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Green synthesis of coffee bean and xylitol mediated Zinc oxide nanoparticles and the assessment of its antioxidant activity

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ABSTRACT

Aim: The aim of this study is to synthesize ZnO NPs from coffee beans and xylitol and evaluate their antioxidant efficacy utilizing the DPHH test.

Materials and method: DPPH assay was used to test the antioxidant activity of biogenic synthesized zinc oxide nanoparticles. Diverse concentrations (10-50 µg/ml) of coffee bean and xylitol extract interceded zinc oxide nanoparticle was mixed with 1 ml of 0.1 mM DPPH in methanol and 450 µl of 50 mM Tris HCl buffer (pH 7.4) and incubated. The percentage of inhibition was determined from the following equation, % inhibition= Absorbance of control- Absorbance of test sample × 100/ Absorbance of control

Result: Inhibition rates for zinc oxide nanoparticles made derived from a formulation of coffee bean and xylitol were 47.9% for 10 µL 60.21,% for 20 µL, 72.3% for 30 µL, 78.3% for 40 µL, and 85.7% for 50 µL. The standard showed 76.56% inhibition at 10 µL, 78.52% at 20 µL, 85.63% at 30 µL, 88.68% at 40 µL, and 93.15% at 50 µL. As a result, the highest level of inhibition, or 50 L, was found to be at higher concentration.

Conclusion: The nanoparticles exhibited substantial antioxidant activity, which could be attributed to the presence of phenolic chemicals in coffee beans. The utilization of green synthesis technologies to create nanoparticles is a viable approach to developing effective and long-lasting antioxidant medications. Further research into the potential applications and efficacy of these nanoparticles in various fields is required.

Keywords: *Zinc oxide nanoparticles, Coffee bean extract, Xylitol, antioxidant, DPPH assay*

INTRODUCTION

Nanoparticles are small particles with sizes ranging from 1 to 100 nanometers (nm)(Poole and Owens, 2003). Because of their small size, they have unique properties compared to their bulk counterparts, such as increased surface area to volume ratio, quantum confinement effects, and changed optical, magnetic, and electrical properties(Yang *et al.*, 2009). Because of these qualities, nanoparticles can be used in a variety of applications, including medicine, electronics, energy production, and environmental cleanup(Bildir, Çobanoğlu and Kaya, 2023).

Metal nanoparticles (e.g., gold, silver, zinc oxide), semiconductor nanoparticles (e.g., quantum dots), carbon nanoparticles (e.g., fullerenes, nanotubes), and lipid nanoparticles (e.g., liposomes) are just a few examples(Kad *et al.*, 2022; Kar *et al.*, 2022). Nanoparticles can be created using a variety of techniques, including chemical, physical, and biological processes.

Green synthesis strategies for the manufacture of nanoparticles have received a lot of interest in recent years due to the growing demand for eco-friendly and sustainable approaches in material synthesis(Rai and Posten, 2013). One method is to use natural plant extracts or biomolecules as reducing and capping agents in the creation of nanoparticles(Koupaei *et al.*, 2016). Coffee beans and xylitol are two examples of natural feedstock employed in the green production of nanoparticles(Abdelmigid *et al.*, 2021). Coffee beans are known to contain a variety of phytochemicals, including polyphenols, flavonoids, and caffeine, all of which have antioxidant, anti-inflammatory, and antibacterial activities(Caprioli *et al.*, 2015). Similarly, xylitol, a natural sugar alcohol, has been found to have antioxidant and anti-inflammatory effects and is commonly utilised in the food sector as a sugar alternative.

Nanoparticles have been intensively researched for their possible applications in disciplines ranging from medicine to electronics to environmental remediation(Ghorbanpour *et al.*, 2020). Their safety and potential toxicity, however, have been the subject of intense research, as their small size allows them to enter cells and tissues, potentially causing harm. As a result, determining the toxicity and biocompatibility of nanoparticles is critical before they are widely used in a variety of applications.

Of these nanoparticles, Zinc oxide nanoparticles (ZnO NPs) have received a lot of attention in recent years because of their unusual physicochemical features and possible uses in industries including electronics, cosmetics, and biomedicine(Kad *et al.*, 2022). However, traditional methods for synthesis of ZnO NPs involve the use of toxic and hazardous chemicals, which have negative environmental and human health consequences(Ganapathy and Professor & Head of Department, Department of Prosthodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Chennai, India., 2021b). As a result, developing environmentally friendly and sustainable ways to the synthesis of ZnO NPs is critical.

