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SYNTHESIS OF COPPER NANOPARTICLES USING *CURCUMA LONGA* (TURMERIC) ROOT EXTRACT AND EVALUATION OF ITS ANTIMICROBIAL POTENTIAL

Shruti Vaidya and Mili Thakkar
Sevadal Mahila Mahavidyalaya, Nagpur, INDIA
Corresponding Email:- shrutikanhere1996@gmail.com

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ABSTRACT:
Turmeric, scientifically known as Curcuma longa, is widely recognized for its medicinal properties, primarily due to the active compound curcumin. The potent reducing and stabilizing characteristics of curcumin make it an ideal candidate for the synthesis of nanoparticles. Numerous studies have demonstrated the use of Curcuma longa extracts as a green, simple, and cost-effective approach to producing copper nanoparticles (CuNPs). Research presented here indicates its phytochemical and antimicrobial properties which help in therapies. Copper nanoparticles are among the most promising agents in nanotechnology, with a wide range of applications across various fields. Copper, an inorganic material known for its safety to humans, is extensively used as an antibacterial, antifungal, and anticancer agent, as well as in catalysts and sensors, particularly in its nanoscale form. This review focuses on the biogenic synthesis of copper nanoparticles (CuNPs) using plants and microorganisms, exploring the reaction conditions, characterization techniques, and various applications

Keywords: - Copper, Nanoparticles, Curcuma longa, Toxicity, Metal.

INTRODUCTION :

Turmeric, scientifically called *Curcuma longa*, is renowned for its therapeutic properties, primarily due to its active compound, curcumin. The active ingredients in Curcuma longa work as reducing agents, helping to stabilize nanoparticles and turn copper ions into a solid form. (Berliner 2013)

The discovery of nanomaterials in the 21st century is regarded as one of the most significant scientific advancements, evident from the extensive global research in this field. Conventional nanoparticle synthesis methods—such as sonochemical reduction, thermal deposition, chemical reduction, and microwave techniques—often rely on hazardous chemicals and harsh reaction conditions. In response, research has increasingly focused on the green synthesis of nanoparticles as a safer and more sustainable alternative. (S. harne 2012)

Turmeric (*Curcuma longa*) is a flowering plant commonly used in food products and known for its wide range of medicinal properties. Curcumin, the active compound in turmeric, has demonstrated antimicrobial effects, particularly against fungi-related spoilage and microbial infections. The medicinal benefits of *C. longa* include insecticidal, antibiotic, antifungal, antimalarial, antiviral, and antioxidant activities. Avanco GB, 2016). In addition, turmeric is a powerful anti-inflammatory, easing conditions such as bursitis, arthriti and back pain. Turmeric's anti-inflammatory action is likely due to a combination of three different properties. (Mohana Priya Karthikeyan 2022). Active functional groups in Curcuma Longa operate as reducing agents and help in the stabilization of nanoparticles, which causes the reduction of copper ions. (Berliner 2013)

Green synthesis offers several advantages, including the avoidance of hazardous chemicals, a clean and non-toxic process, environmental friendliness, easy preparation, cost-effectiveness, and better control over the size and shape of nanoparticles. Copper is one of the most widely used materials in the world and is present in both

plant and animal tissues. Curcumin has antioxidant, anti-inflammatory, antiviral, and antifungal properties. Studies have also demonstrated that curcumin is non-toxic to humans. (Senthil Kumar Raju 2022)

In recent years, the application of nanoparticles (NPs) in medicine has been increased and expanded to the fields of molecular imaging, drug delivery, diagnosis and treatment of cardiovascular diseases, wound healing, development of materials and medical devices with antimicrobial properties (Anbarasu, *et al.*,2018)). Nanoparticles are useful for delivering medications to the target specific locations. Interaction of the nanoparticles with humans and the diversity of organisms in an environment is an essential thing to be considered. (Senthil Kumar Raju 2022)

Scientific Classification of *Curcuma Longa*

Kingdom	Plantae
Subkingdom	Tracheobionts
Super Division	Spermatophyta
Division	Mangoliophyta
Order	Zingiberaceae
Genus	Curcuma
Species	Longa
Scientific name	*Curcuma Longa*

Green synthesis offers several advantages, including the avoidance of hazardous chemicals, clean and nontoxic processes, environmental friendliness, ease of preparation, cost-effectiveness, and precise control over nanoparticle size and shape. Among various metal nanoparticles, copper nanoparticles (Cu NPs) have garnered significant attention due to their remarkable antifungal and antibacterial properties. (N. Jayarambabu 2019). According to the U. S. EPA (United States Environmental Protection Agency), copper is the only solid surface material that destroys microorganisms. Due to the fascinating physical, optical and electronic properties, it is subjected to the intense research of nanoscience. (Anandakumar Karunakaran 2022)

REVIEW OF LITERATURE :

