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Current Trends in Pharmacy and Pharmaceutical Chemistry

Journal homepage: https://www.ctppc.org/

Review Article

Exploring the antifungal properties of neem (Azadirachta indica) during: A comprehensive review (2010-2020)

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ARTICLE INFO

Article history:
Received 05-07-2024
Accepted 16-08-2024
Available online 07-09-2024

Keywords:
Neem
Azadirachta indica
Antifungal
Mechanisms of action
Fungal pathogens

ABSTRACT

Neem (Azadirachta indica) is a versatile medicinal plant with a long history of use in traditional medicine systems. Among its various therapeutic properties, neem has gained attention for its potent antifungal activity. This paper provides a comprehensive review of the antifungal properties of neem, highlighting its mechanisms of action, efficacy against fungal pathogens, and potential applications in clinical and agricultural settings. By synthesizing findings from a wide range of research studies, this review aims to deepen our understanding of neem's antifungal properties and explore its potential as a natural alternative for combating fungal infections.

1. Introduction

Neem (Azadirachta indica), a member of the Meliaceae family, has garnered significant attention for its multifaceted medicinal properties deeply rooted in traditional medicine systems, particularly in the Indian subcontinent. Among its wide array of therapeutic benefits, neem stands out for its potent antibacterial, antiviral, antidiabetic, and notably, antifungal activities (Biswas et al., 2002; Al-Marzoqi et al., 2020). This botanical treasure trove harbors a rich repertoire of bioactive compounds, including nimbin, nimbidin, azadirachtin, and gedunin, which collectively contribute to its pharmacological prowess (Hamzah et al., 2020; Kaur et al., 2019).[1]

The interest in neem's antifungal properties has surged in recent years due to its potential in combating fungal infections. Research endeavors have unveiled the intricate mechanisms underlying neem's antifungal action, elucidating its effectiveness against various fungal pathogens. Nimbidin and nimbin, two key compounds found in neem, have been demonstrated to disrupt fungal cell membranes, leading to their demise (Sujatha et al., 2014). Additionally, azadirachtin, a prominent constituent of neem, inhibits crucial fungal enzyme activities involved in cell wall synthesis and membrane integrity (Singh et al., 2017).[2–4]

Moreover, gedunin, a tetranortriterpenoid abundant in neem, exhibits promising antifungal activity by disrupting fungal mitochondrial function, ultimately inducing cell death (Hamza et al., 2020). Collectively, these bioactive compounds endow neem with formidable antifungal properties, positioning it as a promising candidate for the development of novel antifungal therapies.

Recent studies have expanded our understanding of neem's antifungal efficacy against a wide range of fungal pathogens, including Candida spp., Aspergillus spp., dermatophytes, and plant pathogenic fungi (Al-Marzoqi et al., 2020). Moreover, investigations into neem-based formulations have shown promising results, demonstrating its potential applications in both clinical and agricultural settings (Kaur et al., 2019).

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https://doi.org/10.18231/j.ctppc.2024.020

In light of the escalating challenge posed by fungal infections and the limitations of existing antifungal therapies, there is a pressing need to explore natural alternatives like neem. Continued research efforts aimed at elucidating the mechanisms of neem's antifungal activity and optimizing its formulations hold immense promise in addressing this global health concern. [5–9]

2. Mechanisms of Antifungal Action of Neem

Neem (Azadirachta indica) exhibits potent antifungal effects attributed to its diverse array of bioactive compounds and their multifaceted mechanisms of action. These mechanisms include the disruption of fungal cell membranes, inhibition of fungal enzyme activity, interference with fungal cell wall synthesis, and modulation of fungal gene expression (Oliveira et al., 2018).

2.1. Disruption of fungal cell membranes

Azadirachtin, a prominent bioactive compound in neem, plays a crucial role in disrupting fungal cell membranes. Studies have revealed that azadirachtin alters membrane permeability and integrity, leading to destabilization and subsequent rupture of fungal cell membranes (Pavela, 2016). This disruption compromises the structural integrity of fungal cells, impairs their function, and ultimately leads to cell death.

2.2. Inhibition of fungal enzyme activity

Neem extracts have been shown to inhibit the activity of key fungal enzymes, further contributing to their antifungal effects. Notably, neem extracts have been found to inhibit enzymes such as chitin synthase and glucan synthase, which are essential for fungal cell wall synthesis (Sujatha et al., 2014). By interfering with these enzymatic processes, neem extracts impede the formation of fungal cell walls, thereby rendering the fungal cells vulnerable to environmental stressors and immune responses.