The green synthesis of ZnO NPs utilizing coffee beans and xylitol as reducing and capping agents has been reported in the literature in this context(Ganapathy and Professor & Head of Department, Department of Prosthodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Chennai, India., 2021a). The combination of coffee beans and xylitol not only gives a green and sustainable strategy to the synthesis of ZnO NPs, but it also has the added benefit of utilizing natural sources with possible health advantages(Ganesh and Senior Lecturer, White Lab- Material Research Centre, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences [SIMATS], Saveetha University, Chennai- 77, India., 2021). Furthermore, the antioxidant properties of coffee beans and xylitol can impart antioxidant activity to the synthesis ZnO NPs, which may be useful in a variety of biomedical applications(Lakshmi and Dean -International Affairs, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, 2021).

Therefore, the goal of this study is to synthesize ZnO NPs from coffee beans and xylitol and evaluate their antioxidant efficacy utilizing the DPHH test.

MATERIALS AND METHOD

Preparation of Coffee bean and Xylitol formulation

Coffee bean extract was prepared by mixing 1 g of freshly grounded coffee bean powder with 100 mL of distilled water. The mixture was boiled for 30 mins at 60 °C on a heating mantle. The mixture was then cooled down to room temperature and double filtered using the Whatman no.1 filter paper. 20m M Zinc nitrate was used as precursor and 5 0 mL of coffee bean extract was used as a reducing agent. The mixture was kept on a magnetic stirrer for uniform dispersion of all the contents at 600-800 rpm for 48hrs. 50mg of Xylitol powder was mixed with 10 mL of distilled water. This mixture was then mixed with the previously prepared coffee bean-zinc nitrate extract. The mixture was stirred for 2 h and UV–Visible readings were recorded, wherein a strong peak was observed at the end of 3 h. The mixture was then centrifuged at 8000 rpm for 10 min.

The sedimented pellet was double washed with distilled water and dried in a hot air oven operating at 80 °C. The brown colored powder that was obtained was then used for characterization.

FIGURE 1: Showing coffee bean and xylitol formulation.

Characterisation of Zinc Oxide nanoparticle

Crystalline nature and particle morphology of zinc oxide nanoparticles was analyzed through the Scanning Electron microscope.

Antioxidant activity

DPPH assay was used to test the antioxidant activity of biogenic synthesized zinc oxide nanoparticles. Diverse concentrations (10-50 µg/ml) of coffee bean and xylitol extract interceded zinc oxide nanoparticle was mixed with 1 ml of 0.1 mM DPPH in methanol and 450 µl of 50 mM Tris HCl buffer (pH 7.4) and incubated for 30 minutes. Later, the reduction in the quantity of DPPH free radicals was assessed dependent on the absorbance at 517 nm.

BHT was employed as control(Shunmugam *et al.*, 2021). The percentage of inhibition was determined from the following equation,

% inhibition= Absorbance of control-Absorbance of test sample × 100/

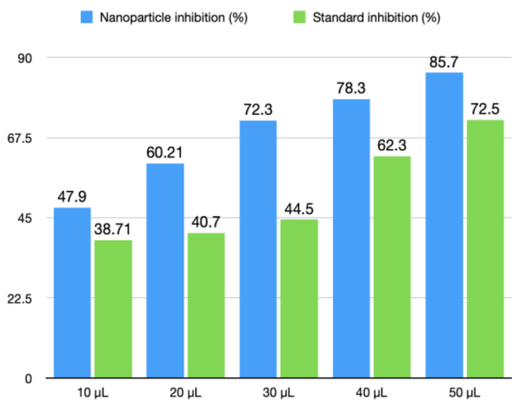
Absorbance of control

RESULTS

TABLE 2: Anti-oxidant assay showed the following values at the end of the study

S.No	Concentration (µl)	Nanoparticles (%)	Standard (%)
1	10	47.9	38.71
2	20	60.21	40.7
3	30	72.3	44.5
4	40	78.3	62.3
5	50	85.7	72.5

Inhibition rates for zinc oxide nanoparticles made derived from a formulation of coffee bean and xylitol were 47.9% for 10 µL 60.21,% for 20 µL, 72.3% for 30 µL, 78.3% for 40 µL, and 85.7% for 50 µL. The standard showed 76.56% inhibition at 10 µL, 78.52% at 20 µL, 85.63% at 30 µL, 88.68% at 40 µL, and 93.15% at 50 µL. As a result, the highest level of inhibition, or 50 L, was found to be at higher concentration.