Soundarya Murugesan (2023) conducted a study on green synthesis of Copper Nanoparticles using Curcuma longa (L.) and Azadirachta indica (L.) and their Antibacterial Activity. The research found that the selected plant nanoparticles, along with their plant compounds, exhibited excellent antibacterial activity, which is particularly promising for industrially important compounds. N. Jayarambabu, A. Akshaykranth, T. Venkatappa Rao, K.Venkateswara Rao, R. Rakesh Kumar (2019) conducted the study on the green synthesis of metallic nanoparticles can be considered as an alternative method to avoid the usage of hazardous compounds and bitter reaction conditions in the production of metal nanoparticles. The synthesized Cu NPs, with their unique structural properties and effective biological effects, have potential applications in antimicrobial, antifungal, and anticancer treatments. The C. longa extract-capped Cu NPs demonstrated strong antibacterial activity against both Gram-positive and Gram-negative microorganisms. These Cu NPs can serve as highly effective antibacterial additives in textile coatings, disinfectants, and antiseptic creams, with potential uses in industries such as food, healthcare, and cosmetics.

Senthil kumar raju, anandakumar karunakaran, shridharshini kumar, Praveen sekar, maruthamuthu Murugesan, mohanapriya karthikeyan (2022) conducted a study on the biogenic synthesis of CuNPs using plants and micro-organisms, reaction conditions, characterization techniques and their applications Copper nanoparticles synthesized through biological methods exhibit a range of activities, including antioxidant, anticancer, antibacterial, antifungal, antidiabetic, antinociceptive, and cutaneous wound healing properties. The limitations, such as the impact of

precursors, extracts, as well as factors like time and temperature, are also discussed.

Engku Noradila ,Zulaika Engku Razali , Siti Amira Othman (2023) conducted the study on the synthesised nanoparticles, including Ultraviolet-Visible Spectroscopy (UV-Vis), Fourier Transform Infrared Spectroscopy (FTIR) and Scanning Electron Microscopy (SEM) were used to study the copper nanoparticles (CuNPs). The potential applications and associated concerns, including the hazards of CuNPs, are also discussed.

Sandhuli S. Hettiarachchi (2021) conducted study on the synthesized nanoparticles of curcumin, nanocurcumin without using nanocarriers. To achieve this, curcumin was extracted from raw turmeric rhizomes using the Soxhlet method. The study concluded that the particle size of nanocurcumin increases with the flow rate and curcumin concentration in the stock solution, while it decreases with longer sonication time. TEM and SEM images revealed that the nanoparticles have a spherical shape with a smooth surface, and their size ranges between 100 and 200 nm.

Tahereh Haghighi (2024) conducted a study on biochemical synthesized copper nanoparticles from methanolic extract of Curcuma longa on an Ag(I) salophen Schiff base complex. This study aims to explore the potential of nanoparticles in addressing this issue, as their activities vary based on factors such as size, shape, charge, and surface area.

Chirag Makvana, Faruk Arodiya and Kokila Parmar (2021) conducted the study on technology, and the Copper nanoparticles, ranging in size from 10 to 100 nm, exhibit both antibacterial and antioxidant activities, suggesting their potential application in healthcare, clinical, and pharmaceutical fields. The synthesized CuNPs were further functionalized with PVP to enhance biocompatibility, without introducing any harmful or toxic substances. UV-visible spectroscopy confirmed the formation of CuNPs, as evidenced by the color change in the plant component absorption on the copper nanoparticles.

RESULT :

The TEM image of the Cu NPs at high magnification reveals that the particle size, measured from the image, ranges between 5 and 20 nm.[1] The synthesized CuNPs exhibited inhibition zones of 3.45±0.34 mm and 4.67±1.14 mm when applied at concentrations of 10 µg/mL and 20 µg/mL, respectively.

The UV absorption spectra of Cu NPs dispersed in an ethanol solution show a maximum absorbance at a wavelength of 524 nm. The diameter of the zone of inhibition indicates the susceptibility of microorganisms. Gram-positive bacteria exhibited a larger zone of inhibition compared to Gram-negative bacteria, suggesting that Gram-positive bacteria are more susceptible to Cu NPs than Gram-negative bacteria. Similar results were observed in terms of antibacterial activity.

DISCUSSION :

We present a simple and cost-effective green synthesis method for copper nanoparticles (CuNPs) using *C. longa* plant extracts as reducing agents. The synthesized CuNPs, in combination with the plant extracts, have the potential to act as effective antifungal agents against various pathogens. The antifungal activity of the samples was comparable to that of the positive control. Similar findings were reported, where significant antifungal activity was attributed to C. longa. In their study, promising antifungal effects were observed with the alcohol extract of C. longa against various species.

The resulting Cu NPs are spherical, crystalline in structure, and have an average size ranging from 5 to 25 nm. The *C. longa* extract acts as a capping agent, enhancing the antibacterial properties of the Cu NPs, which show significant activity

against both Gram-positive and Gram-negative bacteria.

CONCLUSION :

The present conclusion highlights the presence of active antibacterial compounds in medicinal plants, such as *C. longa* (L.). The synthesized particles are spherical and crystalline, with average sizes ranging from 5 to 25 nm. The *C. longa* extract-capped copper nanoparticles (CuNPs) have demonstrated significant antibacterial activity against both Gram-positive and Gram-negative microorganisms.

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