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NEEM (AZADIRACHTA INDICA): A COMPREHENSIVE REVIEW OF ITS MEDICINAL, AGRICULTURAL, ENVIRONMENTAL, AND INDUSTRIAL POTENTIAL

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ABSTRACT

Azadirachta indica A. Juss. (neem), also known as dogonyaro, Indian Lilac, or Margosa, is a highly versatile tree of the tropics with major ecological, medicinal, and agricultural value. Every part of the plant—leaves, bark, flowers, fruits, seeds, gum, oil, and neem cake—contains bioactive compounds with diverse pharmacological effects, including antimicrobial, anticancer, antidiabetic, insecticidal, and immunomodulatory activities. Key constituents such as azadirachtin and nimbin are potent natural pesticides. Neem is deeply rooted in traditional medicine systems like Ayurveda, Unani, and Homeopathy, earning names such as the "Village Dispensary" and "Wonder Tree." It has been historically used for skin diseases, digestive disorders, malaria, and respiratory ailments. Ecologically, it thrives in semi-arid to subhumid climates, improves soil quality, and supports sustainable agriculture through eco-friendly pesticides and fertilizers. While offering significant health, environmental, and industrial benefits, neem also exhibits certain toxic effects in humans and animals. This review highlights its botanical features, ethnomedicinal use, phytochemistry, pharmacology, and applications, emphasizing its potential as a sustainable bioresource while noting the need to manage its risks.

KEYWORDS: Origin, Benefit of neem, extraction, properties, Application. Taxonomical Classification, Phytochemical Studies and Biologically Active Constituents, Future Scop.

INTRODUCTION

The neem tree (Azadirachta indica A. Juss), once called Melia azadirachta (L) and Antelara azadirachta (L), is native to Myanmar (Burma) and India, but also grows in Bangladesh, Sri Lanka, and many African countries. It belongs to the Meliaceae family and typically reaches about 20 feet in height, with a sturdy trunk and insect-repelling properties. It is known worldwide by many names: Indian lilac (English), Azadirakhra (Persian), Margosa and Neeb (Arabic), Tamar (Burmese), Kohomba (Sinhala), Pokok Semambu (Malay), Dogon Yaro (Nigeria), Neem (Hindi, Bangla), Nimba (Sanskrit, Marathi), Arya-Veppu (Malayalam), Vaypum (Tamil), Bevu (Kannada), Nimtree, and Vepu/Vempu/Vepa (Telugu). In East Africa, it is called Mwarobaini (Swahili), meaning "tree of the 40," as it is believed to treat forty different diseases. The entire plant has domestic, industrial, and medicinal value. Leaf extracts are widely used to treat skin problems like eczema, ringworm, acne, and even cancer. Many active compounds—such as nimbin, azadirachtin, nimbidiol, quercetin, and nimbidin—possess antiseptic, antiviral, anti-inflammatory, anti-ulcer, antimalarial, antifungal, and anticancer effects. Because of its wide range of uses, it is often called a "village pharmacy" in India and has been closely linked to human culture for centuries. Cancer remains one of the most difficult diseases to cure due to the many survival pathways of cancer cells. Blocking only a few of these pathways rarely eliminates them completely. Modern research is focusing on herbal medicines like neem because they can target cancer through multiple mechanisms with minimal side effects. Over the past decade, neem extracts have been shown to kill cancer cells (apoptosis), strengthen the immune system, produce antioxidants, and stimulate enzymes that detoxify carcinogens. It has shown promise against cancers of the colon, stomach, lung, liver, skin, mouth, prostate, and breast in both lab and animal studies. The neem tree, native to the Indian subcontinent, has been used in Ayurveda for over 4,000 years. In Sanskrit, neem is called arista, meaning "perfect, complete, and imperishable," and nimba, meaning "to give good health." Ancient Ayurvedic texts like Charaka Samhita and Sushruta Samhita document its benefits. The Persian name Azad-Darakth-E-Hind means "free tree of India."Neem is considered one of the most studied and valuable trees of the 21st century for its roles in medicine, pest control, and environmental protection. It is a natural source of insecticides, pesticides, and other eco-friendly agricultural products. A mature neem can grow up to 25 meters tall with a broad crown. It begins fruiting in 3–5 years and becomes fully productive after 10 years, yielding up to 50 kg of fruit annually. It can live for up to 200 years. Neem grows in a wide range of climates, from dry, rocky soils to calcareous and clay soils, requiring little water but plenty of sunlight. It thrives

where annual rainfall ranges from 450–1200 mm but can survive with as little as 150–250 mm. It grows at altitudes up to 1500 m and tolerates temperatures from 0°C to 49°C, though it cannot survive in waterlogged or poorly drained soils. It grows in soil pH between 4 and 10 and is especially well suited to black cotton and deep, well-drained soils. Remarkably, it can neutralize acidic soils rough a process known as calcium mining.

