Free Radical Scavenging Activity of Copper Nanoparticles Synthesized from Dried Ginger

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Authors’ contributions

This work was carried out in collaboration among all authors. Author RSD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MJ and SP managed the analyses of the study. Author SR managed the literature searches. All authors read and approved the final manuscript.

ABSTRACT

Nano science is considered to be an important area in research in which developing nontoxic, reliable and ecofriendly synthesis of nanoparticles by the green approach has a vital part. Nanoparticles that contain antimicrobial and antioxidant properties are considered to be a new trend for developing therapeutic agents that help in killing drug resistant pathogenic microorganisms. The present study is focused on discovering the antioxidant properties of copper nanoparticles synthesized from dried ginger. Dried ginger is a traditional medicine used widely and has shown to possess good antioxidant and antimicrobial properties. The phytochemical compounds of dried ginger can act as a reducing agent to synthesize copper nanoparticles. Copper nanoparticles were preferred for this study as it has unique physical and chemical properties. There

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are various methods used to synthesize nanoparticles and here in this study we have used the green synthesis method for synthesizing the copper nanoparticles. The copper nanoparticles were characterized by UV-vis spectroscopy and its antioxidant property was evaluated by DPPH assay.

**Keywords:** Antioxidant property; copper nanoparticles; dried ginger; green synthesis; UV-vis spectroscopy.

1. INTRODUCTION

In this modern period, nanoscience and nanotechnology are growing branches of science that deal with various processes like fabrication and characterization of different nano metals and non-metal of different sizes, shapes and compositions. Among the different nanoparticles present, copper nanoparticles (CuNPs) are mostly used as they are simple to produce by reducing copper ions that are present in the aqueous solution of copper sulphate. Further it has various other uses like an antibiotic and an antifungal agent and thus showing antimicrobial activity in treating wounds [1]. Nanoparticles are the particles with size ranging from 1 nm to 100 nm providing solutions to environmental and technological challenges and applied in almost all the fields. The copper nanoparticles because of their unique physical and chemical properties, low cost preparation and less toxic nature have been a great interest to researchers and have become an active area in the academic field and most importantly in the field of nanoscience and technology [2]. Nanotechnology is mainly used to produce and process products eco-friendly and to minimize the use of hazardous environment.

Green chemistry is known as implementation, development and designing of chemical products and making it eco-friendly and biocompatible to be used in medicine and food industry. It was found to be more suitable than other methods such as chemical reduction, electrochemical reduction, photochemical reduction, heat evaporation etc. as it was cost effective, simple, compatible, use of less temperature and less toxic materials. In this method, the plant extract is used both as a capping and reducing agent for synthesizing the copper nanoparticles because of the presence of reducing properties in the leaf extract [3].

The most common antimicrobial and antioxidant agents used in food are the spices in addition to giving taste to food. The scientific name of Ginger is *Zingiber officinale* which belongs to the *Zingiberaceae* family that consists of 800 species. Ginger contains certain active components like curcumin, 6-gingerol, 6-shogaol and 6-paradol. It is considered to have antibacterial and antioxidant properties and hence chosen for this study to synthesize nanoparticles from this. Nanoparticles containing antioxidant and antimicrobial property are considered as a new trend of medicinal and therapeutic agents and even in the prevention of deterioration of food and pathogenic microorganisms [4].

Copper, a transition metal, is the most frequently occurring element to be integrated into essential biochemical pathways [5]. The nanoparticles of metals or metal oxides that are obtained are often combined with nanocomposites. It exhibits various new characteristics and properties that a single material does not have. Copper nanoparticles has gained attention in the last 2 decades because of their simplicity nature and the property of exhibiting a range of potentially useful physical properties depending upon their size, shape and composition [6]. The natural plants have free radical scavengers which help in preventing pathologies like heart disease, cancer, arthritis and liver disease and are useful in preventing oxidative damage [7]. Strong water in copper vessels purifies water by killing some species and strains of bacteria and efficiently destroys bacteria thereby having bactericidal property [8]. Moreover, copper is an inexpensive antimicrobial agent when compared to other agents like gold and silver. It has antioxidant properties and longer shelf life when compared to other organic antimicrobial agents. The presence of these unique physical, chemical and biological properties are due to their highly unusual crystal morphology and high surface area – volume ratio [9]. Khasan et al found the consequence of altering ablation time and laser energy on synthesized copper oxide nanoparticles (CuO NPs) using laser ablation in liquid and along with it the anti-bacterial activity of these CuO NPs with or without Amoxicillin on cultures of gram positive and negative bacteria was also presented [10].

Our previous studies have also focused on similar in vitro studies [11-20]. The current investigation focussed on the dried ginger extract that was used to synthesize copper nanoparticles
(CuNPs) at various experimental conditions through green synthesis and to find if these copper nanoparticles have antioxidant properties.

