

E-BOOK OF EXTENDED ABSTRACT

THE 14TH INTERNATIONAL INVENTION, INNOVATION & DESIGN COMPETITION 2025



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DESIGN COMPETITION 2025

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ANTIBACTERIAL PROPERTIES OF COPPER OXIDE AND GARCINIA ATROVIRIDIS NANOMIXTURE

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ABSTRACT

Copper Oxide (CuO) are well-known for their antibacterial properties due to their high surface area and reactivity, while *Garcinia atroviridis* is rich in bioactive compounds such as phenolics and flavonoids, which exhibit strong antimicrobial and antioxidant properties. Despite their potential, few studies have explored their combined use through physical mixing to enhance antibacterial effectiveness. This study bridges this gap by synthesising a CuO-*Garcinia* nanomixture through physical blending, characterising its structural property using X-ray diffraction (XRD) and antibacterial efficacy against *Proteus vulgaris*. XRD analysis confirmed the cubic lattice structure of CuO, with diffraction peaks at 2θ values of 35.89° , 39.00° , and 52.94° . Antibacterial activity tests showed the highest inhibition zones of 10 mm for Treatment 4 (400 mg/ml CuO + 2 mg/ml extract) followed by treatment 3 and 2. Treatment 1 given the lowest zone of inhibition with 5 mm only with combination of (100 mg/ml CuO + 2 mg/ml extract). The combination of CuO and *Garcinia atroviridis* extract enhances antibacterial activity, likely due to the synergistic effects of CuO's structural properties and the bioactive compounds in *Garcinia*. The findings highlight the potential of this combination as an alternative antimicrobial agent, which could be further optimised for applications in biomedicine and food preservation.

Keywords: Copper oxide, *Garcinia atroviridis*, X-ray Diffraction (XRD) and antibacterial properties

1. INTRODUCTION

Copper oxide (CuO) is widely studied for their strong antibacterial properties, as they can generate reactive oxygen species (ROS), disrupt bacterial membranes, and damage proteins and DNA (Ren et al., 2020). Copper has been used for sterilisation and infection treatment since ancient times (Chaturvedi & Henderson, 2014). However, high concentrations of CuO can be toxic, which limits their use in medical applications (Gudkov et al., 2024). To overcome this, researchers are exploring natural plant extracts to enhance antibacterial effects while reducing toxicity (Chan et al., 2024). One such plant is *Garcinia atroviridis*, a tropical fruit rich in phenolics and flavonoids, known for its antioxidant and antimicrobial properties (Abdullah et al., 2013; Chatatikun et al., 2020). Traditionally, *Garcinia atroviridis* has been used as a natural preservative and antibacterial agent (Niyomdechcha et al., 2021). Despite its potential, few studies have explored the combination of CuO and *Garcinia atroviridis* extract. This study aims to determine the best formulation for maximum antibacterial activity (Sandhu et al., 2023). The structure of the optimised CuO-*Garcinia atroviridis* nanomixture was analysed using X-ray diffraction (XRD). The antibacterial effect was tested against *Proteus vulgaris*, a bacteria linked to infections. By combining CuO with *Garcinia atroviridis* extract this research aims to develop a safer and more effective antibacterial agent to help combat antibiotic resistance.

2. METHODOLOGY

2.1 Preparation of nanomixture

Subsequently, 200 mg of Copper oxide (CuO) was vigorously mixed in 10 mL of ultrapure water by vortex, and 20 mg of *G. atroviridis* extract (GAE) was added to the suspension. The mixture was agitated at room temperature for 24 hours, centrifuged at 12,000 rpm for 15 minutes. The samples were rinsed three times with distilled water, oven-dried at 60°C for 24 hours, ground with a mortar, and stored

in a microcentrifuge tube for analysis. The sample then was analysed for phase confirmation using X ray Diffraction Analysis (XRD).

2.2 Antibacterial properties

For antibacterial studies, According to Table 1, four different treatment of physical mixing CuO and GAE were prepared according to preliminary study conducted before.