DISCUSSION

The study's findings revealed that zinc oxide nanoparticles synthesised from a coffee bean and xylitol formulation exhibited high antioxidant activity. The inhibition rates for 10 L were 47.9%, 60.21% for 20 L, 72.3% for 30 L, 78.3% for 40 L, and 85.7% for 50 L. These findings show that the nanoparticles developed have the potential to scavenge free radicals and protect against oxidative stress. It is worth mentioning that the standard's inhibition rates were also established using the same DPPH scavenging experiment. At all concentrations examined, the standard inhibited faster than the synthesised nanoparticles. The maximum amount of inhibition, however, was detected at the highest concentrations of both the conventional and synthesised nanoparticles, showing a dose-dependent response.

The DPPH (2,2-diphenyl-1-picrylhydrazyl) scavenging assay was used to evaluate the antioxidant activity of zinc oxide nanoparticles synthesised from coffee bean and xylitol formulation(Shukla and Iravani, 2018). The DPPH assay is a popular method for determining the antioxidant capacity of natural chemicals and nanoparticles(Swathy, Roy and Rajeshkumar, 2020). It assesses a compound's ability to scavenge free radicals by transforming the purple DPPH solution into a yellow-colored solution when the DPPH free radical is decreased('Anti-inflammatory activity of silver nanoparticles synthesised using hing oil: An in vitro study', 2020).

Coffee beans are known to be high in bioactive chemicals such as caffeine, chlorogenic acid, trigonelline, and tocopherols, all of which are powerful antioxidants(*View of Anti inflammatory and antifungal activity of zinc oxide nanoparticle using red sandalwood extract*, no date). These bioactive chemicals are thought to have been absorbed into the nanoparticles during the green production of zinc oxide nanoparticles utilising coffee bean and xylitol, contributing to their antioxidant activity(Nardini *et al.*, 2002). Furthermore, zinc oxide nanoparticles have been shown to have antioxidant activity due to their ability to scavenge free radicals. Free radicals are unstable chemicals that can cause cell damage and oxidative stress, which has been linked to the development of diseases such as cancer, cardiovascular disease, and neurological disorders(Chu *et al.*, 2009).

When coffee beans and xylitol are mixed, they can form nanoparticles with improved antioxidant capabilities. The green synthesis method employed to make these nanoparticles is both environmentally benign and cost-effective. The resultant nanoparticles have a high surface area to volume ratio, allowing for enhanced free radical scavenging(Zhao *et al.*, 2008).The use of coffee bean and xylitol as a green production method for zinc oxide nanoparticles may also have contributed to their antioxidant activity. Xylitol is a sugar alcohol with antioxidant properties and the ability to scavenge free radicals. As a result, the use of coffee bean and xylitol in the synthesis process may have increased the antioxidant activity of the nanoparticles.

These nanoparticles' antioxidant properties have been investigated and proven to be effective in reducing free radical activity. They have shown significant promise in reducing oxidative damage to DNA and lipids, both of which are key markers of cellular damage. Furthermore, the nanoparticles have been discovered to be non-toxic, making them a safe option for use in a variety of applications.

CONCLUSION

In conclusion, the antioxidant efficacy of coffee bean nanoparticles can be related to the integration of bioactive chemicals derived from coffee beans, the intrinsic antioxidant activity of zinc oxide nanoparticles, and the antioxidant activity of xylitol employed in the green manufacturing process.

The nanoparticles exhibited substantial antioxidant activity, which could be attributed to the presence of phenolic chemicals in coffee beans. The utilisation of green synthesis technologies to create nanoparticles is a viable approach to developing effective and long-lasting antioxidant medications. Further research into the potential applications and efficacy of these nanoparticles in various fields is required.

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