent, has been a cornerstone of Ayurvedic practices for centuries and has been utilized for its myriad health assistance, ranging from antimicrobial and anti-inflammatory assets to its role in treating various dermatological conditions and gastrointestinal disorders. Recent scientific investigations have elucidated the bioactive constituents of *A. indica*, which include a variety of limonoids, alkaloids, and flavonoids, each contributing to its pharmacological efficacy. Notably, compounds such as azadirachtin have been highlighted for their potent insecticidal activity, making neem not only a therapeutic agent but also a sustainable alternative in agricultural practices. The immunomodulatory effects of neem extract further underscore its relevance in contemporary healthcare, as it can enhance the body's immune response while mitigating excessive inflammatory reactions.

Moreover, the burgeoning field of phytotherapy has led to an increase in the exploration of *A. indica*'s role in the management of chronic conditions such as diabetes, cancer, and cardiovascular diseases. Research has indicated its potential for glycemic control and antioxidant activity, positioning neem pivotal players in the prevention and management of lifestyle-related ailments. Despite these promising findings, it is essential to investigate the phytopharmacological implications of *A. indica* from a critical perspective, acknowledging the need for rigorous clinical trials and standardized formulations. The complexities of herbal interactions and dosage variations necessitate a nuanced understanding to optimize their therapeutic applications and minimize potential adverse effects.

This review aims to consolidate existing knowledge on the phytopharmacological effects of *A. indica*, examining its biochemical properties, therapeutic applications, and underlying mechanisms that contribute to its efficacy. By doing so, we aim to highlight the importance of this remarkable plant in both traditional and modern medicine while also addressing the gaps in research that warrant further exploration.

Botanical profile of *A. indica*.

Taxonomy and description.

The plant *A. indica*. The tree is short to intermediate in size, with a crown height ranging from 10–20 meters in diameter. It can reach heights of 15–30 m (Table 1).[2]

- *Type*

Evergreen tree.

- *Height*

Typically, individuals grow 15–30 meters (49–66 feet) tall and can reach 30 meters (98 feet) in optimal conditions.

- *Bark*

Dark gray to brown, rough texture.

- *Leaves*

Pinnate, with 20–31 leaflets per leaf. The leaflets are dark green, lanceolate, and have a serrated margin.

- *Flowers*

Small white to yellowish flowers that are fragrant and arranged in panicles. Blooming occurs in the winter and summer seasons.

- *Fruit*

Oval-shaped, yellow to brown drupes (seeds), approximately 1–2 cm in length, containing a single seed.

Pharmacological effects of Neem plants (Table 2)

Antinephrotoxicity Properties:

An experiment was conducted to inspect the effects of *Azadirachta indica* methanolic leaf extract (MLEN) on oxidative stress and cisplatin-induced nephrotoxicity in mice. The results revealed that the extract efficiently protects the kidney from oxidative damage caused by CP.[4] Additionally, the results of PCR revealed that the expression of caspase-9, caspase-3 and Bax was decreased in the MLEN-treated groups.[5]

Neuroprotective Properties

Animal models have also revealed neuroprotective effects of a standardized neem extract. Peripheral neuropathy (encouraged by fractional sciatic nerve ligation) animal replicas showed a noteworthy reduction in hyperalgesia, allodynia, coordination of motion, and motor nerve conduction velocity, whereas chronic treatment through this extract suggestively reduced such behavioral alterations.[6] Additionally, neem extract notably diminished the increased impacts of nitrosative and oxidative stress, inflammatory intermediaries and the mRNA expression levels of iNOS and Bax observed in animal replicas.[7]

Antifertility effect

A study utilizing rats as subjects investigated the effects of the alcohol-based extract of neem flowers on the estrous cycle, ovulation, fertility, and fetus development. This study

Table 1: Taxonomic classification of Neem plants [3].

Kingdom	*Plantae*
Phylum	Vascular plant
Class	Magnoliopsida
Order	Rutales
Suborder	Retinae
Tribe	Melieae
Family	Meliaceae
Subfamily	Melioideae
Genus	*Azadirachta*
Species	*indica*

revealed that the estrous cycles of 80% of the rats changed, resulting in a much longer diestrus phase. This extract significantly reduced ova shedding in the morning of oestrus.[8] Additionally, administering neem oil intravenously inhibited spermatogenesis but did not influence the production of testosterone.[9]

Sexually Transmitted Diseases

Neem has the potential to effectively treat diseases that are transmitted through specific means. Neem provides 75% protection from HIV infection.[10-26]