ORIGIN NEEM

Two species of Azadirachta have been reported, Azadirachta indica A. Juss native to Indian sub-continent and Azadirachta excelsa Kack. confined to Philippines and Indonesia The former grows as a wild tree in India, Bangladesh, Burma, Pakistan, Sri Lanka, Malaysia, Thailand and Indonesia. Presently neem trees can be seen growing successfully in about 72 countries world-wide, in Asia, Africa, Australia, North, Central and South America The neem tree is native to the Indian subcontinent and South-east Asia. There are two closely related species, A. Indica and A. azedarch. The former is popularly known as Indian neem (margosa tree) or Indian lilac, and the latter as the Persian lilac. The genus Azadirachta A. Juss., which comprises three spe cies of Indo-Malayan origin, has also been characterised in detail The tree was considered so valuable and miraculous that it became a major component of the Indian ecosystem.

Multidi-rectional therapeutic uses of neem have been known in India since the Vedic times. Almost all parts of the tree-stem, bark, roots, leaves, gum, seeds, fruits, flowers, etc-have been in use as traditional medicine for house-hold remedies against various human ailments from antiquity One of the Sanskrit names of neem tree is "Arishtha" meaning "rellever of sick-ness"; in India the tree is considered as "Sarbaroganibarini", which means "reliever of all diseases", and it is regarded as the "village dispensary". Over 700 herbal preparations based on neem a found in Ayurveda, Siddha, Unani, Amchi and other local health traditions; over 160 local practices are known in different parts of the country in which neem forms an important or sole ingredient in curing human ailments or disorders. Besides its therapeutic efficacies, neem has established its potential as a source of naturally occurring insecticide, pesticide, antimalarial agent and agrochemical. For thousands of years, Indian farmers have been aware of the insecticidal prop-erties of neem tree. Its branches were hung in granules to protect stored grain from pest attack. Historically, neem has also been used in India for cosmetic and medicinal purposes. For example, neem oil extracted from the seeds is used in soap, wax and lubricants, and its twigs have been traditionally used as toothbrushes. These

spectacular properties of neem have attracted the scientific communities, particularly the organic chemists, biologists, clinicians and agriculturalists, around the world to undertake systematic research on this unique plant in various directions. Since the 1970s, scientists in Europe and the United States have been interested in neem. because of its insecticidal properties and Its low toxicity to mammals. In this connection, it would be appropriate to recall the report entitled "Neem-A Tree for Solving Global Problems" published in 1992 by the US National Academy of Sciences. A number of review articles on neem have appeared, thereby reflecting the importance and applicability of this ver-satile medicinal plant. The aim of the present article is mainly to focus on the medicinal efficacies of various parts of neem tree used directly or through commercially available products along with their aspiring uses as cheap and eco-friendly agro-chemicals, insecticides, pesticides and parasiticides reported in recent years. A brief account of the evaluation of safety as-pects of different parts of neem tree and neem compounds along with commercially available formulations is also include

TAXONOMICAL CLASSIFICATION OF NEEM

Table No. 1: Taxonomical Profile.

Order	Rutales
Suborder	Rutinae
Family	Meliaceae
Subfamily	Melioideae
Genus	Azadirachta
Specie	Indica
Latin	Azadirachta indica

Fig. No. 1: Neem Tree.

Benefits of Neem

Antioxidant Activity: Medicinal plants are known to possess antioxidant properties. Neem's

leaves, bark, seeds, oil, fruits, and roots are rich sources of antioxidants, making them valuable in disease prevention. Research on Azadirachta indica leaf and bark extracts grown in lowland areas has shown significant antioxidant activity.

Anticancer Activity: Neem contains flavonoids and other bioactive compounds that play a crucial role in preventing cancer development. Epidemiological studies suggest that a high intake of flavonoids may be linked to a reduced risk of cancer.

Anti-Inflammatory Effects: Neem seed oil has demonstrated dose-dependent analgesic (pain-relieving) andanti-inflammatory effects in rat models, with up to 53% reduction in inflammation at higher doses.

Hepatoprotective Effects: Neem has liver-protective benefits without harmful side effects. In animal studies, azadirachtin-A, a key compound in neem, reduced liver damage caused by carbon tetrachloride (CCl_4) in a dose-dependent manner, restoring liver tissue toward normal.

Wound Healing Effects: Neem extracts, especially from leaves and root bark, promote wound healing by enhancing the inflammatory response and stimulating new blood vessel formation. Studies in diabetic and non-diabetic rats have shown improved wound closure, greater tissue strength, and reduced blood glucose levels with neem treatment**.**

Antibacterial Activity: Neem leaf extracts have been shown to inhibit the growth of various harmful bacteria, sometimes more effectively than standard solutions like 3% sodium hypochlorite. Neem compounds also demonstrated strong activity against food-borne pathogens, suggesting a potential role in food safety.

Antiviral Activity: Neem bark extract (NBE) has been shown to block the entry of herpes simplex virus type 1 (HSV-1) into cells at concentrations of 50–100 µg/mL. Neem leaf extracts also demonstrated virucidal activity against coxsackievirus B-4, disrupting the virus's replication cycle.

Antifungal Activity: Neem leaf extracts (both water-based and alcohol-based) have been shown to significantly inhibit the growth of fungal species like Aspergillus and Rhizopus, with alcoholic extracts being more effective.

