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Study on Green Zinc Nanoparticles from Plant Extract and Antimicrobial Effects on Pathogen Urease-producing Bacteria

Shadab Salehpour[1], Mohammad Mojaradi[2], Batool Heydari Sadegh[3], Hossein Poormasoumi[4], Tayebeh Ahmadi[5], Narjes Dahmardeh[6], Masoomeh Aghayari[7]*, Shima Sanjari[8]* and Khadijeh Saravani[9]

[1] *Department of Pediatrics, Faculty of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[2] *Student Research committee, Faculty of Medicine, North Khorasan University of Medical Sciences, Bojnurd, Iran*
[3] *Department of Emergency Medicine, School of Medicine, Zabol University of Medical Sciences, Zabol, Iran*
[4] *Department of Infectious Diseases, School of Medicine, Zabol University of Medical Sciences, Zabol, Iran*
[5] *Department of Medical Laboratory Science, College of Science, Knowledge University, kirkuk Road, Erbil 44001, Iraq*
[6] *Department of Anatomical Sciences, Faculty of Medicine, Zabol University of Medical Sciences, Zabol, Iran*
[7] *Department of Microbiology, Faculty of Sciences, Urmia Branch Islamic Azad University, Urmia, Iran*
[8] *Department of Biology-Plant Physiology, Faculty of Science, Shahid Bahonar University of Kerman, Kerman, Iran*
[9] *Department of Community Medicine, School of Medicine Pediatric Gastroenterology and Hepatology Research Center Amir al Momenin Hospital, Zabol University of Medical Sciences*

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***Corresponding author**
shimasanjari60@gmail.com,
Masoomeh.aghayari@gmail.com

ABSTRACT

In recent years, the resistance of bacterial strains has been increasing, and effective treatment has decreased. For this purpose, researchers are looking for nanoparticles with antibacterial properties. In this experimental study, the aqueous extract of Capparis is combined with 0.1 M zinc sulfate solution to form zinc nanoparticles. The average diameter of the nanoparticles is measured by X-ray diffraction and Scanning Electron Microscopy (SEM). Then, the diameter of the inhibitory zone and the minimum inhibitory concentration against the bacterial strains are determined. The results of the study showed that the largest diameter of the inhibition zone at a concentration of 1500 µg/ml was 23 mm, and the smallest diameter of the inhibition zone at the same concentration was 7 mm. The lowest inhibitory concentration at a concentration of 750 µg/ml was 4 mm, while the largest diameter of the inhibition zone at a concentration of 750 µg/ml was 19 mm. The results of this study showed that there is a direct relationship between the concentration of nanoparticles and the elimination of bacteria, meaning that increasing the concentration of zinc nanoparticles increases the rate of bacterial killing.

Keywords: Nanoparticles, Extract plant, Pathogen, Green Synthesis, SEM

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INTRODUCTION

Bacterial resistance to antibiotics is increasing daily, indicating a slowdown in drug development in the future. Various reasons have been cited, including reduced funding for new drug discovery in universities [1]. Today, nanotechnology has shown great progress in the field of producing materials with Nano properties as well as new methods [2]. In the green method, living organisms such as microorganisms, fungi, bacteria, yeasts, and algae are used as intermediates for the synthesis of nanoparticles [3]. These nanoparticles have excellent anti-inflammatory and antimicrobial properties and have become very important in this regard [4].

Metal nanoparticles are used for biosensors, cancer treatment, and in household and industrial appliances [5]. Today, the prevalence of multidrug resistance in clinical pathogens, especially urinary tract pathogens, has increased due to the overuse of antibiotics and the accumulation of antibiotics in the environment [6]. Urinary tract infection is one of the most common urological diseases in the world, affecting many people, while the bacteria that cause this disease have shown a high resistance to antibiotics [7]. Among the bacteria that cause office infections, Escherichia coli is the most prevalent [8].

MATERIALS AND METHODS

This study was conducted experimentally over five months in 2022, focusing on urine samples obtained from 100 women diagnosed with urinary tract infections caused by Escherichia coli. Comprehensive identification tests were performed on the Escherichia coli samples to ensure accurate results [9].

In this examination, we conducted the biosynthesis of oxide nanoparticles using a shoot extract of Capparis, a medicinal plant. Zinc acetate dihydrate and sodium hydroxide were employed as precursors in the process, and the structure and morphology of the synthesized nanoparticles were analyzed (FE-SEM, X-ray) [10].

The determination of bacterial susceptibility to zinc (Zn) was carried out using the well-dilution method. The diameter of the inhibition zone at concentrations of 750-1500 and 3000 µg/ml was determined by the well method on the bacteria studied [11].

RESULTS

FTIR Results Analysis of Zinc Nanoparticles Synthesized in Capparis shoot Extract:

However, the presence of a variety of functional groups in the sample is revealed (Fig. 1).

