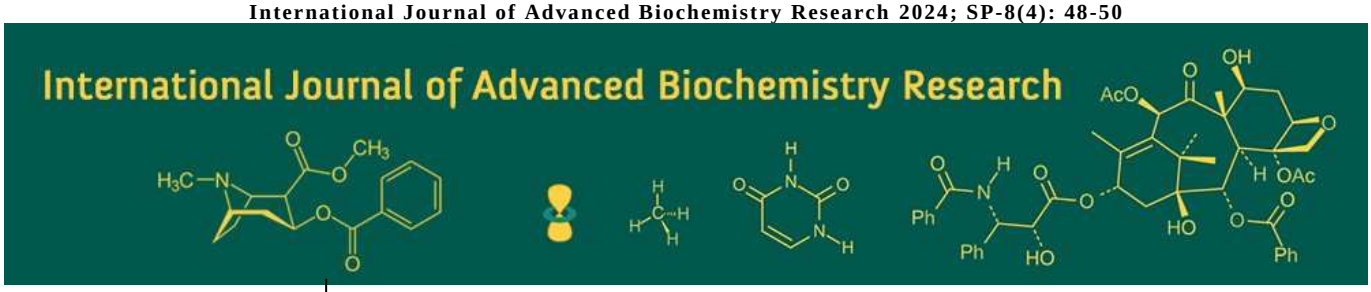

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Azadirachta indica: A source of potential antibacterial activity against various bacterial strains

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Abstract
Neem, scientifically known as *Azadirachta indica*, exhibits potent antibacterial activity due to its bioactive compounds. The plant's leaves, seeds, and oil have been traditionally used in various cultures for their medicinal properties. Neem contains nimbin, nimbidin, and azadirachtin, among other constituents, which contribute to its antibacterial effects. These compounds disrupt bacterial cell membranes, inhibit enzymes essential for bacterial growth, and interfere with DNA replication, ultimately leading to bacterial cell death.
Studies have shown that neem extracts or neem-based products display significant antibacterial activity against a wide range of bacterial strains, including *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*. Neem's antibacterial properties make it effective against both Gram-positive and Gram-negative bacteria. Additionally, neem's anti-inflammatory and immune-boosting properties further enhance its ability to combat infections. However, while neem offers promising antibacterial benefits, further research is necessary to optimize its usage, and understand potential interactions with other treatments. Nonetheless, neem stands as a natural source of antibacterial compounds with the potential to contribute to alternative or complementary antibacterial strategies.

Keywords: Neem, bacterial strains, anti-bacterial activity

Introduction
In recent years, the emergence of drug- resistant pathogenic microorganisms has posed a significantly threat to public health. Researchers and scientists are actively exploring alternative source of antimicrobial agents to combat this growing concern. One such natural remedy is *Azadirachta indica***,** commonly known as neem**.** Neem has a long history of traditional use in various cultures for its medical properties, including its potential as an antimicrobial agent. This article delves into the antimicrobial activity of *Azadirachta indica* against pathogenic microorganisms. In Indian culture neem has been used as a source of many therapeutic agents. According to Maragatharavlli (2012) [12] neem contains active substances as well as multiple medicinal properties. Neem leaf contain an aqueous extract which acts as a good therapeutic potential like antihyperglycemic agent in IDDM and NIDDM (Mossadek and Rashid 2008; Patil *et al*. 2013) [14, 22]. Neem has many antibacterial properties which are used to control air borne bacterial contamination in the residential premise (El- Mahmood *et al*. 2010) [7]. Neem extracts are very functional for controlling malarial parasites, both chloroquin-resistant and sensitive strains of malarial parasites. Oil from neem leaves acts as an antibacterial action against gram positive and gram negative microorganisms. Apart from that neem has excellent qualities that are anti-inflammatory, insecticidal, larvicidal, anti-malarial, anti-ulcer, and other biological activity (Herrera-Calderon *et al*. 2019) [8].

