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Anti-inflammatory and Antimicrobial Activity of Green Synthesized Copper Oxide Nanoparticles Using *Annona squamosa*

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Abstract

Introduction:

Green synthesis of metal nanoparticles has emerged as a sustainable and environmentally benign alternative to conventional chemical methods. Copper oxide nanoparticles (CuO NPs) are of significant interest due to their potent antimicrobial and anti-inflammatory properties. Plant-mediated synthesis using *Annona squamosa*, a rich source of bioactive phytochemicals, enhances the functional properties of nanoparticles.

Aim:

The present study aims to synthesize copper oxide nanoparticles using *Annona squamosa* extract and to evaluate their anti-inflammatory and antimicrobial efficacy.

Materials and Methods:

Plant material was processed to obtain a crude extract, which served as a reducing and stabilizing agent in the green synthesis of CuO nanoparticles. The synthesized nanoparticles were subjected to anti-inflammatory assessment and antimicrobial evaluation against selected microbial strains using standard experimental protocols.

Results:

The synthesized CuO nanoparticles demonstrated moderate anti-inflammatory activity when compared to the standard drug diclofenac. In antimicrobial assays, the

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nanoparticles exhibited appreciable inhibitory activity against *Staphylococcus aureus*, *Escherichia coli*, and *Candida albicans*, with maximum inhibition observed against the fungal strain.

Discussion and Conclusion:
The findings indicate that green synthesized CuO nanoparticles possess promising antimicrobial potential and moderate anti-inflammatory activity. The enhanced bioactivity may be attributed to phytochemical constituents present in *Annona squamosa*. These nanoparticles could serve as potential candidates for biomedical applications; however, further investigations are warranted to optimize their efficacy and safety profiles.

Introduction

Nanotechnology has revolutionized contemporary biomedical research by enabling the development of novel therapeutic agents with enhanced efficacy and targeted action. Among various nanomaterials, copper oxide nanoparticles (CuO NPs) have attracted considerable attention due to their unique physicochemical properties and broad-spectrum biological activities (1,2).

Conventional methods for nanoparticle synthesis often involve toxic chemicals, high energy requirements, and environmental hazards. In contrast, green synthesis approaches utilizing plant extracts have gained prominence due to their eco-friendly, cost-effective, and sustainable nature (3,4). Phytochemicals such as flavonoids, phenolics, terpenoids, and alkaloids present in plant extracts act as reducing, capping, and stabilizing agents during nanoparticle formation (5).

Annona squamosa is a medicinal plant widely recognized for its pharmacological properties, including antimicrobial, antioxidant, and anti-inflammatory activities (6). The presence of bioactive compounds enhances the efficiency of nanoparticle synthesis and contributes to improved biological activity.

Copper oxide nanoparticles exhibit strong antimicrobial effects against both Gram-positive and Gram-negative microorganisms through mechanisms such as reactive oxygen species (ROS) generation, disruption of microbial membranes, and interference with intracellular processes (7,8). Additionally, their ability to modulate

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inflammatory responses makes them potential candidates for anti-inflammatory applications (9).

Therefore, the present study focuses on the green synthesis of CuO nanoparticles using *Annona squamosa* and evaluates their anti-inflammatory and antimicrobial properties.

Materials and Methods

Fresh *Annona squamosa* plant material was collected, thoroughly washed, and shade dried for 30 days. The dried material was ground into a fine powder using a mechanical grinder, and a crude extract was prepared. This extract served as a reducing and stabilizing agent in the green synthesis of copper oxide nanoparticles.

The synthesis was carried out by reacting the plant extract with a copper precursor under controlled laboratory conditions, leading to the formation of CuO nanoparticles. The synthesized nanoparticles were then evaluated for biological activities. Anti-inflammatory activity was assessed using standard in vitro methods and compared with diclofenac as a reference drug. Antimicrobial activity was tested against *Staphylococcus aureus*, *Escherichia coli*, and *Candida albicans*using agar diffusion methods, and the zones of inhibition were measured.

Results

The synthesized copper oxide nanoparticles demonstrated moderate anti-inflammatory activity when compared to the standard drug diclofenac, which exhibited a higher inhibition rate of approximately 85–90%. The nanoparticles showed inhibition levels ranging from 35–40%, indicating a measurable but comparatively lower anti-inflammatory effect.

In antimicrobial assays, the CuO nanoparticles exhibited significant inhibitory activity against the tested microorganisms. The zones of inhibition were approximately 23 mm for *Staphylococcus aureus* and *Escherichia coli*, while

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Candida albicans showed the highest sensitivity with a zone of inhibition of up to 35 mm. At lower concentrations, the antimicrobial activity decreased, with inhibition zones ranging between 11–16 mm. These results indicate that the synthesized nanoparticles possess considerable antimicrobial efficacy.