Dental Health: Neem-based mouth rinses have been found to be as effective as chlorhexidine in reducing gum inflammation and plaque formation. Neem extracts show strong antibacterial

activity against Streptococcus mutans, S. salivarius, and other oral pathogens. Chewing sticks made from neem have also demonstrated significant antimicrobial effects**.**

Kidney Protection (Antinephrotoxic Effects): Methanolic neem leaf extracts protect against cisplatin-induced kidney toxicity and oxidative stress in rats by downregulating pro-apoptotic genes such as caspase-3, caspase-9, and Bax.

Neuroprotective Effects: Neem leaf extracts protect brain tissue from cisplatin-induced damage, maintaining normal brain structure and biochemical balance in animal studies.

Contraceptive Potential: Neem extracts have shown both pre- and post-coital contraceptive effects, preventing sperm proliferation at very low concentrations (0.05–1%). These effects are reversible, with normal fertility returning after a few cycles.

Immune-Boosting Properties: Neem stimulates both humoral and cell-mediated immunity, enhancing the activity of immune cells such as “killer” T cells, which destroy pathogens and cancer cells.

Other Reported Benefits

1. **HIV Prevention:** Neem has shown potential in preventing HIV infection in early research.
2. **Stress Reduction**: Low doses have sedative effects, reducing stress and anxiety.
3. **Ulcer Protection**: Neem bark reduces gastric acid secretion, gastric volume, and pepsin activity.
4. **Arthritis Relief**: Reduces inflammation and joint pain.
5. **Heart Health**: Lowers cholesterol, blood pressure, and prevents abnormal heart rhythms.
6. **Skin Care**: Improves complexion, reduces excess body heat, and supports wound healing.
7. **Hair Health**: Promotes shiny, smooth hair and soothes scalp irritation.
8. **Insect Repellent**: Neem oil repels mosquitoes and black flies.
9. **Psoriasis Treatment**: Improves symptoms when combined with sunlight and topical treatments.
10. **Malaria Prevention**: Inhibits the development of malaria parasites.
11. **Vitiligo Support**: Oral neem and topical application may help restore skin pigmentation.
12. **Viral Infections**: Traditionally used for smallpox and chickenpox.
13. **AIDS Research**: Early studies suggest neem may aid in prevention or treatments

Different Parts of Neem and Their Uses

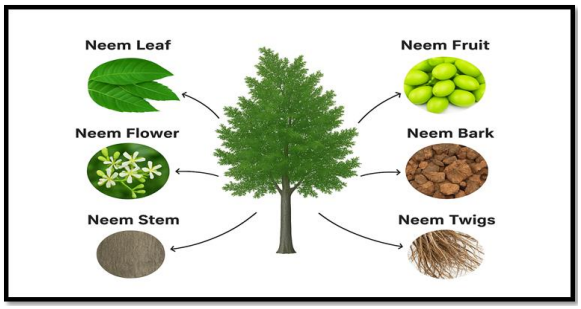

Fig. No. 2: Different Parts of Neem.

Flowers: During the monsoon, the ground beneath a neem tree is often scattered with fallen flowers. Known as Vepampoo in Tamil, neem flowers can be used fresh, dried, or powdered. In South India, they are a common ingredient in traditional dishes such as flower rice, pachadi, rasam, and lentil preparations. Often, they are dry-roasted and sprinkled over dishes as a garnish. Medicinally, neem flowers are used to treat anorexia, nausea, bloating, belching, and intestinal worm infestations**.**

Leaves: Neem leaves are renowned for their medicinal value. Beyond their role in pest control and disease prevention, they are sometimes used as animal feed when mixed with other fodder grains. In parts of South India, neem leaves are applied as organic manure in rice fields. In other countries, they are used as mulch in crops like tobacco and tomato. The leaves are also effective in weed control—spreading them around plant roots helps retain soil moisture while suppressing weeds. Additionally, neem leaves can protect stored wool and silk garments from insect damage.

Neem Cake: Neem cake, a by-product of oil extraction from neem seeds, is highly versatile. It serves as livestock feed, fertilizer, and a natural pesticide. Rich in organic nitrogen, it also slows the nitrification process when mixed with urea before field application. A 90:10 mixture of neem-coated urea can reduce chemical nitrogen loss by up to 30%, lowering agricultural costs. In India, neem cake is widely used as fertilizer for sugarcane, vegetables, and other cash crops.

Fruits: Neem fruits possess a distinctly bitter taste and are valued for their medicinal qualities. They act as a laxative, help control bleeding (antihemorrhoidal), and work as an anthelmintic, aiding in the expulsion of intestinal worms.

Twigs & Bark: In India, using neem twigs as natural toothbrushes is an age-old practice. Chewing on a neem twig kills germs, balances the pH level of saliva, reduces bacterial

growth, soothes inflamed gums, and whitens teeth. When chewed, the twig frays into bristle-like fibers, which help clean teeth and prevent plaque buildup.

Neem Oil: Neem oil, extracted from the seeds, is rich in therapeutic compounds and widely used in cosmetics and personal care products such as soaps, shampoos, hair oils, and hand washes. It treats various skin disorders and acts as a powerful mosquito repellent. Traditionally, in some parts of India, neem oil has even been given to children as a general health tonic. In addition to its medicinal use, neem oil protects plants from pests and is a key ingredient in creams, cleansers, and other skincare products.