Neem: The Magical Drug
Neem (*Azadirachta indica*) trees are mostly grown in Indian subcontinent. It contains a plethora of bioactive compounds such as nimbin, nimbidin, azadirachtin and nimbolide. These compounds are believed to contribute to the plant's antimicrobial properties as well as antimalarial, antiviral, anti-inflammatory, analgesic, antipyretic, hypoglycaemic, antiulcer, antifertility, anticarcinogenic, hepatoprotective, antioxidant, anxiolytic, molluscicidal, acaricidal, and antifilarial properties (Kharwar *et al*. 2020) [9] (Fig. 1).

Neem's mechanisms of action against pathogenic microorganisms are multifaceted and include disrupting microbial cell membranes, interfering with cell division, inhibiting enzymatic processes, and altering gene expression. The popularity of neem are increasing day by day because of their biodegradability, least persistence and least toxic to non- target organisms and they are easily available. Boiled neem water are also acts as an excellent antiseptic to clean wounds, swelling and eases skin problems (Bonjar and Holland, 2004) [4]. The neem leaves are used as a protection against paracetamol induced liver necrosis due to its antioxidant activity (Chattopadhyay and Bandopadhyay, 2005) [5]. Antifertility effect of neem oil has also been noticed in recent studies and are suggested as one of the best methods of contraception. Aqueous extract of old and tender neem leaf was found to immobilize and kill 100% human spermatozoa within 20 s (Khillare and Shrivastav, 2003) [10].

