

A COMPREHENSIVE REVIEW ON NEEM (*AZADIRACHTA INDICA*)

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ABSTRACT

Neem (*Azadirachta indica*), commonly known as the "village pharmacy," is a tropical tree indigenous to the Indian subcontinent. It belongs to the Meliaceae family and is renowned for its diverse medicinal, agricultural, and ecological benefits. Every part of the neem tree, including its leaves, bark, seeds, and fruit, contains bioactive compounds that have been used in traditional medicine for centuries. The plant is rich in azadirachtin, nimbin, and other terpenoids, which exhibit potent anti-inflammatory, antimicrobial, antiviral, antifungal, and antioxidant properties. As a result, neem is utilized in treating various health conditions such as skin disorders, diabetes, dental issues, and gastrointestinal problems. In agriculture, neem-based products serve as effective natural pesticides and insect repellents, promoting sustainable farming practices. Neem oil and neem extracts are widely used as organic alternatives to chemical pesticides, offering a non-toxic and eco-friendly solution to pest control. Neem has also demonstrated promising potential in the field of cancer research, with studies indicating that its compounds may inhibit the growth of cancer cells and act as a chemo preventive agent. Ecologically, neem plays a vital role in promoting soil fertility and combating desertification due to its deep root system and drought tolerance. It is also utilized in reforestation efforts, especially in arid semi-arid regions. Despite its numerous advantages, concerns regarding the overexploitation of neem resources and its potential environmental impact need be addressed through sustainable management practices. This review highlights the multifaceted applications of neem, emphasizing its significance in health, agriculture, and environmental sustainability. Future research is needed to further explore the therapeutic potential and optimize the use of neem in modern medicine and sustainable agricultural practices.

KEYWORDS: Neem (*Azadirachta indica*), Bioactive compounds, Antimicrobial properties, Sustainable agriculture.

INTRODUCTION

Neem a tropical evergreen tree native to the Indian subcontinent, is widely celebrated for its numerous medicinal, agricultural, and ecological benefits. Belonging to the **Meliaceae family**, neem has been an integral part of Indian culture and traditional healing practices for thousands of years. Often referred to as the "village pharmacy" or "the healer tree," neem holds a special place in the history of herbal medicine due to its diverse therapeutic properties. Over the years, it has gained international recognition for its potential to address various health issues, environmental concerns, and agricultural challenges.^[1,2] Neem's importance extends beyond its cultural and historical significance; it is a symbol of nature's remarkable ability to provide solutions to modern-day problems. It has become a focal point in the pursuit of sustainable agriculture, natural health remedies, and environmental conservation. This introduction explores the botanical characteristics, medicinal properties, agricultural applications, and ecological value of neem, along with its promising future in scientific research and global usage. Neem is an extraordinary plant that offers a wide range of benefits to human health, agriculture, and the environment. Its long history of use in traditional medicine, coupled with its increasing recognition in modern science, underscores its importance as a multi-functional natural resource. As research continues to uncover the full potential of neem, its role in sustainable farming, natural health solutions, and ecological conservation is poised to grow.^[2,3] Despite its many benefits, the overexploitation of neem resources in certain regions could threaten its long-term availability. It is crucial to promote sustainable harvesting practices and ensure that neem cultivation remains environmentally responsible. With its numerous applications and potential for innovation, neem is set to remain a valuable asset to society, providing solutions to contemporary challenges in health, agriculture, and environmental preservation.^[4,5]

Neem is not only valuable in agriculture but also plays a significant role in environmental sustainability. Its ability to thrive in challenging climatic conditions makes it an important species for reforestation and land reclamation projects. Neem's drought tolerance and rapid growth rate make it an ideal tree for combating desertification, a major environmental issue in many parts of the world. Neem is also beneficial for biodiversity. Its flowers attract a wide range of pollinators, including bees and butterflies, and its leaves provide shelter and food for various wildlife species. Additionally, neem helps improve air quality by absorbing carbon dioxide and releasing oxygen, making it an essential component of urban greening initiatives. Neem is also beneficial for soil health. The decomposed neem cake, a byproduct of neem oil extraction, is rich in nitrogen, phosphorus, and potassium, making it an excellent natural fertilizer.^[6,7] When used in farming, neem cake improves soil structure, promotes microbial activity, and provides essential nutrients to plants. Furthermore, neem's deep root system helps prevent soil erosion and aids in water retention, making it especially useful in drought-prone regions. One of the most well-known applications of neem is in treating skin conditions. The antimicrobial and anti-inflammatory properties of neem make it an effective remedy for acne, eczema, psoriasis, and other dermatological issues. Neem oil is often used topically to soothe irritated skin, reduce redness, and prevent infections due to its ability to fight harmful bacteria and fungi.^[9,10,11] Additionally, neem's detoxifying effects help to purify the skin, reduce the appearance of scars, and promote overall skin health. Neem is commonly used in oral hygiene due to its antibacterial and antifungal properties. In traditional medicine, neem twigs are chewed as a natural toothbrush to prevent tooth decay and gum diseases. Modern research supports these claims, showing that neem extracts can help reduce plaque buildup, fight oral infections, and prevent gum diseases like gingivitis.

Morphological Description



Fig. 1: Neem leaves.

The **neem tree** is a fast-growing evergreen tree that belongs to the **Meliaceae** family.