Uses

Neem is renowned for its durable wood. In addition to timber, a wide range of non-wood products such as flowers, fruits, seeds (oil and cake), leaves, bark, and gum have diverse applications. These products are well-documented for their antifungal, antibacterial, insecticidal, and other versatile biological properties[9], making them highly valuable in daily life. The seeds are the most important product, yielding about 40% of a deep yellow oil known as margosa oil.

Medicinal: Analgesic, anticholinergic, antihelminthic, antihistaminic, antiprotozoal, antipyretic, antiviral, bactericidal, contraceptive, fungicidal, insecticidal, insect-repellent, veterinary medicines.

Technical: Cosmetics, hair oils, lubricants, propellants, shampoos, soaps, toothpastes.

Neem Cake: Animal feed, soil fertilizer, moisture retainer, pH neutralizer, soil protectant.

Leaves: Antidermatic, antifungal, anticoagulant, antihelminthic, antitubercular, antitumor, antiseptic, antiviral, contraceptive, cosmetic, fertilizer, insecticidal, nematicidal, insect-repellent.

Twigs: Used as natural toothbrushes, oral deodorants, and for toothache relief. **Bark**: Antiallergenic, antidermatic, antifungal, antiprotozoal, antitumor, deodorant. **Wood**: Agricultural implements, carts, boats, building materials, furniture, idols, tools. **Flowers**: Analgesic, used in curries, nectar sources, soaps, stimulants.

Other Products: Adhesives, edible fruit products, firewood, glue, honey, pulp for biogas, resin, tannins, windbreakers, wood preservatives Over 135 bioactive compounds have been

identified from neem, classified into:

Isoprenoids: Including diterpenoids, triterpenoids (protomeliacins, liminoids, azadirone derivatives, gedunin derivatives, vilarin-type compounds, csecomeliacins such as nimbin, salannin, azadirachtin). Nimbin was the first compound studied.

Non-Isoprenoids: Proteins, carbohydrates, sulphur compounds, polyphenolics (flavonoids, glycosides, dihydrochalcone, coumarin, tannins), aliphatic compounds, phenolic acids.

ENVIRONMENTAL BENEFITS

Neem is highly stress-tolerant, improves soil fertility and water-holding capacity, and plays a significant role in combating desertification, deforestation, and soil erosion. It has a high photosynthesis rate, releasing more oxygen than many tree species, cooling the surrounding temperature by ~10°C during hot summers.

Notable environmental projects include:Planting ~50,000 neem trees on the plains of Arafat, providing shade for Muslim pilgrims. Acting as windbreakers, e.g., in Niger's Maijia Valley, where millet yields rose by 20%. Large-scale plantations in Tanzania and efforts to halt Sahara desert expansion. Neem biomass yield: 10–100 tons/ha, with 50% leaves, 25% fruits, and 25% wood.

The wood is termite-resistant and durable, suitable for furniture, construction, and fuel (high-calorific charcoal). Neem leaf powder can purify water and remove dyes like Congo red.

AGRICULTURAL APPLICATIONS

Globally, about one-third of agricultural produce is lost to over 20,000 pest species.[35] In India, pest damage costs ~₹5,000 crores annually. Synthetic pesticides reach only 0.1% of target pests, with the rest polluting the environment. Neem offers a biodegradable, eco-friendly, and cost-effective alternative to chemical pesticides. Effective against 350+ arthropod species, 12 nematodes, 15 fungi, 3 viruses, 2 snails, and 1 crustacean. Compounds like meliantetyraolenone and odoratone show insecticidal activity against Anopheles stephensi. Pests resistant to synthetic pesticides can still be controlled with neem extracts due to its unique mode of action.

Neem-based products: Safe for humans, animals, and beneficial pollinators. Used as biofungicides, biorodenticides, and seed treatments for fungal root rot. Neem cake-coated urea

improves nitrogen assimilation. Neem vermicompost provides fertilizer and pest control benefit.

Veterinary Uses: Neem has been used for centuries in animal healthcare. Treats stomach worms, ulcers, skin diseases, and helminthiasis. Controls livestock parasites like maggots, horn flies, and biting flies. Leaves and cake serve as protein-rich animal feed; oil is used in poultry feed. Prevents aflatoxicosis in poultry by inhibiting toxin-producing fungi.

Medicinal Applications; Widely used in Ayurveda, Unani, and Homeopathy for Anti-inflammatory, antihyperglycemic, antiulcer, antimalarial, antifungal, antibacterial, antiviral, antioxidant, antimutagenic, anticarcinogenic, and immunomodulatory effects. Treating malaria (compounds like gedunin show quinine-like effects), smallpox, chickenpox, skin disorders, and dental problems. Exhibiting anticancer, antihypertensive, and antidiabetic properties. Serving as a contraceptive and spermicidal agent (e.g., NIM-76 vaginal contraceptive).

Industrial Uses: Promoted as an "Industrial Plant" since 2002. Neem products are used in:Pharmaceuticals, cosmetics, disinfectants, rubber, textiles, and biopesticide industries. Soaps, shampoos, toothpaste, tanning, dyeing, methane production, and fermentation processes. Employment generation through seed collection, oil extraction, and processing. India produces ~540,000 tons of neem seeds annually, yielding ~107,000 tons of oil and ~425,000 tons of cake, with an estimated market turnover of ₹1,000–1,200 crores.