2. MATERIALS AND METHODS

2.1 Plant Material and Extraction

Zingiber officinale normally called ginger was obtained from the local market and was made to dry in a shady region to finalize the moisture content. After this, they were crushed to fine powder using a grinder. Then 50 mL of water was added to 0.5 g of dried ginger in a conical flask which was then labeled and set for heating. For this heating process, the heating mantle was set to a temperature of 50 to 60°C and the time taken for this process to complete was 6-8 minutes. The solution was then filtered using a filter paper and finally the plant extract was prepared.

2.2 Synthesis of Copper Nanoparticles (CuNPs)

0.507 g of anhydrous copper sulphate and 70 mL of distilled water was added to 30 mL of plant extract that was already prepared before and found that the solution was light blue in color. The extract was then further clogged with foil paper. Using an orbital shaker, uniform dispersion was made to initiate the synthesis process and the color change of the solution was observed periodically. The product was then dried and heated in a furnace. The annealed product thus obtained was taken as the sample for this study.

2.3 Characterization of Synthesized Nanoparticles

The copper nanoparticles synthesized were measured optically using double beam UV–vis spectroscopy. It refers to absorption spectroscopy in visible ranges and directly affects the color of the chemicals present. It is mostly used in analytical chemistry for quantitative determination of different ions, compounds and biological macromolecules at different wavelengths. The synthesized CuNPs were optically measured at different wavelengths ranging from 250 nm to 350 nm.

2.4 Antioxidant Activity

DPPH radical scavenging assay was done to assess the antioxidant property of the extract. The DPPH is considered as a stable lipophilic free radical, having nitrogen at the center exhibiting purple color. The antioxidant donates an electron to the DPPH radical and the change in absorbance occurs at a wavelength of 517 nm and the color changes to pale yellow slowly.

2 mL of the synthesized CuNPs in the concentration range of 10-50 mL (5 different concentrations) were obtained by adding 50% of the methanol solution to equal volume of 0.1mM of DPPH solution at different concentrations and was incubated for 30 minutes in dark at room temperature. The absorbance was measured at 517 nm. Here the Methanol solution mixed with 0.1mM of DPPH solution was used as control and ascorbic acid was used as a standard. The IC50 value was calculated. % inhibition was calculated using the below equation:

\[
\%\text{inhibition} = \frac{\text{Absorbance of control} - \text{Absorbance of sample} \times 100}{\text{Absorbance of control}}
\]

3. RESULTS AND DISCUSSION

3.1 Visual Identification

Color change was found to be an important factor for the synthesis of CuNPs [21]. Here, the CuNPs were synthesized from dried ginger. The color change of the mixture was observed at different intervals during the incubation period. The color change occurs due to the reduction of Cu$^{2+}$ ions. The color changed from light blue to greenish blue at room temperature suggesting the formation of copper nanoparticles (Fig. 1).

Recently, interest and attention have been turned towards natural products and drugs to be used as antioxidant agents by reactions using free radicals and other reactive species. The implication of the oxidative stress in human disease etiology has made the researchers to find treatment for diseases.

3.2 UV–vis Spectroscopy

The results depend upon the presence of the color that arises during the reaction. The maximum absorption peak was at 300 nm because of excitation of the characteristic surface plasmon resonance band by the synthesized copper nanoparticles (Fig. 2). Since the dried ginger is a rich source of flavonoids and phenolics they are said to play an important role in the reduction process during synthesis of nanoparticles [4]. It was observed that with
increase in incubation time, the absorption spectrum steadily increases.

### 3.3 Antioxidant Property of Copper Nanoparticles using Dried Ginger

The odd electron molecule in the DPPH free radical gave a strong absorption at 517 nm where it turned from yellow to brown color (Fig. 3). The % inhibition for different concentrations of copper nanoparticles were calculated and is found to be maximum at 10 µl concentration (Fig. 4). This confirmed the reducing action of DPPH radical indicating its antioxidant property [22].

![Reduction process of copper nanoparticles visually identified by color change at various periods of incubation time](image1)

**Fig. 1.** Reduction process of copper nanoparticles visually identified by color change at various periods of incubation time

![UV-vis absorption spectra analyses of copper nanoparticles synthesized using dried ginger recorded as function of time](image2)

**Fig. 2.** UV-vis absorption spectra analyses of copper nanoparticles synthesized using dried ginger recorded as function of time
Fig. 3. Evaluation of antioxidant activity by DPPH assay

Fig. 4. The quality of antioxidant activity of copper nanoparticles synthesized using dried ginger

4. CONCLUSION

This study was done to find a way for a greener approach of synthesizing the copper nanoparticles using dried ginger thereby giving pharmacological evidence against the antioxidant activity. The copper nanoparticles were identified by bluish green color and the surface plasmon resonance was positioned peak at 300 nm. The copper nanoparticle synthesized using *Zingiber officinale* has potent free radical scavenging activity, hence has antioxidant property and has a wide array of medical and dental applications.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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