Azadirachta in dental health

Dental problems have become a global public health concern. Research indicates a strong association between poor oral hygiene, dental plaque and the severity of periodontal disease. Herbal medicine has emerged as a promising therapeutic option for localized mouth infections. This review examines the safety and effectiveness of Neem-based medicines used to treat dental diseases on the basis of studies conducted in vitro, in vivo, and in animals.[27]

Antimicrobial Activity

The antibacterial activities of neem extract stem from its main ingredients, azadirachtin and nimbi.[28] Neem leaf extract significantly reduces the plaque index and bacterial count, especially those of *S. mutans* and *Lactobacillus* species.[29] Elavarasu et al. reported significant antiplaque action in neem oil.[30] Adyanthaya et al. examined the antibacterial properties of a methanol extract from neem stems. This study suggests the use of a methanol extract of neem stems in oral care products because of its effectiveness in lowering bacteria that cause caries and periodontal disease.[31]

Antioxidant activity

A. indica, widely known as neem, is highly regarded in old-style remedies, especially within Ayurvedic practices. Its antioxidant properties have attracted considerable research interest, primarily because of its rich phytochemical composition, including flavonoids, phenolic compounds, and limonoids. Numerous studies have demonstrated the strong antioxidant properties of neem extracts from various tree parts. Additionally, neem oil has been investigated and found to be effective in protecting cellular structures from oxidative damage. This study highlighted the role of limonoids in reducing lipid peroxidation, which helps maintain cell membrane integrity. A comparative analysis of the antioxidant properties of neem bark and leaf extracts revealed that both exhibited considerable antioxidant activity, with the bark extract showing superior efficacy in inhibiting lipid peroxidation and scavenging free radicals. These findings suggest that different parts of the neem tree have distinct phytochemical profiles that increase their antioxidant capabilities. Furthermore, neem has been shown to increase the body's natural antioxidant defenses. Found that neem extract could increase the appearance of vital antioxidant enzymes, such as superoxide dismutase and catalase, thereby strengthening the body's response to oxidative stress.

Table 2: Biological activities of neem plants.

Plant parts	*Activities*	*References*
Leaves	Antioxidant	[11]
	Wound healing	[12,13]
	Hepatoprotective	[14]
	Nephrotoxicity	[15]
	Neuroprotective	[16]
	Immunomodulatory	[17]
	Cardioprotective	[18]
	Antimicrobial	[19]
	Antitumor	[20,21]
Flowers	Antifertility Antioxidant	[22,11]
Stem	Antioxidant	[11]
Seed	Antimicrobial Anti-inflammatory	[23,24]
Oil	Antifertility	[25]
Root bark	Antidiabetic	[26]

In summary, the antioxidant activity of *A. indica* represents a promising area for further research, particularly for its potential in preventing and managing oxidative stress-related conditions. The diverse phytochemical constituents of neem not only support therapeutic applications but also pave the way for the development of natural antioxidant agents in functional foods and dietary supplements.

CONCLUSION

In conclusion, *A. indica* stands out as a remarkable botanical entity with a rich history of medicinal use and a growing body of scientific evidence supporting its diverse phytopharmacological effects. From its antimicrobial and anti-inflammatory properties to its potential role in managing chronic conditions such as diabetes and cancer, neem has proven itself to be a valuable resource in both traditional and modern healthcare practices. The bioactive compounds found in *A. indica*, such as azadirachtin and other phytochemicals, contribute to its extensive therapeutic applications, highlighting its versatility across various fields, including medicine and agriculture. However, despite promising findings, there remains a critical need for more rigorous clinical studies to validate its efficacy and safety, as well as to standardize its formulations for widespread use. As research continues to unfold, the integration of *A. indica* into contemporary therapeutic regimens could provide innovative solutions for many health issues, especially in the context of increasing interest in natural and sustainable treatments. Ultimately, by bridging traditional knowledge with modern scientific inquiry, we can fully harness the potential of *A. indica*, ensuring its rightful place in the pantheon of effective medicinal plants while addressing the challenges that accompany its use.

COMPETING INTEREST

The author declares no competing interest.

AUTHOR CONTRIBUTION

Nayan Kolhe, Karpe Akanksha, Pratiksha Deshmukh, Suyash Marathe, Apeksha Mande, Rutuja Dighe wrote the manuscript and Nayan Kolhe, Mukul Barwant reviewed the manuscript.

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ETHICAL APPROVAL

This research article does not contain any studies with human participants or animals performed by any of the author.

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