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GREEN SYNTHESIS AND CHARACTERIZATION OF ZINC OXIDE NANOPARTICLES FROM GINGER EXTRACT IN THE APPLICATION OF WOUND HEALING IN MICE

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Abstract

Zingiber officinale, commonly known as ginger, is a widely recognized medicinal herb renowned for its diverse therapeutic properties. Phytochemical analysis reveals its rich composition, including zingiberene, bisabolene, gingerols, and shogaols, which confer anti-inflammatory, antioxidant, anti-tumorigenic, radioprotective, and antibacterial properties. Harnessing the potential of nanotechnology, ginger nanoparticles offer a promising avenue for therapeutic applications. By integrating ginger extract with silver nitrate solution, nanoparticles are synthesized and characterized using XRD, FTIR, and SEM techniques. The antioxidant activity of ginger nanoparticles is evaluated through the DPPH assay, demonstrating significant antioxidant properties. Further research is warranted to explore the diverse therapeutic uses of ginger nanoparticles, including wound healing and targeted drug delivery. Utilizing natural nanoparticles derived from ginger offers a safe and effective approach to delivering therapeutic agents, minimizing adverse effects, and enhancing medication bioavailability. This study contributes to the expanding knowledge of utilizing natural resources and nanotechnology in public health interventions.

Keywords: Public Health, Zinc Nanoparticles, XRD, FTIR, Ginger, Wound Healing.

INTRODUCTION

Ginger plants are commonly cultivated for their rhizomes. Because of its hot, spicy, and somewhat bitter flavor, fresh ginger is utilized as a flavoring factor in meals and beverages. It can, however, be utilized as a therapeutic herb (Hassan et al., 2023). Cotton, flax, and jute are among the fiber plants used to make surgical bandages (Kim et al., 2023). The green synthesis method should be utilized to synthesize zinc oxide nanoparticles entirely from ginger root extract. Nanoparticles with sizes ranging from 1 to 100 nm are particularly useful in the medical field (Andleeb et al., 2023).Due to their capacity to inhibit free radicals, relative availability, and affordability, therapeutic plants have gained favor (Anh Nga et al., 2023)(Varshan and Prathap 2022). The inquiry will concentrate on the characteristics of the metal complexes and bioactive substances that ginger extract forms. Previous research based on the in vitro testing of ginger formulations have shown that ginger has anti-inflammatory properties. Along with its already well-known benefits, ginger has also been linked to arthritis, muscle pain, menstrual pain, low back pain, chest discomfort, and low back pain. Infections in the upper respiratory tract, coughing, and bronchitis can all be treated. It is recommended for joint conditions due to its ability to reduce inflammation (Anh Nga et al., 2023;)(Prathap and Lakshmanan 2022). Angiogenesis and re-epithelialization, which include the migration and proliferation of endothelial and epithelial cells, are key components in wound healing (Mo et al., 2023). These processes are then followed by the implantation of connective tissue and wound contraction to replace the tissue structure that has been destroyed. However, the entire functionality of the repaired tissues might not be achieved. Depending on whether the repaired tissues are

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restored, a number of bioactive chemicals, including growth factors, cytokines, their receptors, and matrix components, influence wound healing (Wu, 2019). Growth hormones, matrix molecules, and inflammatory mediators are a few examples of bioactive chemicals that regulate how quickly wounds heal (Zepka et al., 2021)(USHANTHIKA and MOHANRAJ 2020).

The process of healing a wound involves numerous mechanisms, various cell reactions, and organ penetration (Barbieri & Gotta, 2023). A few days after tissue injury, the transcriptional machinery starts to mediate it. Contrary to the transcription-independent processes of the first day, during tissue injury, wounded cells create chemokines, hydrogen peroxide, lipid mediators, and injury-associated molecular patterns that activate transcription-independent pathways (Sharma et al., 2023). Inflammatory cells, particularly neutrophils, which are the main source of inflammation, are then signaled as a result (Kim et al., 2023)(Prathap and Jayaraman 2022).

