

COPPER NANOPARTICLES (CUNPS) FROM CITRUS (KINNOW) WASTE AND THEIR ANTIBACTERIAL ACTION AGAINST CANKER-CAUSING *XANTHOMONAS CITRI*

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Abstract

Biologically synthesized nanoparticles are emerging as attractive alternatives to chemical pesticides due to the ease of their synthesis, safety, and antimicrobial activities in lower possible concentrations. In the present study, we have synthesized copper-based nanoparticles (CuNPs) using the aqueous extract of the citrus peel and tested them against the plant pathogenic bacterium *Xanthomonas citri*, the causative agent of citrus canker, via an *in-vitro* experiment.

Citrus (Kinnow) peel and rag after oven drying were subjected to prepare a peel extract in distilled water and purified by centrifugation. Anhydrous copper sulfate was supplemented to peel extract and CuNPs were synthesized by treating with 0.1 M NaOH/0.05 M H₂SO₄. The synthesized copper nanoparticles were characterized by techniques such as UV-Vis spectroscopy, energy-dispersive X-ray spectroscopy, and X-ray diffraction analysis. Moreover, the extracts were investigated for total phenolics by Folin Ciocalteu assay, total flavonoids by Aluminum chloride colorimetric assay, and antioxidant activity by DPPH assay, as well as antibacterial potential using the disc diffusion plate method.

The results confirmed the synthesis of centered cubic, spherical-shaped, and crystalline nanoparticles using standard characterization techniques. A qualitative and quantitative phytochemical analysis revealed the presence of phenolics (153.14 mg GAE/g) and flavonoids (34.2 mg QE/g). Different concentrations (1000 µg/mL to 15.62 µg/mL - 2-fold dilutions) of CuNPs and peel extract (PE) alone, and both in combination (CuNPs-PE), exhibited a differential inhibition of *X. citri* in a high throughput antibacterial assay. Overall, CuNPs-PE was superior in displaying significant antibacterial activity, followed by CuNPs alone. A remarkable anti-oxidant potential was observed along with excellent antibacterial activity. The observed antibacterial and antioxidant potential may be attributed to eight phenolic compounds identified in the extract.

The citrus peel-extract-induced synthesized CuNPs exhibited strong antibacterial activity against *X. citri*, which could be exploited as an effective alternative preparation against citrus canker.

Key words: Citrus immunity, Citrus infections, Green synthesis, Kinnow, Nano-formulations.