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An Overview of Antibacterial and Antifungal Effects of *Azadirachta indica* Crude Extract: A Narrative Review

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Azadirachta indica, commonly known as neem, or Margosa, originated in India. It is one of the species in the Azadirachta genus. It is native to South Asia's Indian subcontinent and dry areas such as India, Nepal, Sri Lanka, Bangladesh, Pakistan and the Maldives. The plant has long been used in Ayurvedic and folk medicine and it is now commonly used in cosmetics and organic agriculture. Several pharmacological activities were identified from the crude extract of Azadirachta indica, which have attracted a lot of research interest from scientists. This narrative review explores the vast potential of neem in eliciting antibacterial and antifungal effects. Furthermore, we highlight the various effects of different types of solvent and several parts of the neem plant on growth inhibition of bacteria and fungi by performing the inhibition zone technique using the disc diffusion method, one of the commonly used methods to measure bacterial, fungal growth.

Keywords: Azadirachta Indica; Antibacterial; Antifungal; Disc Diffusion; Inhibition Zone.

Herbal medicines have been known to man for centuries as records of their uses have been reported since ancient times. The medicinal use of herbal remedies was first mentioned in ancient Hindu texts such as Vedas. These herbs formed an essential part of Indian culture's medical science - Ayurveda (Rastogi *et al*., 2002). Currently, practitioners of traditional medicines worldwide have described the therapeutic effects of many plant species for multiple disorders, either in the forms of natural herbs or their various extracts (Joshi & Sahu, 2014). The bulk of the population in developed countries also harness traditional folk medicines extracted from plant materials. Herbal medicines are a significant source of novel drugs which make up the ingredients in conventional medicinal systems, pharmaceutical intermediates, modern medicines, nutraceutical food supplements, lead compounds in synthetic drugs, and bioactive principles (Bijauliya *et al*., 2018). However, the significance and value of medicinal plants are still not recognized by many new generation people.

Neem (*Azadirachta indica*), an evergreen tree, is an extremely beneficial plant and was first discovered in Indonesia, a tropical climate (Saleem *et al*., 2018). Neem belongs to the Meliaceae family, a subfamily of Meloidae and the tribe of Melieae, and its botanical name is *Azadirachta indica A. Juss*. Neem is also generally known as 'Indian lilac' or 'Margosa' and could be found easily in India (Bhat & Girish, 2008). Some parts of neem plants can cure many diseases, including acute and chronic diseases (Chen *et al*., 2018). In addition, for thousands of years, people, especially from the Asian and African regions, have been using neem as a remedy for various types of diseases (Gupta *et al*., 2017). Neem plants are now grown in different countries worldwide, including Asian countries, the United States of America, Australia and African countries (Ghosh *et al*., 2016). The United Nations acknowledged the many advantages of the plant in treating various ailments that they referred neem as "trees of the 21st century" and "a tree to solve global issues" (Kumar & Navaratnam, 2013).

Neem is a big tree (Figure 1) that can grow on dry and rocky soil, up to 700 m in height in various climatic conditions, and it can live for over 200 years. Neem plants often grow in rainfall regions with 450-1200 mm; pH varies from 4-10 and temperatures from 0-49 °C. In addition, neem could grow in very low-rain areas of 150-200 mm (Saleem *et al*., 2018). The tree becomes mature and productive within 10 years (Maragathavalli *et al*., 2012).

The neem leaves (Figure 2a) can grow for up to 30 cm. Each leaf contains 10-12 serrated leaflets, 7 cm long by 2.5 cm wide, mildly yellowish-green in color, odorless and bitter. In early summer, the tree produces delicate flowers (Figure 2b). The flowers (fragrant and white) have axillary arrangements, typically almost drooping panicles up to 25 cm long. Its fruit (Figure 2c) is semi-sweet and olive-sized. The bark of this tree (Figure 2d) varies considerably in thickness, depending on the age and sections of the tree from which it is taken; rusty-grey and fissured, rugged outer surface, foliaceous and yellowish laminated inner surface, crack, fibrous, odor, bitterness. The seed (Figure 2e) is rich in oil with significant therapeutic and botanical properties. Neem tree grows in almost all soil types, such as clay, saline soils, and alkaline, and it does not need much water and sunlight to grow (Ghosh *et al*., 2016).