ROLE OF NEEM IN GENERAL HEALTH AND DISEASE MANAGEMENT

1. **AIDS**: According to the National Institutes of Health, neem extracts have demonstrated the ability to inactivate the AIDS virus. Patents have been granted for these extracts as potential AIDS treatments (Anyaehie, 2009).
2. **Heart Disease:** Neem helps delay blood coagulation, stabilizes irregular heartbeats, and assists in reducing elevated heart rates and high blood pressure.
3. **Diabetes**: Oral administration of neem leaf extracts has been shown to reduce insulin requirements by 30–50% in non-ketonic, insulin-sensitive diabetic patients.
4. **Periodontal Disease**: Studies by German researchers confirm that neem extracts help prevent tooth decay and periodontal disease (Prashant et al., 2007; Chava et al., 2012), thus promoting good oral health (Balappanavar et al., 2013). Neem leaf extract also exhibits antimicrobial activity against Enterococcus faecalis and Candida albicans,

making it a promising natural endodontic irrigant (Vinothkumar et al., 2013).

5. **Skin Diseases**: Neem has shown significant benefits in chronic skin conditions such as acne, psoriasis, eczema, and ringworm. Even persistent warts can be effectively treated with high-quality organic neem oil. In Siddha medicine, both neem oil and leaves are traditionally used for skin ailments. Neem oil is also a valuable cosmetic ingredient for cleansing, rejuvenating, and enhancing skin appearance (Thas, 2008).
6. **Ulcers**: Neem extracts provide notable relief from discomfort and accelerate the healing of gastric and duodenal ulcers (Maity et al.).
7. **Sexually Transmitted Diseases:** Research has highlighted neem's effectiveness in treating various sexually transmitted infections, with highly positive outcomes reported. Its efficacy against Neisseria gonorrhoeae infection has been well established.

PHYTOCHEMICAL STUDIES AND BIOLOGICALLY ACTIVE CONSTITUENTS

Since the first report of nimbin isolation from neem seed oil by Siddique in 1942, more than 140 compounds have been identified from various parts of the neem tree. Organic chemists, particularly those specializing in natural products, continue to investigate the active principles of Azadirachta indica.

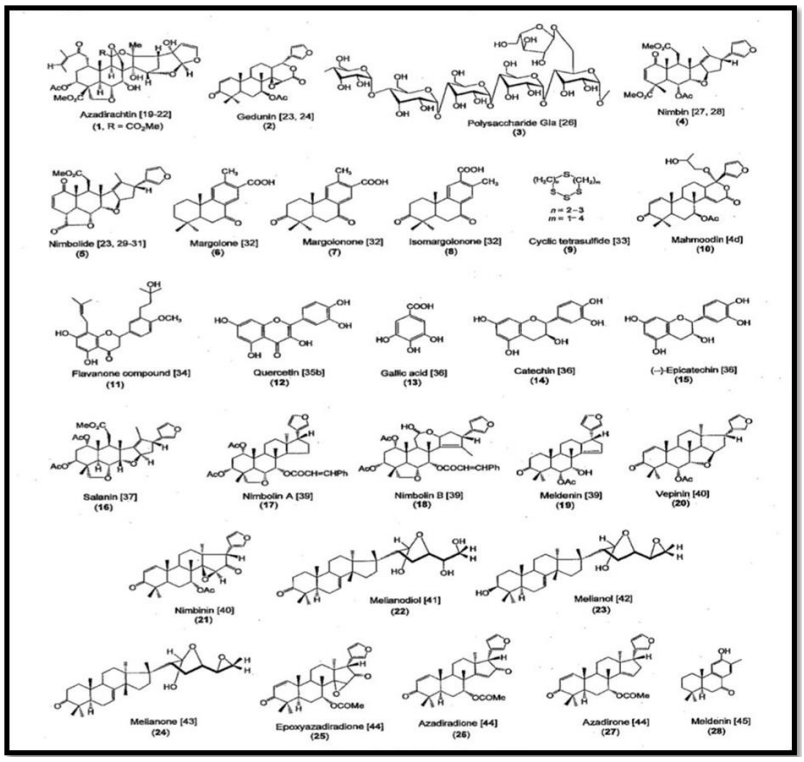

Fig. No. 3: Structure of Some Useful Compounds Of Neem.

These compounds can be broadly classified into two major categories

1. Isoprenoids – including diterpenoids and triterpenoids such as protomeliacins, limonoids,

azadirone and its derivatives, gedunin and its derivatives, vilasinin-type compounds, and C-seco-meliacins such as nimbin, salannin, and azadirachtin.

2. **Non-Isoprenoids** – comprising proteins, amino acids, carbohydrates, sulfur-containing compounds, and polyphenolics such as flavonoids and their glycosides, dihydrochalcones, coumarins, tannins, as well as aliphatic compounds. Although a wide range of constituents has been isolated from neem, only a relatively small number have been extensively studied for their biological activities. Several earlier reviews have covered the chemistry, structural diversity, and biological activities of many of these molecules.