1. Tree Size

- **Height:** Typically grows between **15 to 20 meters** (50 to 65 feet), although it can sometimes reach up to 30 meters (98 feet) in favorable conditions.
- **Crown:** Neem has a **broad, dense, and umbrella-shaped crown** that provides ample shade.^[12,13,14,15]

2. Leaves

- **Shape:** The leaves are **pinnately compound**, meaning each leaf consists of multiple leaflets arranged on either side of a central stem.
- **Size:** Each leaf is around **20–40 cm** (8–16 inches) long, with **9 to 15 leaflets** arranged in an alternating pattern.
- **Leaflets:** The individual leaflets are **lance-shaped, saw-edged** (serrated), and are **dark green** in color.
- **Texture:** The leaves are **glossy** on the upper surface and **lighter** on the underside.^[14,25,26]

3. Flowers

- **Arrangement:** The flowers are small, fragrant, and are borne in **panicles** (loose clusters) at the end of branches.
- **Color:** They are typically **white** or **creamy-yellow**.
- **Size:** The flowers are about **1.5–2 cm** (0.6–0.8 inches) in size.
- **Blooming Period:** Neem flowers bloom during the **spring** and **summer** months, usually between **March and May**.^[28,29,30]

4. Fruits

- **Shape:** The fruit is a **drupaceous** (fleshy, single-seeded) structure.
- **Size:** It is about **2 to 4 cm** (0.8 to 1.6 inches) long.
- **Color:** The fruit starts out as **green** and ripens to **yellow or reddish-brown** when mature.
- **Texture:** The fruit has a **fleshy outer layer** and a **hard seed** inside.
- **Taste:** The pulp is **bitter**.^[15,37,38,39]

5. Bark: The bark of the neem tree is **dark gray** or **brown** with deep, vertical fissures. It becomes rough as the tree ages.^[32,34,33]

6. Roots: Neem has a **strong, deep taproot system**, allowing it to thrive in dry, arid conditions.

7. Wood: The wood of the neem tree is **hard, dense, and durable**, with a reddish-brown color. It is often used for making furniture, tools, and other items.^[40,41,42]

8. Seeds: Neem seeds are **oval-shaped**, with a **hard shell**, and contain the oil used for medicinal and pesticidal purposes. Neem is characterized by its **evergreen, dense crown, pinnate leaves, fragrant white flowers**, and **bitter fruits** with a significant medicinal and environmental value.^[43,44,45]

Chemical constituents

1. Azadirachtin

- **Location:** Primarily found in the seeds, but also in the leaves and bark.
- **Uses:** Pesticidal properties: Azadirachtin is the most well-known bioactive compound in neem. Antifungal and Antibacterial: Azadirachtin exhibits antimicrobial and antifungal properties, thus used in agriculture to protect crops from a range of pathogens.^[16,47,48,49]

2. Nimbin

- **Location:** Found in **neem leaves**.
- **Uses:** Anti-inflammatory: Nimbin is known for its anti-inflammatory effects and is used in the treatment of conditions like arthritis and other inflammatory diseases.^[17,50,51]

3. Nimbidin

- **Location:** Found in neem seeds and leaves.
- **Uses:** Antioxidant and Antibacterial: It has antioxidant and antibacterial properties, making it useful in protecting the body from infections and cellular damage.^[52,53,54]

4. Nimbolide

- **Location:** Found in neem leaves and seeds.
- **Uses:** Anti-inflammatory: It also helps in reducing inflammation, making it beneficial for inflammatory disorders. Antioxidant: It protects cells from damage caused by oxidative stress.^[55,56,57]

5. Salannin

- **Location:** Found in neem seeds.
- **Uses:** Antifungal: It exhibits antifungal properties, useful for treating fungal infections. Anti-inflammatory: It reduces inflammation, and thus has applications in treating inflammatory diseases.^[59,60,61]

6. Quercetin

- **Location:** Found in neem leaves.
- **Uses:** Antioxidant: Quercetin is a flavonoid that exhibits strong antioxidant properties, which help in fighting oxidative stress and protecting cells from damage.^[63,64,65]

7. Triterpenoids (e.g., Azadirachtol)

- **Location:** Found in neem leaves, bark, and seeds.
- **Uses:** Anti-inflammatory: Triterpenoids are known for their anti-inflammatory effects. Antimicrobial: They have antibacterial and antifungal properties and are used in treating skin infections and diseases.^[66,67]

8. Fatty Acids

- **Location:** Found in neem seeds.
- **Uses:** Skin care: Neem oil, which is rich in fatty acids like oleic acid and linoleic acid, is used in cosmetics and skin care for moisturizing and treating dry, flaky skin.^[68,69,70]

9. Steroids (e.g., Beta-sitosterol)

- **Location:** Found in neem seeds and bark.
- **Uses:** Immune modulation, Beta-sitosterol has immune-boosting properties and is used in improving overall immunity.^[72,73]

10. Alkaloids (e.g., Azadirachtinine)

- **Location:** Found in neem seeds and bark.
- **Uses:** Antimalarial, some alkaloids in neem, such as azadirachtinine, have shown potential in malaria treatment. Antibacterial, Alkaloids also have significant antibacterial activity, making them useful for combating infections.^[16,17,74]

11. Saponins

- **Location:** Found in neem leaves and seeds.
- **Uses:** Insecticidal, Saponins act as natural insecticides and are often used in agriculture to control pests. Anti-inflammatory and Immunomodulatory, They also play a role in reducing inflammation and boosting immune function.

12. Flavonoids (e.g., Kaempferol, Catechins)

- **Location:** Found in neem leaves.
- **Uses:** Antioxidant, Flavonoids are potent antioxidants, which help in preventing cellular damage due to oxidative stress.^[17,71]

CONCLUSION

Neem's multifaceted benefits make it a remarkable resource with vast potential in a range of fields, from health and wellness to agriculture and environmental sustainability. The extensive use of neem in traditional medicine, coupled with modern scientific validation of its properties, underscores its importance as a holistic, sustainable, and natural solution for contemporary challenges. Further research and global collaboration can unlock even more of its untapped potential for both human health and environmental preservation.

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