Neem leaves have been reported to elicit various therapeutic effects such as antioxidant, anti-inflammatory, antimalarial, antiulcer, antihyperglycemic, antimutagenic, antidiabetic, anticarcinogenic, immunomodulatory and anticancer. Neem leaves and paste are also conventionally used to cure allergic skin reactions and treat smallpox and chickenpox (Hla *et al*., 2011). Furthermore, neem leaves have shown antifungal and antibacterial activities against various pathogenic microorganisms and antiviral effects for treating measles, Chikungunya, Vaccinia and Coxsackie B viruses (Gupta, 2016; Gupta *et al*., 2017). In addition, neem leaves have been reported for effects on antifertility (Saleem *et al*., 2018), spermicidal and contraception (Gupta, 2016), as this form of herbal contraception is non-hormonal and has reported no side effects (Tiwari *et al*., 2014). The diverse, active constituents contribute to the potential antifertility effect of neem leaves in the leaves (Hashmat *et al*., 2012). Women in the village of northwest Madagascar were reported

Plant Profile: Neem Tree

- Biological source: *Azadirachta indica*
- Family : Meliaceae
- Kingdom : Plantae
- Division : Magnoliophyta
- Order : Sapindales
- Genus : Azadirachta
- Species : Indica

Fig. 1. Tree of *Azadirachta indica* (adapted from http://www.bothranursery.com/)

to take neem leaves to avoid pregnancy. Women in villages in southwestern Madagascar chew neem leaves every day to prevent conception; in Gambia and Ghana, they drink tea prepared from neem leaves to induce abortion during the first 2-3 months of pregnancy (Ketkar *et al*., 2005). Besides that, most urban Bangladeshis, Nepalese and Indians have been using neem twigs to clean their teeth. The green juice of neem has also been used as a tonic to increase appetite and kill intestinal worms (Ghimeray *et al*., 2009). Other effects of neem include hypolipidemic, hypoglycaemic, hypotensive and hepatoprotective activities and reducing fever (Chaturvedi *et al*., 2011). The leaf extract has been used therapeutically for its antimicrobial effects against dental pathogens (Khan *et al*., 2010). Due to neem's vast therapeutic applications, products from the plant were manufactured for various ailments such as cancer, digestive disorders, AIDS and skin diseases (Kumar & Navaratnam, 2013).

Neem Leaf's Active Compounds

A. Indica (neem) contains several constituents with different therapeutics properties, whereby proteins, carbohydrates and fat derivatives are the main compounds. In contrast, *A. Indica* has secondary metabolites such as alkaloids, flavonoids, saponins, and steroids (Kumar *et al*., 2016). The active compounds of neem are divided into two major categories, isoprenoid and non-isoprenoid. Triterpenoid and diterpenoid are part of the isoprenoid group, named limonoid, gedunin, protomeliasin and azadiron. Non-isoprenoid compounds include sulfur, proteins, dihydrochalcone, carbohydrates, glycoside and polyphenols (Saleem *et al*., 2018). Azadirachtin is the essential constituent with Nimbin, nimbidol, nimbolinin, nimbidin, sodium nimbinate, salannin, quercetin and gedunin. The leaves also contain Nimbin, nimbandiol, 6-desacetylnimbine, nimbanene, nimbolide, n-hexacosanol, ascorbic acid, amino acid nimbiol, 17-hydroxyazadiradione, 7-desacetyl-7-benzoylgedunine and 7-desacetyl-7-benzoylazadiradione (Hossain *et al*., 2011). Quercetin and â-sitosterol, polyphenolic flavonoids, are purified from fresh neem leaves and possess antibacterial and antifungal effects (Govindachari *et al*., 1998).