2.3. Interference with fungal cell wall synthesis

In addition to enzyme inhibition, neem compounds interfere with fungal cell wall synthesis through various mechanisms. These compounds disrupt the synthesis of fungal cell wall components, including chitin and glucans, crucial for maintaining fungal cell wall integrity and rigidity (Oliveira et al., 2018). This disruption compromises the structural integrity of fungal cells, impeding their growth and proliferation.

2.4. Modulation of fungal gene expression

Furthermore, neem components have been shown to modulate fungal gene expression, influencing various cellular processes essential for fungal survival and virulence. By targeting specific genes involved in fungal metabolism, cell cycle regulation, and stress response pathways, neem compounds disrupt vital cellular functions, leading to growth inhibition and cell death (Oliveira et al., 2018). [10–14]

Neem's antifungal properties are mediated through a complex interplay of bioactive compounds and multiple mechanisms of action. By targeting key fungal cellular components and processes, neem exerts potent antifungal effects, making it a promising candidate for the development of novel antifungal therapies.

2.5. Efficacy

2.5.1. Efficacy against fungal pathogens

Neem (Azadirachta indica) exhibits broad-spectrum antifungal activity, demonstrating effectiveness against a diverse array of fungal pathogens, including Candida spp., Aspergillus spp., Cryptococcus neoformans, and dermatophytes (Bardají et al., 2015). This wide-ranging efficacy makes neem a promising candidate for the development of novel antifungal therapies.

2.6. Activity against planktonic and biofilm forms

Studies have elucidated the efficacy of neem extracts and neem-derived compounds against both planktonic and biofilm forms of fungal pathogens (Singh et al., 2017). Neem's ability to target fungal biofilms, which are notoriously resistant to conventional antifungal treatments, underscores its potential as a therapeutic agent against recalcitrant fungal infections. By disrupting biofilm formation and eradicating established biofilms, neem compounds offer a promising strategy for combating persistent fungal infections.

2.7. Inhibition of multidrug-resistant strains

Moreover, neem-based formulations have shown promising results in inhibiting the growth of multidrug-resistant fungal strains, further highlighting its potential as an alternative therapeutic option (Al-Marzoqi et al., 2020). In the face of rising antimicrobial resistance, the discovery of effective alternatives like neem is of paramount importance. Neem's ability to overcome resistance mechanisms exhibited by multidrug-resistant fungi underscores its value as a versatile and sustainable antifungal agent.

2.8. Clinical applications

Neem-based formulations, encompassing products such as neem oil, neem leaf extracts, and neem-based creams, have emerged as promising therapeutic options for the management of various fungal infections in clinical settings. Clinical studies have underscored the efficacy of these formulations in treating conditions such as

candidiasis, dermatophytosis, and onychomycosis, among others (Siddiqui et al., 2017).

3. Treatment of Candidiasis, Dermatophytosis, and Onychomycosis

Clinical investigations have reported favorable outcomes with the use of neem-based products in the treatment of candidiasis, a common fungal infection caused by Candida species. Neem extracts have demonstrated antifungal activity against Candida species, thereby offering a viable therapeutic option for the management of candidiasis (Siddiqui et al., 2017).

Similarly, neem-based formulations have shown efficacy in the treatment of dermatophytosis, also known as ringworm, a fungal infection affecting the skin, hair, and nails. Neem oil and neem leaf extracts possess antifungal properties that can inhibit the growth of dermatophytes, thereby alleviating symptoms and promoting healing (Siddiqui et al., 2017).

Furthermore, onychomycosis, a fungal infection of the nails, has been effectively managed with the use of neem-based treatments. Clinical studies have demonstrated the antifungal efficacy of neem oil and neem-based creams in treating onychomycosis, leading to improvements in nail health and appearance (Siddiqui et al., 2017).

4. Topical Application for Fungal Skin Infections

In addition to systemic treatments, the topical application of neem oil has shown promise in alleviating symptoms associated with fungal skin infections. Neem oil possesses anti-inflammatory, antipruritic, and antimicrobial properties, which can help reduce itching, redness, and inflammation associated with fungal skin infections (Kaur et al., 2019). Moreover, neem oil exhibits moisturizing properties that can soothe and hydrate the skin, promoting faster healing and recovery.

5. Conclusion

Neem emerges as a valuable natural resource with significant antifungal properties, offering a promising avenue for the development of novel antifungal agents. Its diverse mechanisms of action, broad-spectrum efficacy against fungal pathogens, and potential applications in both clinical and agricultural settings underscore its importance in the field of fungal infection management. Further research is warranted to elucidate the specific bioactive compounds responsible for neem's antifungal activity and to optimize its formulations for enhanced therapeutic efficacy.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Cite this article: Kale S, Kaldoke A, Rane P. Exploring the antifungal properties of neem (Azadirachta indica) during: A comprehensive review (2010-2020). *Curr Trends Pharm Pharm Chem* 2024;6(3):73-75.