Table 1 The concentrations of CuO and *Garcinia atroviridis* nanomixture in different treatments used for antibacterial activity testing

	CuO (mg/ml)	<i>G. atroviridis</i> extract (mg/ml)
Treatment 1	100	2
Treatment 2	250	7
Treatment 3	250	14
Treatment 4	400	2

To assess antibacterial activity, the agar disc diffusion method was used following Ammer et al. (2016). First, 100 μ L bacterial inoculum (*P. vulgaris*) was spread evenly on sterile agar. Next, filter paper discs (6 mm in diameter) were each soaked in one of the following: negative control (distilled water), positive control (CuO), or Treatment 1 mixture. These discs were then placed onto the inoculated agar surface, with separate plates used for each treatment set. The plates were incubated at 37°C for 2 days. Antibacterial activity was determined by measuring the diameter (in millimeters) of the inhibition zones around each disc. Controls include distilled water (negative) and copper (positive).

3. FINDINGS

3.1 XRD analysis

Figure 1 represents the diffraction pattern of CuO with *Garcinia atroviridis* in which the peaks at 2θ value of 35.89°, 39.00° and 52.94° correspond to (-111), (111) and (112) planes respectively, confirming the cubic lattice of copper. The very intense peaks indicate the highly crystalline nature of the sample and the significant broadening of peaks attributed to the nanocrystalline nature of particles (Ahmad, 2018).

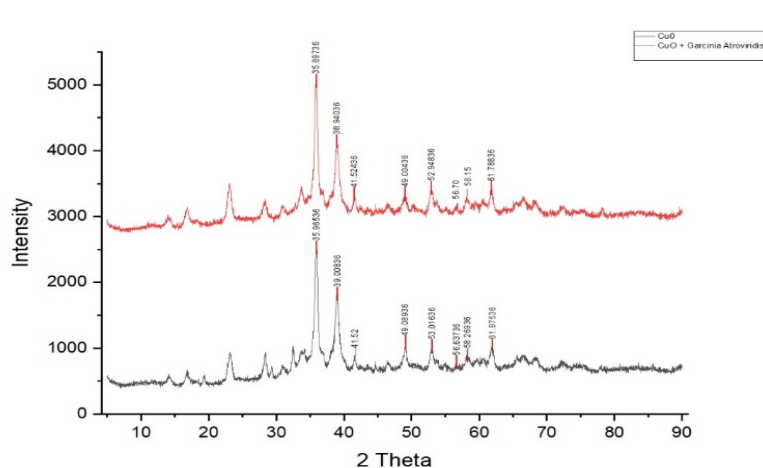


Figure 1 XRD diffraction patterns of CuO nanoparticles and CuO-*Garcinia atroviridis* nanomixture.

The antibacterial activity of CuO-*Garcinia atroviridis* nanomixtures against *P. vulgaris* showed a dose-dependent effect, with higher concentrations yielding greater inhibition zones. As shown in Table 1, Treatment 4 (400 mg/ml CuO + 2 mg/ml extract) exhibited the highest inhibition zone (10 mm), while Treatment 1 (100 mg/ml CuO + 2 mg/ml extract) showed the lowest (5 mm). This suggests a synergistic effect between CuO nanoparticles and *Garcinia atroviridis* bioactive compounds, such as flavonoids and phenolics, which may contribute to bacterial membrane disruption and reactive oxygen species (ROS) generation.

Table 1 The inhibition zones (mm) of different CuO-*Garcinia atroviridis* treatments against *P. vulgaris*

	Inhibition zones (mm)
Treatment 1	5
Treatment 2	7
Treatment 3	6
Treatment 4	10

The nanocrystalline nature of CuO enhances its surface area, promoting stronger interactions with bacterial cells. *Garcinia atroviridis* extract may further enhance this effect by interfering with bacterial metabolism, leading to cell damage. These findings align with previous research where *Garcinia atroviridis* extracts exhibited moderate to strong antibacterial activity, suggesting that the CuO-extract combination holds potential for enhanced efficacy.

4. CONCLUSION

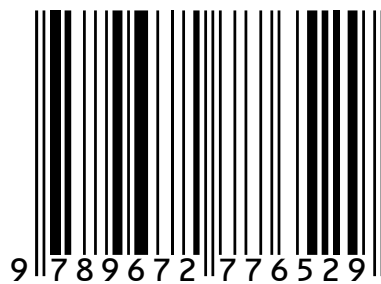
The combination of CuO and *Garcinia atroviridis* extract exhibits antibacterial activity against *Proteus vulgaris*. The structural analysis confirmed the crystalline nature of CuO, which, along with bioactive compounds from *Garcinia atroviridis*, likely contributed to bacterial inhibition. These findings highlight the potential of CuO-extract nanomixtures as an effective antibacterial agent, though further studies are needed to optimize formulations and explore broader applications.

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