With the rising phenomena of antimicrobial resistance, many medicinal plants were screened for their possible antimicrobial action. Furthermore, plants contain a wide range

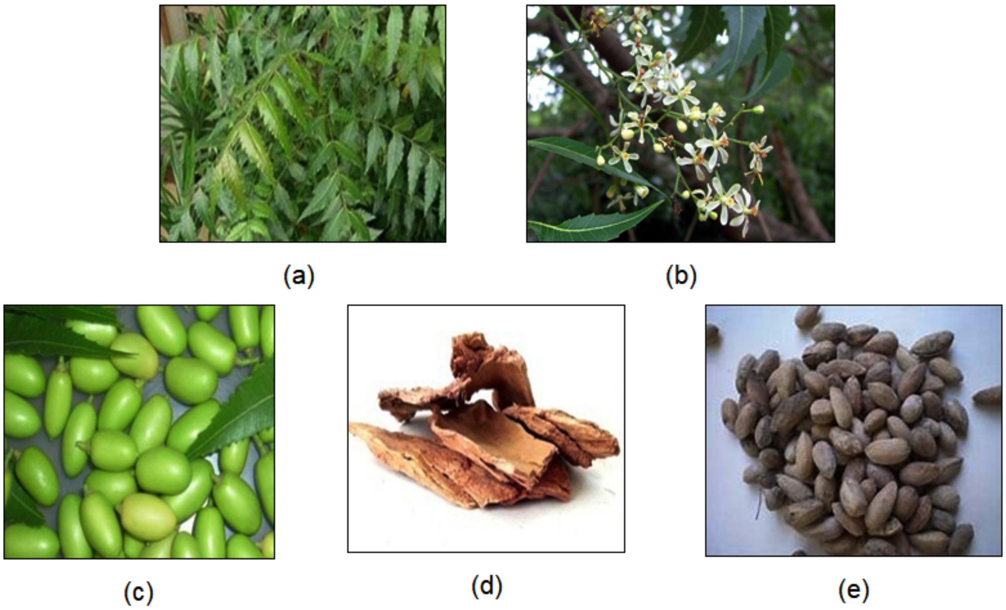

Fig. 2. (a) Leaves of *A. indica*; (b) Flowers of *A. indica* (adapted from http://keyserver.lucidcentral.org/weeds/data/media/Images/azadirachta_indica/azadirachtaindica36.jpg; (c) Fruits of *A. indica*; (d) Stem bark of *A. indica*; (e) Seeds of *A. indica* (adapted from https://ijpsr.com/bft-article/an-updated-review-of-pharmacological-studies-on-azadirachta-indica-neem/?view=fulltext)

of biologically active molecules, making them rich sources of various medications; consequently, it is necessary to identify and evaluate such plants with potential antimicrobial activities. This narrative review provides pharmacological activities such as antibacterial and antifungal effects of neem and its medicinal uses.

MATERIALS AND METHODS

This study utilized various types of literature databases, which included Springer Nature and ScienceDirect. A combination of several keywords used included 'neem tree,' 'Azadirachta indica,' 'neem leaf active compounds,' 'phytochemical analysis of neem compound,' 'antibacterial and antifungal effects of neem leaf extract' and 'pharmacological activity of A. indica.' Relevant articles have been selected to be reviewed for information collection purposes.

Literature Review on Pharmacological Activities of Neem

Neem and its components play a vital part in inhibiting the growth of various microbes, like bacteria and fungi. Antibacterial and antifungal activities of neem are described in the following sections.

Antibacterial effect of neem extract

Oil extracted from neem bark, leaves and seeds reveal its potent activity against organisms of gram-negative, gram-positive and mycobacterium tuberculosis (Srivastava *et al*., 2020). Neem oil extract yields four fractions of hexane in organic solvent methanol, such as methanol miscible for the first fraction (a), methanol immiscible for the second fraction (b), hexane miscible for the third fraction (c) and hexane immiscible for the fourth fraction (d). The first fraction displays a maximum antibacterial effect at 95%. The second and third fractions indicate 85% activity, and the fourth fraction exhibits 65% activity (Barman *et al*., 2009). Methanol, aqueous and petroleum ether extracts of the *A. indica* leaves have been screened for their antimicrobial properties using the cup plate agar well diffusion technique. The evaluation was conducted on six types of bacteria, which were gram-positive bacteria, *Bacillus subtilis* (*B. subtilis*) and *Staphylococcus aureus* (*S. aureus*) and four gram-negative bacteria, *Escherichia coli* (*E. coli*), *Proteus vulgaris* (*P. vulgaris*), *Pseudomonas aeruginosa* (*P. aeruginosa*) *and Salmonella typhi* (*S. typhi*). It was found that the *A. indica* methanol extract showed marked action against *B. subtilis* with an inhibition zone around 28 mm (Grover *et al*., 2011).