Discussion

The results of the present study highlight the effectiveness of green synthesis in producing biologically active copper oxide nanoparticles. The use of *Annona squamosa* extract plays a crucial role in nanoparticle formation due to the presence of phytochemicals that act as natural reducing and stabilizing agents (5,6).

The moderate anti-inflammatory activity observed in this study may be attributed to the interaction of plant-derived compounds with inflammatory mediators. Although the activity is lower than that of standard drugs such as diclofenac, it indicates potential for further optimization (9).

The antimicrobial activity demonstrated by CuO nanoparticles is consistent with earlier studies, which report their ability to induce oxidative stress, damage microbial cell membranes, and disrupt essential cellular functions (7,10). The higher sensitivity of *Candida albicans* suggests that these nanoparticles may be particularly effective as antifungal agents.

Furthermore, green synthesized nanoparticles offer advantages such as reduced toxicity, improved biocompatibility, environmental safety, and cost-effectiveness (3,4). These features make them promising candidates for applications in nanomedicine and drug development. However, further studies are required to evaluate their toxicity, stability, and in vivo efficacy before clinical application.

Conclusion

The study demonstrates that copper oxide nanoparticles synthesized using *Annona squamosa* exhibit significant antimicrobial activity and moderate anti-inflammatory

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properties. The strong inhibitory effect against *Candida albicans*highlights their potential as antifungal agents. Green synthesis provides a sustainable and efficient approach for nanoparticle production, and further research is necessary to optimize their therapeutic applications.

References

1. Azam A, Ahmed AS, Oves M, Khan MS, Memic A. Size-dependent antimicrobial properties of CuO nanoparticles against Gram-positive and Gram-negative bacteria. *Int J Nanomedicine*. 2012;7:3527–35.
2. Ren G, Hu D, Cheng EW, Vargas-Reus MA, Reip P, Allaker RP. Characterisation of copper oxide nanoparticles for antimicrobial applications. *Int J Antimicrob Agents*. 2009;33(6):587–590.
3. Ahmed S, Ahmad M, Swami BL, Ikram S. A review on plant extract mediated synthesis of nanoparticles. *J Adv Res*. 2016;7(1):17–28.
4. Iravani S. Green synthesis of metal nanoparticles using plants. *Green Chem*. 2011;13(10):2638–2650.
5. Singh P, Kim YJ, Zhang D, Yang DC. Biological synthesis of nanoparticles from plants and microorganisms. *Trends Biotechnol*. 2016;34(7):588–599.
6. Patel S, Patel JK. A review on pharmacological and phytochemical properties of *Annona squamosa*. *Int J Pharm Sci Rev Res*. 2011;9(2):24–29.
7. Dizaj SM, Lotfipour F, Barzegar-Jalali M, Zarrintan MH, Adibkia K. Antimicrobial activity of metal oxide nanoparticles. *Mater Sci Eng C*. 2014;44:278–284.
8. Lemire JA, Harrison JJ, Turner RJ. Antimicrobial activity of metals: mechanisms and applications. *Nat Rev Microbiol*. 2013;11(6):371–384.
9. Mittal AK, Chisti Y, Banerjee UC. Synthesis of metallic nanoparticles using plant extracts. *Biotechnol Adv*. 2013;31(2):346–356.
10. Raghupathi KR, Koodali RT, Manna AC. Size-dependent bacterial growth inhibition and mechanism of antibacterial activity of zinc oxide nanoparticles. *Langmuir*. 2011;27(7):4020–4028.

10.48047/jocaaa.2025.34.02.30

11. Jayaseelan C, Rahuman AA, Kirthi AV, et al. Novel microbial route to synthesize ZnO nanoparticles using *Aeromonas hydrophila*. *Spectrochim Acta A*. 2012;90:78–84.
12. Sankar R, Manikandan P, Malarvizhi V, et al. Green synthesis of colloidal copper oxide nanoparticles using *Carica papaya*. *Spectrochim Acta A*. 2014;121:746–750.
13. Logeswari P, Silambarasan S, Abraham J. Synthesis of silver nanoparticles using plants extract and analysis of their antimicrobial property. *J Saudi Chem Soc*. 2015;19(3):311–317.
14. Sharmila G, Thirumarimurugan M, Muthukumaran C. Green synthesis of CuO nanoparticles using plant extracts. *J Mol Struct*. 2016;1125:605–611.
15. Prabhu YT, Rao KV, Kumari BS, Pavani T. Synthesis of ZnO nanoparticles by sol–gel method. *J Nanostruct Chem*. 2017;7:1–9.