Fig. No. 04: Leaf Of Neem.

Morphology of Neem Leaves

When fully developed, neem leaves measure 20–40 cm in length, bearing 10–20 leaflets. They are alternate, petiolated, and clustered at the tips of branches. The leaves are unevenly pinnate, glabrous, and dark glossy green in color. Each leaflet is sickle-shaped, slightly serrated (denticulate), and measures 5–10 cm long and 1.2–4 cm wide.

Base: Unequal Color: Deep, glossy green Odor: Mild or indistinct Taste: Characteristically bitter.

Maceration Method of Extraction

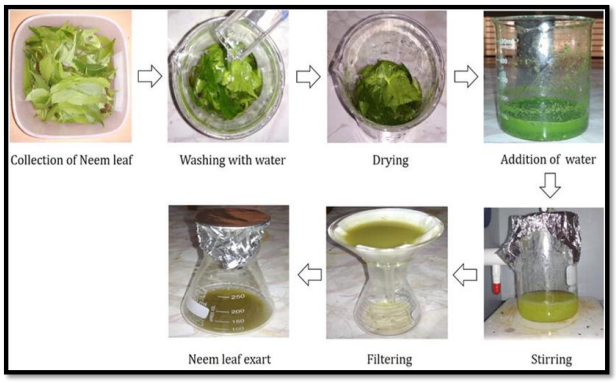

Fig. No. 05: Maceration Method of Extraction.

Home Remedies Using Neem Leaves

A home remedy is a simple, self-prepared treatment or tonic, often taken regularly, usually

without professional medical guidance, and with variable scientific support for its effectiveness.

1. Neem Oil for Joint Pain

Neem leaves are rich in calcium and other minerals. Neem oil, applied externally, can help reduce inflammation and relieve pain in arthritis sufferers.

2. Natural Insecticide

Neem leaves have strong insect-repelling and mosquito-deterring properties. Burning dried neem leaves can keep mosquitoes and other pests away from homes and livestock areas.

3. Dental Health

Chewing fresh neem leaves can, Reduce tooth decay, Eliminate harmful oral bacteria Maintain healthy gums, Keep breath fresh, Preserve the mouth's natural pH.

4. Immunity Booster

Neem tea can help the body fight illnesses such as fever and common colds. It has also been noted to support recovery in malaria-affected cells, with effects comparable to quinine in some traditional practices.

5. Hair Care

Neem leaf paste can be applied as a hair mask to promote strong, healthy hair. It also helps treat scalp fungal infections and dandruff.

ECOLOGY

Neem grows in fields and in regions up to an altitude of 1,850 m. In its introduced range, it is cultivated from sea level to about 1,500 m. Neem tolerates most soil types, including dry, stony, shallow soils, lateritic crusts, highly leached sands, and clays. With its extensive and deep root system, the hardy neem tree can survive and flourish even in poor and degraded soils. It is well-known for its drought resistance. Neem typically thrives in semi-arid to sub-humid climates, with annual rainfall between 400 mm and 1,200 mm. It can also grow in areas receiving less than 400 mm of rainfall, but in such conditions, it relies heavily on groundwater reserves.

While neem can adapt to a wide variety of soils, it grows best in well-drained, deep, sandy soils with a pH of 6.2–7.0. It is a typical tropical to subtropical tree, thriving at mean annual

temperatures between 21°C and 32°C. Although it tolerates high heat, it does not withstand temperatures below 4°C, which can lead to leaf shedding and even death.

HEALTH BENEFITS

Neem is so widely recognized in India that it is often referred to as the "free tree of India" due to its presence across the country. Revered as a "miracle tree," neem is believed to both prevent and cure various ailments. For thousands of years, it has been an invaluable resource to humankind, regarded as sacred and protective. Tradition holds that evil spirits do not approach a neem tree, which is why it is often planted near homes. Neem is used in the treatment of eye conditions such as night blindness and conjunctivitis. In cases of night blindness, fresh neem leaf juice can be applied directly to the eyes for best results. The juice is prepared by crushing neem leaves into a fine paste with water, straining it through a clean cloth, and applying it with an eye stick. For conjunctivitis, the same preparation is used for direct application. For over 5,000 years, neem has been used as a remedy for skin disorders such as eczema. When applied topically, it relieves itching and discomfort. A common Indian practice is to bathe in water infused with neem leaves, which also helps in minor infections. Its antibacterial properties combat acne-causing microbes. Boiling neem leaves in water and using it for bathing is a time-tested home remedy.