Another study was conducted by Muhammad et al. (2019) were investigated the antibacterial activity of neem leaf extract against specific clinical isolates, which were *E. coli*, *Klebsiella pneumonia* (*K. pneumonia*) and *S. aureus*. The phytoconstituents in neem were extracted using ethanol as a solvent; a Soxhlet extractor was used to evaluate the extract using standard techniques. Some of the studied bioactive compounds were saponin and alkaloids, flavonoids, phenols and tannins. Compared with gram-positive *S. aureus*, the extract was much more efficient in inhibiting the growth of gram-negative *K. pneumonia* and *E. coli*. The extract inhibition zones at the 125 mg/ml concentration were 21 mm and 16 mm, respectively, for gram-positive and gram-negative bacteria. The means of the minimum inhibitory concentrations (MICs) of *A. indica* leaf extracts *in-vitro* were shown to be at a significantly lower concentration of 50 mg/ml for *E. coli* relative to 100 mg/ml for *S. aureus*. Meanwhile, the minimum bactericidal concentrations (MBCs) of *A. indica* leaf extract indicated that the extract has bacteriostatic activity against gram-negative bacteria but a static effect against gram-positive bacteria.

A review was conducted to assess the antimicrobial sufficiency of herbal substitutes as endodontic irritants and differentiated with generic irritant sodium hypochlorite (Giri *et al*., 2019; Ahmad *et al*., 2019). The result verified that neem leaf extract demonstrated profound inhibition zones of indicated antibacterial activity. It was also found that neem leaf extract exhibited more specific inhibition zones than 3% sodium hypochlorite (Ghonmode *et al*., 2013). Furthermore, the antibacterial efficacy of neem extracts toward 21 strains of foodborne pathogens was tested. The examination findings suggested that extracts produced compounds with an antibacterial activity that could be important in inhibiting the growth of foodborne pathogens and other life forms of deterioration (Hoque *et al*., 2007).

Further research was conducted by

Ghonmode *et al.* (2013) to evaluate the antibacterial efficacy of *A. indica* seed, fruit, bark and leaf extracts on bacteria isolated from the adult mouth. The results displayed that leaf and bark extracts exhibited antibacterial effects against all of the tested microorganisms. Moreover, fruit and seed extracts exhibited higher concentrations of antibacterial activities. Results also indicated that neem bark extract blocked the herpex simplex virus (HSV-1) entry into cells at 50 and 100 ìg/ml (Yerima *et al*., 2012).

In one study by Bijauliya *et al.* (2018). *A. indica* methanolic leaf extract was evaluated for its antibacterial, antihemorrhagic and antisecretory effects against Vibrio cholera (Thakurta *et al*., 2007). In addition, methanol, chloroform and hexane extracts of *A. indica* were tested for antibacterial effects against *K. pneumonia*, *E. coli*, *Micrococcus luteus*, *Enterococcus faecalis*, *P. Vulgaris*, *B. subtilis* and *Streptococcus faecalis*.

Another study by Koona & Budida (2011) concluded that methanol neem extract exhibited the highest antibacterial activity, while chloroform extract exhibited moderately active antibacterial activity. Hexane extract exhibited the lowest antibacterial activity against several types of bacteria.

Neem leaf, bark and seed oil extracts provided a wide range of antibacterial effects against gram-negative and gram-positive microorganisms, including *streptomycin-resistant strains* and *Mycobacterium tuberculosis*. Active compounds including alkaloids, flavonoids, tannins, saponins, steroids and crude glycosides of the neem plant were screened against pathogenic strains of *S. aureus*, *E. coli* and *Corynebacterium bovis* for antibacterial activity (Aslam *et al*., 2009).