MATERIALS AND METHODOLOGY

To make zinc oxide (ZnO) nanoparticles, 10 mL of ginger extract was mixed with 5 g of zinc oxide solution. This reaction solution was heated for 3 hours to produce zinc oxide nanoparticles. After 3 hours, the solution was placed in a 100°C oven for 5 hours to produce the dried precipitate(BABU and MOHANRAJ 2020). The precipitated Zinc oxide NPs were then calcined for 3 hours at 500°C. The agar well diffusion technique was used to test antimicrobial activity.

Characterization: XRD, FTIR, and SEM analyses are used to further analyze the produced zinc oxide nanoparticles.

Animal Experiment:

The wound healing experiment was investigated in the mouse model. The wound was created on the mice's skin under ketamine/xylazine (70/10 mg/kg b.w.) anesthesia. Which kept the mice unconscious for about an hour. On the wound, the ginger nanoparticle solution was applied and repeated for 7 days. On the 8th day, the animal was sacrificed, skin tissue collected and stored in 10% formaldehyde, and sent for histopathological examination.

RESULTS

The salts were insoluble in the ginger gel aqueous extracts. When ginger roots are cut, a profuse fluid containing phenolic compounds forms, which may be detected chromatographically as more than 100 major zones stained with various dyes in diverse colors. So yet, just a few of the compounds discovered in these areas have been identified as chromone, anthraquinone, or anthrone derivatives. According to chemical analysis, ginger includes a range of carbohydrate polymers, including glucomannans, as well as a number of other organic and inorganic components.