MEDICINAL PROPERTIES

The medicinal value of neem has been known in India since ancient times. Early Sanskrit medical texts describe the benefits of neem's fruit, seeds, oil, leaves, roots, and bark. In Ayurvedic medicine, neem bark is characterized as cooling, bitter, astringent, and refrigerant, useful in fatigue, cough, fever, loss of appetite, worm infestations, wound healing, and various disorders involving excessive kapha. Neem leaves are recommended for eye ailments and insect bites, and they are considered anti-leprotic. Its fruits are described as purgative, anti-hemorrhoidal, and anthelmintic. Traditionally, neem has been used against a broad spectrum of ailments, including heat rash, boils, wounds, jaundice, leprosy, stomach ulcers, and chickenpox. Modern research confirms many of these traditional uses and suggests further potential in disease management. Neem is rightly called sarvaroghari ("the curer of all diseases"). Despite centuries of social and environmental change, neem has remained a trusted companion in Indian daily life. In preventive and promotional healthcare, neem's low cost, availability, and efficacy make it an important indigenous resource for achieving the goal of "Health for All." Historically, neem's role is evident even from Indus Valley seals

dated 5,000 years ago. Folk traditions still honor its healing reputation. In rural India, neem branches are associated with the goddess Sitala, believed to protect against smallpox. Delivery rooms are fumigated with burning neem bark for sanitation. Neem seed oil has been tested as a topical contraceptive and spermicide. Dried leaves are burned to repel mosquitoes, and tender leaves are consumed to build resistance against malaria. Neem preparations are widely recognized for their antiseptic and disinfectant qualities. Leaves are applied as poultices for boils, ulcers, and acne. The oil is used for chronic skin conditions like scrofula, indolent ulcers, and ringworm. Laboratory studies have shown neem's effectiveness against several pathogenic fungi, including those causing athlete's foot, ringworm, intestinal yeast infections, bronchial and pulmonary mycoses, and oral thrush. Neem has also been used traditionally to address viral infections. While it may not directly cure illnesses such as smallpox or chickenpox, neem leaf paste applied to the skin can help prevent secondary infections and promote recovery. Its effectiveness is further enhanced by its abundance, affordability, and potential to create employment for rural communities.

SCIENTIFIC REPORTS

1. **Antibacterial Compounds:** Recent research has highlighted the antibacterial activity of neem, particularly in the oral cavity. It has shown effectiveness in preventing periodontal diseases, dental caries, and also in reducing the risk of sexually transmitted infections. Neem has further been investigated as a potential vaginal prophylactic agent.
2. **Antifungal Properties:** Current studies confirm the antifungal potential of neem, demonstrating activity against fungi responsible for athlete's foot, ringworm, and Candida albicans—the causative agent of yeast infections and oral thrush**.**
3. **Antifertility Effect:** Oral administration of neem seed extracts during the early post-implantation stage has resulted in pregnancy termination in rodents and primates, without causing permanent reproductive damage. Although the exact mechanism remains unclear, Praneem—a licensed herbal vaginal tablet (Panacea Biotec, India)—has been shown to effectively immobilize sperm
4. **Anti-inflammatory Activity:** Nimbidin, a bioactive constituent of neem, exhibits pronounced anti-inflammatory and anti-arthritic properties. It suppresses the functions of macrophages and neutrophils involved in the inflammatory process**.**
5. **Analgesic Effect**: In studies involving albino rats, neem seed oil (NSO) at a dose of 2 ml/kg body weight demonstrated analgesic efficacy comparable to morphine at 1 mg/kg. NSO produced a superior pain-relieving effect after 45 minutes. A related study by

Srinivasa et al. (2014) reported that neem's analgesic potential was similar to that of indomethacin**.**

6. **Antioxidant Compounds**: Although the formation of free radicals is a normal physiological process, excessive accumulation can damage cells and contribute to disorders such as cardiovascular disease, ocular conditions (cataracts, macular degeneration), neurodegenerative diseases, and cancer. Neem protects against chemically induced carcinogenesis and liver damage by enhancing antioxidant levels in the body.
7. **Antiviral Compounds in Neem**: Neem has shown inhibitory effects against the dengue virus—a hemorrhagic fever virus—and has been found to disrupt the replication of the coxsackie B virus, an enterovirus second only to the common cold in human infectious prevalence
8. **Anti-tumour Effect**: Experimental studies on Azadirachta indica have revealed chemopreventive properties, including regression of hepatocarcinogenesis induced by diethyl nitrosamine (DEN) and 2-acetylaminofluorene (AAF) in Sprague-Dawley rats.
9. **Potential Contraceptive Properties of Neem:** Neem has been reported to function as both a pre- and post-coital contraceptive, effectively inhibiting sperm cell proliferation at concentrations as low as 0.05–1%.
10. **Effects on Pregnancy:** Neem contains immunomodulatory compounds that activate immune cells, including macrophages, capable of terminating early pregnancies. Fertility was restored within one or two menstrual cycles, with no apparent adverse effects on future pregnancies**.**

FUTURE SCOPE OF NEEM

1. **Medicinal Applications**: Herbal remedies are widely used across the globe for treating various ailments, and neem remains a cornerstone of traditional medicine. It holds a prominent position in ancient medical texts, particularly in the Indian pharmacopeia. Owing to its remarkable therapeutic properties, the bark, leaves, flowers, seeds, and fruit pulp of neem have been used for centuries to address conditions ranging from cancer, diabetes, and ulcers to skin disorders and constipation. Modern researchers worldwide are actively studying neem to develop new antibiotics and pharmaceutical formulations**.**
2. **Cosmetic Industry**: Various parts of the neem tree are extensively used in manufacturing soaps, skin creams, lotions, shampoos, toothpastes, and other personal care products. Neem twigs, traditionally used as natural toothbrushes, are still valued for their germicidal properties. Neem oil and extracts serve as key ingredients in many cosmetic and hygiene