Hymete *et al*. (2005) also supported the outcomes and conveyed FIGUREthat flavonoids possess antimicrobial properties. A study by Hafiza *et al*. (2002) also showed that saponins inhibited the growth of microbes. Acetone and methanol extracts of *A. indica* leaves have been evaluated for antibacterial properties against two distinct bacterial strains, which were *B. subtilus* and *E. coli*, and methanol extracts have been reported to have higher antibacterial properties compared with acetone extracts (Lall *et al*., 2013).

Another research was conducted by Bassey and colleagues (2016) using the agar diffusion technique to conduct *in vitro* analysis of the antibacterial capability of acetonic, ethanolic and methanolic extracts of bark and leaves of the neem plant. These extracts had been prepared and tested for the presence of various phytochemicals. The findings revealed that both bark and leaf extracts contained an alkaloid, reducing sugar, flavonoid, tannin, polyphenol and saponin. The neem plant's methanolic, ethanolic, and acetonic bark and leaf extracts have been screened against selected pathogens, including *S. aureus*, *E. coli*, *P. aeruginosa*, *Aspergillus fumigatus*, *Candida albicans*, and *Aspergillus niger* by agar well diffusion method. The MIC for stem bark extract was 6.25 mg/ml, while the MBC for stem bark extract was 25 mg/ml. Analysis indicated that the bark extract elicited more robust antimicrobial activity toward fungi and bacteria at different concentrations when compared with the leaf extract. The zone of inhibition for acetonic stem bark extract was 22 mm, a maximum antibacterial activity.

The methanol stem bark extract had maximum antifungal activity, with an inhibition zone of 22.50 mm. In contrast, ethanol extract from the stem bark reported an inhibition zone of 21 mm. Therefore, the results indicated some bioactive compounds and antimicrobial properties in leaf and stem bark extracts (Bassey *et al*., 2016).

An *in vitro* study by Francine *et al*. (2015) was performed to examine the antimicrobial effect of bark and leaf extracts of *A. indica*. Aqueous and ethanol extract of barks and leaves were screened against *E. coli* and *S. aureus*, which are known to be resilient to numerous antibiotics. Using the agar disc diffusion technique, the effectiveness of the extracts of various concentrations was observed on two cultivated bacterial strains. Aqueous and ethanol extracts were extracted from the fresh and dried barks and leaves of neem. Results suggested that fresh neem materials caused significant effects on *S. aureus* and *E. coli* compared to dry extracts. In addition, ethanol extracts were found with higher antibacterial activity compared to aqueous extracts. The findings demonstrated that the efficiency of the extracts relied on the concentration used; therefore, an increase in the concentration of the extracts increased the zone of inhibition (Francine *et al*., 2015).

The susceptibility of the pathogenic microorganisms to the leaves extracts has been contrasted with one another and chosen antibiotics (Chhibber & Sharma, 2014). *A. indica* methanol extract showed marked action against *B. subtilis* with an inhibition zone around 28 mm (Dholi *et al.*, 2011). The preparation of neem oil has been reported to elicit effective inhibitory activity against a broad spectrum of *bacteria viz.*, *B. cereus*, *B. pumilus*, *E. coli*, *P. Vulgaris*, *S. aureus*, *M. tuberculosis*, *S. Typhi*, *K. pneumonia*, *Salmonella dysentery*, *E. faecalis*, *Streptococcus mutants*, *Streptococcus sanguis*, *Streptococcus mitis*, *Streptococcus salivarius* and even *Streptomycin resistant strains* (Mehrota *et al.*, 2010; Sarmiento *et al.*, 2011; Rosaline *et al.*, 2013). *A. indica* leaf extract has good antibacterial activity, thereby validating the enormous potential of phytoconstituents and justifying the usage of this plant in primary health care (Koona & Budida, 2011). Besides that, neem oil possesses an antiplaque effect (Elavarasu *et al.*, 2012), while neem leaf extract inhibits the growth of *P. aeruginosa* by obstructing the biofilm formation in this bacteria strain (Harjai *et al.*, 2013).