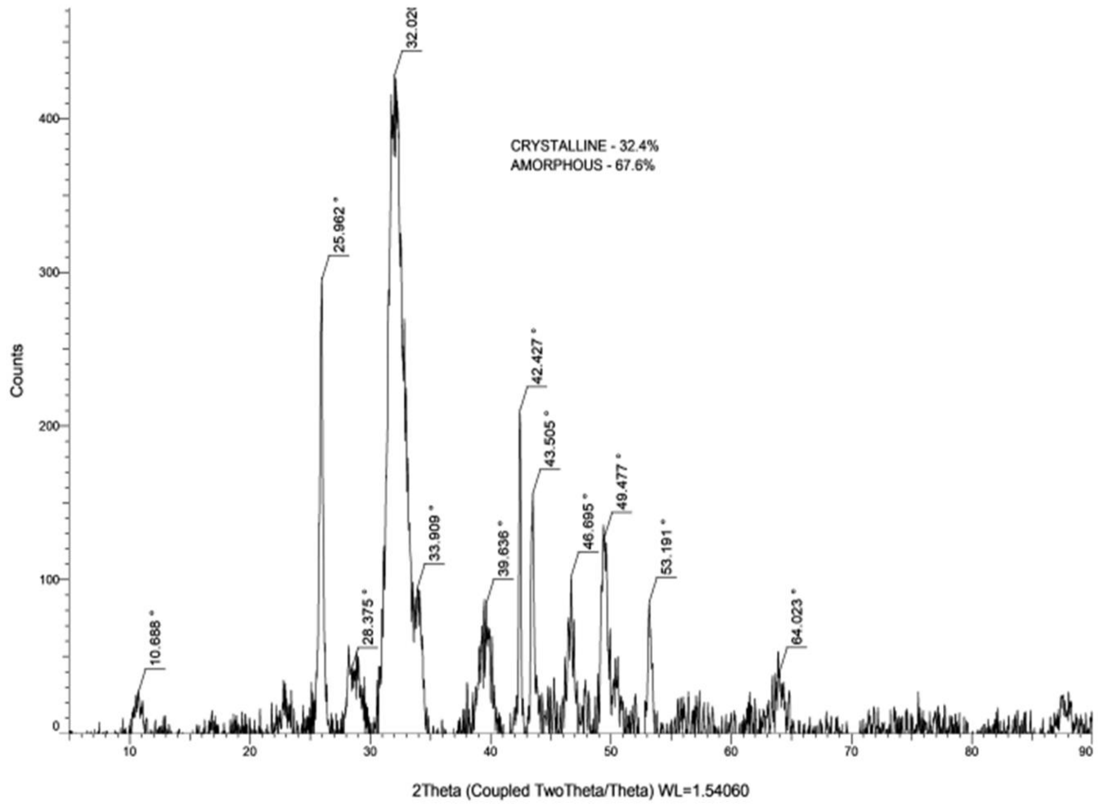

Figure 1: XRD pattern of zinc oxide nanoparticles of ginger extract.

Figure 1 represents the peaks of the crystalline nature of ginger extract with zinc oxide nanoparticles. 10.65, 25.98, 28.37, 32.02, 33.90, 39.63, 42.42, 43.5, 46.6, 49.47, 53.19, 64.2.

The term "Fourier transform infrared" (FTIR) refers to the most popular kind of infrared spectroscopy. All infrared spectroscopies operate under the premise that some IR energy is absorbed when it passes through a material.

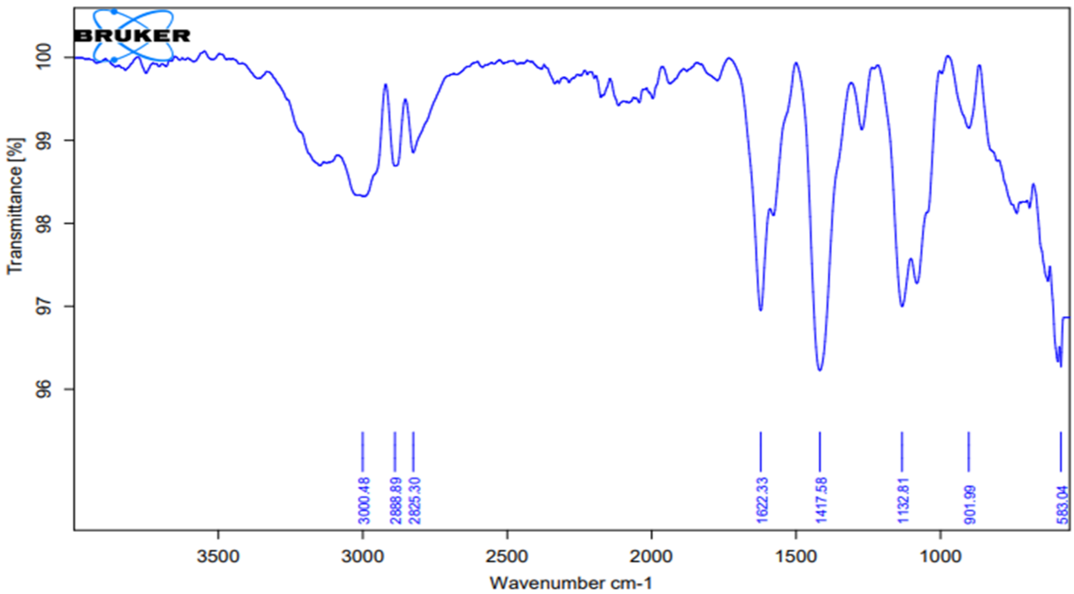

Figure 2: FTIR analysis of zinc oxide nanoparticles of ginger extract.