products due to their antimicrobial and skin-healing benefits**.**

3. **Agricultural Uses:** A significant portion of scientific research on neem focuses on its role in sustainable agriculture. Neem oil, neem cake, leaves, and other plant parts are used globally for crop protection and soil health. Their main applications include: Natural insecticide for stored grains and produce Soil amendment and fertilizer efficiency enhancer Foliar pesticide for crop protection
4. **Food Storage:** In tropical regions, a large share of harvested food is lost during storage due to insect and pest infestations. Farmers often avoid synthetic chemical insecticides for stored food, especially for personal consumption. Neem oil provides an effective, natural solution—when applied as a light coating, it can protect stored crops for up to 20 months without affecting their quality or edibility. Fresh neem leaves are also used on a small scale to protect household grain supplie.
5. **Soil Amendment**: Neem cake, a by-product of neem seed oil extraction, has been used for centuries across the Indian subcontinent as an effective soil conditioner. Farmers have observed that neem cake improves plant growth, reduces pest problems, and promotes healthier crops. Scientific studies confirm that neem cake is richer in plant-available nutrients than many conventional fertilizers, helps control harmful nematodes, promotes earthworm populations, and retains soil nitrogen for plant use. Nematodes, which feed on plant roots and hinder nutrient uptake, are effectively suppressed by neem cake, thereby improving crop resilience and yield. Additionally, neem compounds absorbed through the soil enhance plants' natural defense mechanisms with proven nutritive, antifungal, and insect-repellent properties**.**
6. **Population Control and Poverty Reduction:** The rapid growth of the global population is straining natural resources and economic stability. In many developing regions, the lack of affordable, culturally acceptable contraceptive methods remains a barrier to effective family planning. Promising research indicates that certain neem derivatives may serve as safe, inexpensive, and widely accessible contraceptives. A controlled study within the Indian army confirmed neem's contraceptive potential. The Washington-based International Food Policy Research Institute has projected that by 2020, the world would face Global South, particularly in Africa. Neem's potential role in sustainable agriculture and reproductive health could help address these challenges
7. **Environment and neem:** Neem is highly adaptable to stress conditions, improves soil fertility, and enhances water retention, making it valuable for combating desertification, deforestation, soil erosion, and global warming. It has a high photosynthesis rate, releases

more oxygen than many species, and cools the surrounding temperature by ~10°C. Large-scale plantations, such as those in Arafat, Niger, and Tanzania, have improved microclimates, increased crop yields, and acted as windbreaks. Neem provides durable, termite-resistant wood, firewood, and high-calorific charcoal. It resprouts after cutting, making it ideal for sustainable pole production, and its leaves can purify water by removing dyes like Congo red.

8. **Neem and Agriculture**: Around one-third of global agricultural produce is lost annually to over 20,000 pest species, costing India about ₹5,000 crores each year. Synthetic pesticides, though widely used, deliver only 0.1% to target pests, with the rest polluting the environment, fostering pest resistance, and posing serious health risks—WHO estimates 220,000 annual deaths from acute pesticide poisoning. Eco-friendly, biodegradable botanical pesticides are urgently needed, and neem is the most dependable option among 2,400 known pesticidal plants. Neem-based products are non-toxic, non-phytotoxic, long-lasting, and effective against hundreds of insect species, nematodes, fungi, viruses, snails, and even resistant pests. Their unique mode of action disrupts pest life cycles without causing resistance. Unlike synthetic chemicals, neem pesticides leave no harmful residues, are safe for humans and animals, and help lower environmental chemical loads. With global interest in green technologies rising, neem stands out as a sustainable, reliable alternative to hazardous pesticides.
9. **Veterinary uses**: In India, neem has been used for centuries to promote livestock health and as animal feed. References in the Mahabharata (3000 B.C.) describe Nakul and Sahadeva treating injured horses and elephants with neem oil and leaves. Neem's anti-ulcer, antibacterial, antiviral, antifungal, and antiparasitic properties make it effective against stomach worms, ulcers, skin diseases, intestinal helminths, and viral infections such as vaccinia, variola, fowlpox, and Newcastle disease.

CONCLUSION

Neem (Azadirachta indica) stands as one of nature's most valuable multipurpose resources, offering an exceptional combination of medicinal, agricultural, environmental, and industrial. benefits. Rich in bioactive compounds such as azadirachtin, nimbin, and salannin, neem exhibits a wide range of pharmacological activities—including antibacterial, antiviral, antifungal, anti-inflammatory, antioxidant, anticancer, and immunomodulatory effects—many of which are scientifically validated. Its applications extend from traditional healing systems like Ayurveda and Unani to modern pharmaceuticals, cosmetics, and sustainable

agriculture. Ecologically, neem thrives in diverse and challenging environments, improves soil fertility, combats desertification, and serves as a renewable source of biopesticides that are safe for humans, animals, and beneficial insects. Agriculturally, neem products such as oil, cake, and leaf extracts provide eco-friendly pest control, enhance fertilizer efficiency, and contribute to higher crop yields. Industrially, it supports the production of medicines, personal care products, disinfectants, and more, while generating employment, especially in rural areas.

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