El-Mahmood *et al.* (2010) reported the antibacterial activity of neem seed crude extracts against microorganisms involved in the eye and ear infection. Pure methanol, acetone and ethanol extracts of neem seeds were tested against bacterial strains such as *E. coli*, *S. typhus*, *B. subtilis*, *S. aureus*, *K. pneumonia* and *Staphylococcus epidermis*. Irshad *et al.* (2011) also reported that acetone neem extracts exhibited maximum antibacterial effect relative to other solvent extracts. Another study reported that neem seed oil showed bactericidal action against 14 pathogenic bacterial strains (Baswa *et al.*, 2001). Furthermore, crude aqueous and solvent extracts of *A. indica* were tested against 20 pathogenic bacterial strains, wherein crude extracts showed better outcomes (Srinivasan *et al.*, 2001). Ethanolic neem leaf extracts and bark of the neem plant were tested for antibacterial effects on S. mutants. It was found that neem stick extracts possessed more antibacterial activity than leaf extracts (Siswomihardjo *et al.*, 2007).

Neem leaf extracts were screened against *Vibrio alginolyticus* (*V. alginolyticus*) and *Vibrio parahaemolyticus* (*V. parahaemolyticus*), isolated from shrimps. Aqueous leaf extract produced no inhibitory zone. In contrast, neem juice produced an inhibitory zone which demonstrated a linear relationship to neem juice concentration on both bacteria. The MICs were 6.25 and 3.13 mg/ml for *V. parahaemolyticus* and *V. alginolyticus,* respectively. At the same time, the MBCs were 25.00 and 12.50 mg/ml for *V. parahaemolyticus* and *V. alginolyticus,* respectively. Thus, neem juice could be concluded as an antibacterial agent and is beneficial for the vibrios inhibitors in shrimp (Banerjee *et al.,* 2013). The methanolic extract of neem has the most potent growth-inhibitory action on both clinical and standard isolated strains of *P. aeroginosa*. Ethanol and ethyl acetate extracts showed a growth inhibitory effect on both standard isolated strains of *S. aureus*. In the case of *E. faecalis*, methanol and ethanol extracts revealed maximum growth inhibitory effects against the clinical and standard strains, respectively. Based on the MIC index effects, methanolic extract possessed bactericidal effect against both standard and nosocomial strains of *P. aeroginosa* and *S. aureus* and bacteriostatic effect against the nosocomial strain *E. faecalis*. The ethanolic extract exhibited bactericidal activity towards both standard and nosocomial strains of *P. aeroginosa* and *E. faecalis* and bacteriostatic activity against the nosocomial strain of *S. aureus*. Ethyl acetate extract had revealed bactericidal activity against standard strains of *P. aeroginosa* and *S. aureus* and bacteriostatic against the standard strain of *E. faecalis* and nosocomial strain of *S. aureus*. Thus, neem can be an effective therapeutic agent to fight antibiotic-resistant bacteria (Maleki *et al.*, 2018).

Antifungal effect of neem extracts

Alcoholic extract of neem leaves is beneficial in retarding *Aspergillus* and *Rizopous* fungal species (Srivastava *et al.*, 2020). The antifungal properties of neem could also be found in oil and bark extracts and the other parts of neem extracts (Mahmoud *et al.*, 2011).

Another study was conducted to determine antifungal activity of various neem leaf concentrates on seed-borne parasites such as *Aspergillus* and *Rhizopus*; the findings showed that the growth of both infectious species was profoundly depressed and regulated by aqueous and alcoholic extracts (Giri *et al.*, 2019). Moreover, an alcoholic neem leaf extract was tested.

Leaves and seed kernels of neem were utilized as antifungal agents (Ahmad *et al*., 2019). Neem seed kernel extract decreases significantly (P<0.05) on post-harvest diseases, pathogens of *Penicillium expansum*, *Monilinia fructicola*, *Alternaria* and *Trichothecium Roseum* alternate in-vitro (Singh & Purohit, 2011). It could also be observed that ethanolic, aqueous. Ethyl acetate neem leaf extracts (5, 10, 15 and 20%) inhibited human pathogens (*A. niger*, *Aspergillus flavus*, *A. fumigatus*, *A. terreus*, *C. Albicans* and *M. gypsum*).