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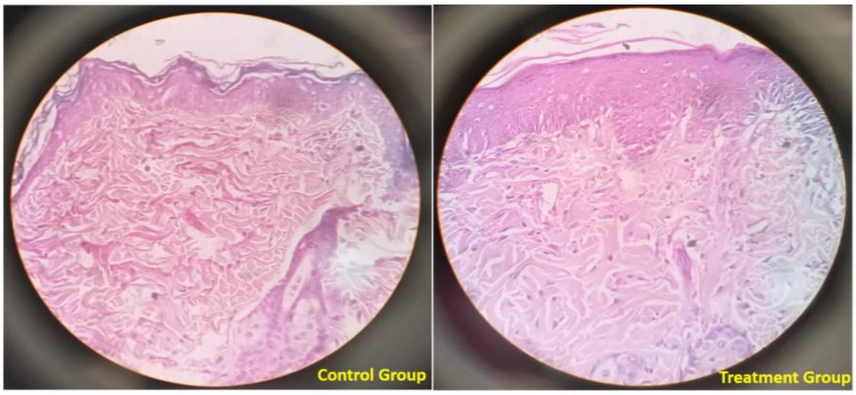
The FTIR image shows the functional groups 3000.48, 2888.89, 2825.30 , 1622.33, 1417.58, 1132.81, 901.99 and 583.04, respectively.

Figure 3: SEM analysis of ZnO and ginger nanoparticles showed a rod-shaped morphology.

Wound Healing Effect of ZnO NPs:

By treating a mouse wound, the healing capacity of ZnO and ginger nanoparticles was evaluated. The wound diameters were dramatically reduced compared to the control condition after receiving a 7-day therapy with ZnO and ginger nanoparticles. The treatment with ZnO and ginger nanoparticles was linked to the growth of new blood vessels, according to histological studies of the wound edge that demonstrated re-epithelialization.

Histopathological Analysis of wound healing in a mouse model



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DISCUSSION

There are multiple processes in the wound healing process, as well as different cellular reactions and tissue infiltration. As shown in the current study, the administration of 50 µL ginger NPs facilitates wound healing, and epithelization will be finished 7 to 15 days after application.

Figure 1 demonstrated a significant variation in the process of wound contraction, with samples demonstrating the quickest completion of wound contraction and epithelialization. Speeding up the process of wound closure and raising the expression of collagen II and III while decreasing the expression of the TGF-1 gene indicate the 50 µL sample for wound healing.

Zinc is an essential trace element that plays a crucial role in various physiological processes, including wound healing. It is known to be involved in cell proliferation, immune function, collagen synthesis, and tissue repair. When used in nanoparticle form, zinc's effects on wound healing are hypothesized to be amplified due to its increased surface area and improved bioavailability.

Studies conducted on animal models, including mice, have shown promising results regarding the potential benefits of zinc nanoparticles in wound healing. Some of the observed effects include:

Enhanced cell proliferation: Zinc nanoparticles may promote the proliferation of cells involved in wound healing, such as fibroblasts and endothelial cells, which can speed up the tissue repair process. Anti-inflammatory properties: Zinc has anti-inflammatory effects that could help reduce inflammation at the wound site, creating a more favorable environment for healing(USHANTHIKA and MOHANRAJ 2020).

Antimicrobial activity: Zinc nanoparticles may exhibit antimicrobial properties, helping to prevent or reduce the risk of infection in the wound area(Mihai, Dima et al. 2019, Divya Sri, Vishnu Priya et al. 2020).

Collagen synthesis: Zinc is involved in collagen production, which is essential for wound closure and tissue regeneration. However, it's important to note that while preliminary results from animal studies are promising, the translation of findings to human applications requires further research.

Nanoparticles, including zinc nanoparticles, have complex interactions within biological systems, and potential toxicity and safety concerns need to be thoroughly evaluated before considering their widespread use in wound healing treatments. Before any practical applications in human medicine, extensive preclinical studies and clinical trials are required to assess the efficacy, safety, and appropriate doses of zinc nanoparticles for wound healing. It's also essential to understand the potential long-term effects.

CONCLUSION

The synthesized zinc oxide nanoparticles were found to be crystalline in nature, and to have many Functional groups. The SEM images show the rod-like structures of the nanoparticles prepared. In the wound healing study, the nanoparticles were found to have a good wound healing effect.

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