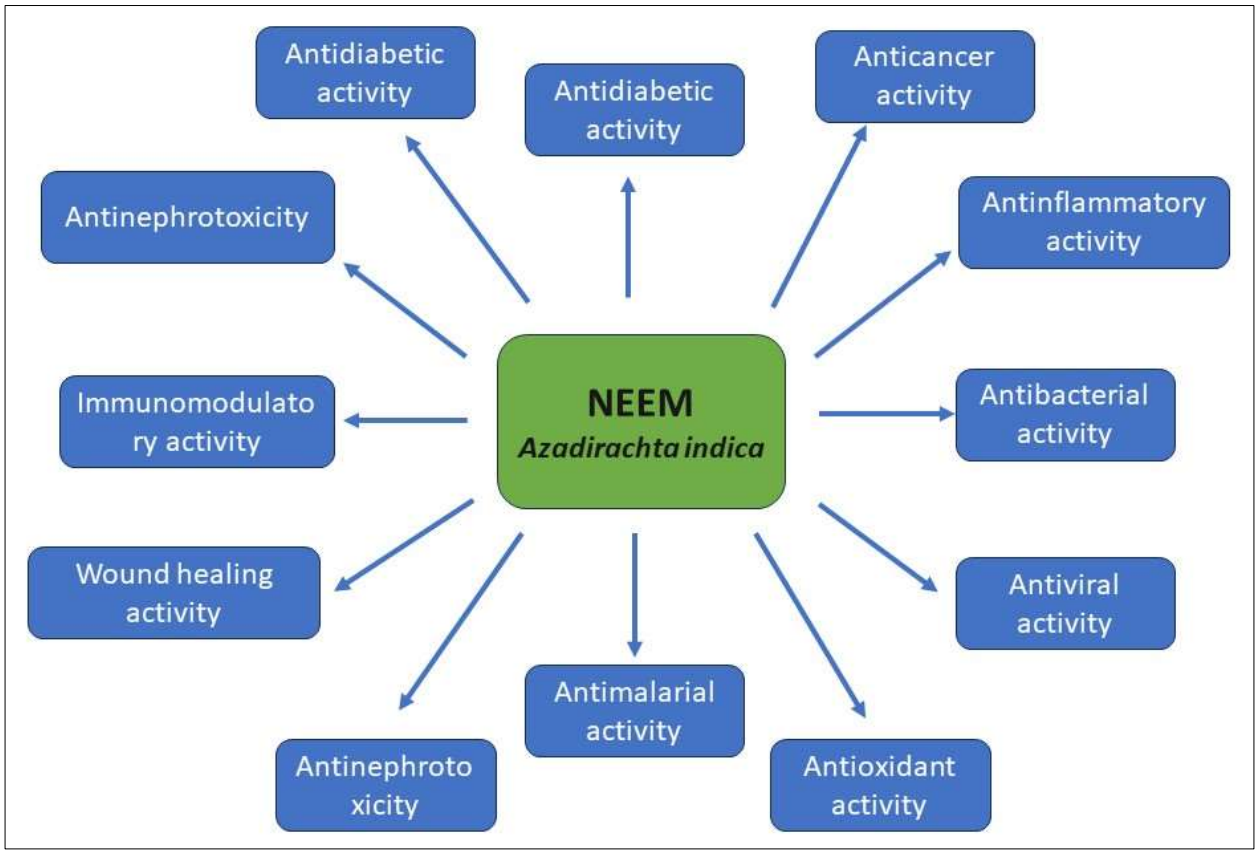

Fig 1: Pharmacological activities of Neem

Antibacterial Activity

Numerous studies have demonstrated Neem's effectiveness against a wide range of bacterial pathogens. It has shown significant antibacterial activity against both gram positive and gram negative bacteria due to presence of a limonoid named 'mahmoodin' extracted from neem oil (Siddiqui *et al*. 1992) [19]. Neem has numerous applications in pharmaceuticals and medicinal field. Against *Klebsiella*, *Serratia* species, and *Streptococcus*, the stem and bark of Neem have strong antibacterial properties (Mafou-Sonhafouo *et al*. 2019) [11]. While chloroform extracts of Neem are effective against *E. coli*, *Bacillus subtilis*, *Enterococcus faecalis*, and *Streptococcus faecalis*, methanolic extracts of Neem are effective against *Vibrio cholera* (Shah *et al*. 2017) [18].

An analysis of the antibacterial properties of *Azadirachta indica* (neem) leaf, seed, bark, and fruit extracts on bacteria taken from mouths of adult samples was conducted. The results showed that leaf and bark extracts have an antibacterial impact on all of the examined microorganisms (Chauhan *et al*. 2015) [6]. A wide variety of bacteria, including strains of *Mycobacterium tuberculosis* and gram-positive and gram-negative bacteria with streptomycin-resistance mechanisms, are resistant to oil derived from leaves, bark, and seeds of neem. The phytoconstituents such as alkaloids, tannins, saponins, steroids, and flavonoids were employed to have a sterile effect on *Corynebacterium bovis*, *Staphylococcus aureus*, and *Escherichia coli* strains. Neem oil has been shown to be effective against a variety of bacteria, including *Salmonella*, *Staphylococcus*, *Pseudomonas*, *Escherichia coli*, *Klebsiella pneumonae*, *Bacillus*, *Streptococcus* spp. *Azadirachta indica* leaf extracts have the strongest antibacterial activity, demonstrating the efficacy of the bioactive components and confirming the use of the neem plant in vital health benefits (Herrera-Calderon *et al*. 2019) [18]. Raut *et al*. (2014) [17] studied the leaf and bark extract of neem on various bacteria among which *Vibrio cholerae* and *Bacillus subtilis* showed highest inhibition zone against the extract while *E. coli* and *Salmonella typhi* were more resistant to the neem extract.

Neem was described as an antibacterial agent against harmful bacteria found in fish by Barua *et al*. in 1999 [2]. In order to combat bacteria (*Pseudomonas fluorescens*, *Aeromonas hydrophila*, *Mycobacteria* spp. and *Escherichia coli*), found in fish aqua-neem made from neem kernels was utilized. This experiment showed high sensitivity of aqua-neem towards these bacteria especially the first three.

In some studies, it was found that neem mouthwash also shows antibacterial activity against salivary level of *Streptococcus mutans* and *Lactobacillus* (Vanka *et al*. 2001) [20]. Alcoholic extracts of neem leaves act against human bacterial pathogens like *Bacillus pumillus*, *Pseudomonas aeruginosa* and *Staphylococcus aureus.*

Conclusion

Azadirachta indica, commonly known as Neem. It exhibits noteworthy antimicrobial activity against a variety of pathogenic microorganisms. Its diverse bioactive compounds and multifaceted mechanisms of action make it a promising candidate for addressing the global challenge of antimicrobial resistance. As research progresses, neem based treatments could potentially contribute to the development of novel antimicrobial therapies and strategies. Every part of neem plant have many beneficial effect for controlling pathogenic microbial organisms and they are also used to control leprosy, respiratory disorder in children. Now a days the demand for neem has increased as they have many medicinal as well as antibacterial properties and because of their biodegradability and are very easily available.

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