Antidermatophytic activity against dermatophyte isolates has been demonstrated using the agar dilution method to produce aqueous and ethanolic neem leaf extracts (Bijauliya *et al*., 2018). Ethanol extract exhibited more visible activity than aqueous extract (Venugopal & Venugopal, 1994). Antifungal properties were also screened using acetone and methanolic extracts of *A. indica* against two distinct fungal strains, such as *A. fumigatus* and *A. niger*. It was stated that methanolic neem extract exhibited extreme antifungal effects compared to acetonic extracts (Lall *et al*., 2013).

In vitro antifungal activity of different concentrations of ethyl acetone and aqueous ethanolic extracts of neem leaves was investigated on a few human pathogens (*C. Albicans, A. flavus, A. fumigates, A. niger, A. terreus*, and *M. gypsum*). It was documented that these extracts helped to prevent the growth of the tested pathogenic organisms, and the effect improved significantly as the concentrations increased (Mahmoud *et al*., 2011). Gedunin segregated from neem seed oil has conveyed antifungal properties. Mohanty *et al*. (2008) conducted a study to evaluate the antifungal effect of neem against *Metarhizium anisopliae* (*M. anisopliae*) and *Lagenidium giganteum* (*L. giganteum*) in Emerson's Yeast Soluble Starch (YpSs) and Peptone Yeast Extract Glucose Broth (PYG) agar media. A higher MIC value of neem oil was reported for *L. giganteum* compared to *M. anisopliae*. For both fungi, a less fungicidal concentration of neem oil was observed in the PYG medium than YpSs (Mohanty *et al*., 2008). Another study examined antifungal properties of neem leaf extract against three fungal species – *Cladosporium, Alternaria solani* and *A. flavus*. Methanolic and ethanolic extracts in distinct concentrations (25, 50, 75 and 100%) were screened against test organisms using the disc diffusion technique. Ketoconazole was a positive control to relate neem leaf extract's toxicity against its antifungal properties (Shrivastava & Swarnkar, 2014).

Another experiment by Alzohairy (2016) was conducted to determine the effectiveness of different neem leaf extracts inhibiting the growth of seed-borne fungi. Results confirmed that the growth of *Rhizopus* and *Aspergillus* was substantially controlled and inhibited by both alcoholic and water extracts. Furthermore, alcoholic leaf extract was more effective than aqueous extract to retard the growth of both fungal species (Mondali *et al*., 2009). Other findings displayed the antimicrobial role of aqueous extracts of neem by inhibiting spore germination against three sporulating fungi, including *H. pennisetti*, *C. lunata* and *C. gloeosporioides f. sp. mangiferae* (Kumari *et al*., 2013), while results of another study demonstrated that ethanol and methanol extracts of *A. indica* displayed growth inhibition against *Cladosporium*, *A. solani* and *A. flavus* (Shrivastava & Swarnkar, 2014). Aqueous extracts of neem oil and its main principles possess antifungal properties conveyed by earlier investigators (Lloyd *et al*., 2005). An experiment was undertaken to observe the antifungal effect of *A. indica* against *A. solani*. The findings showed that the ethyl acetate fraction was most effective in retarding fungal growth with a MIC of 0.19 mg. This fraction was also significant than fungicide (metalaxyl and mancozeb) as the fungicide has a MIC of 0.78 mg (Jabeen *et al*., 2013).

CONCLUSION

This review paper presented an overview of the antibacterial and antifungal effects of *Azadirachta indica* neem Extract. Neem is a powerful medicinal plant endowed with potential therapeutic benefits, mainly for antibacterial and antifungal properties. In addition, industrial and medicinal sectors prepare countless formulations of neem through potent clinical uses in developing novel drugs to treat different ailments due to their effectiveness against pathogens. Thus, these past few decades have shown a progressively growing interest in neem research in chemistry exploration and therapeutic discovery. Even with this establishment, it is still imperative that research on neem's clinical importance and value is actively continued for enhanced economic and medicinal applications.

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Conflict of Interest

We declare that we have no conflict of interest.

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