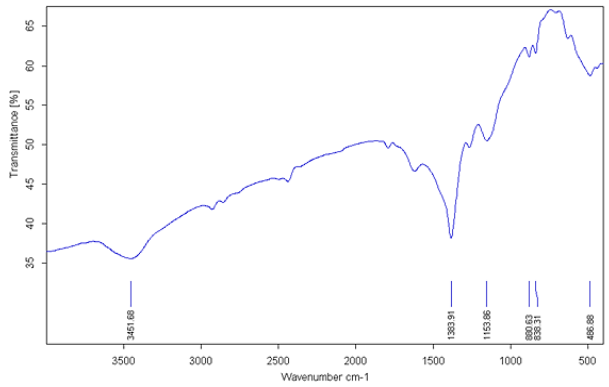

Fig. 1 FTIR analysis of caparis samples: The Fourier Transform Infrared Spectroscopy (FTIR) results obtained from seepage and extracts indicate that there is an absence of clear and distinct structural information about the compounds present. This ambiguity can arise from several factors.

Analysis XRD

The X-ray diffraction (XRD) pattern of the sample synthesized using the Capparis plant is illustrated in Figure 3. The XRD analysis revealed peaks at angles of 31.89°, 34.45°, 36.51°, 47.42°, 51.48°, 63.01°, 66.53°, 68.01°, 69.03°, and 73.04°, which affirm the successful formation of nanoparticles. No additional peaks were observed, indicating the purity of the phase Fig. 2.

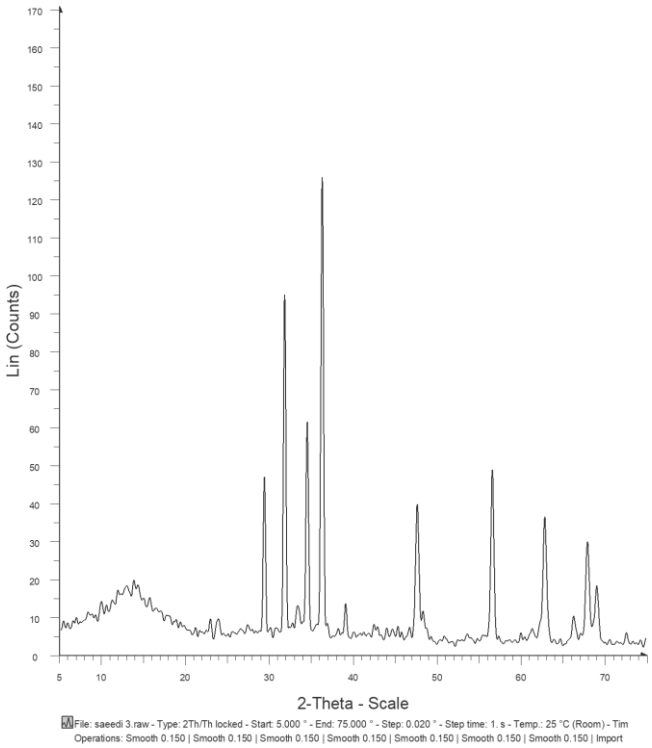

Fig. 2 XRD of Capparis

SEM Analysis

Scanning Electron Microscopy (SEM) was employed to capture images and analyze the morphology of zinc oxide nanoparticles synthesized via a green chemistry method. The SEM images revealed that the particle size was less than 234 nm, and the particles exhibited a uniform spherical shape Fig. 3.

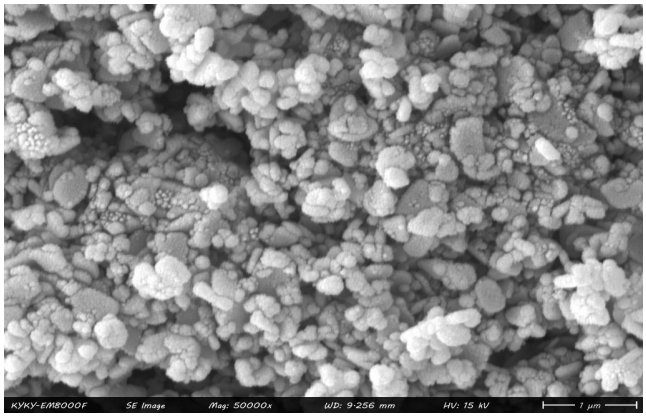

Fig. 3 Electron microscopic image of green zinc nanoparticles synthesized in Capper extract

Determination of the MIC and MBC of Synthesized Zinc Nanoparticles

The results of the study showed that the highest inhibitory concentration was 3000 µg/ml, and 9 strains were inhibited at this concentration. The lowest inhibitory concentration was 750 µg/ml, and 4 strains were inhibited at this concentration. The results also showed that the highest lethal concentration of zinc nanoparticles was 3000 µg/ml, and 11 strains were killed at this concentration.

The observations showed that the largest diameter of the inhibition zone at a concentration of 1500 µg/ml was 23 mm, and the smallest diameter of the inhibition zone at a concentration of 1500 µg/ml was 7 mm (Table 1). The results of the study also showed that the smallest inhibitory concentration at a concentration of 750 µg/ml was 4 mm. In comparison, the largest diameter of the inhibition zone at a concentration of 750 µg/ml was 19 mm (Table 1) (Fig. 4).

Table 1 Determination of the diameter of the inhibition zone at different concentrations of zinc nanoparticles on Escherichia coli bacteria (mm)

1500 Mg/ml	750 Mg/ml	Strain	1500 Mg/ml	750 Mg/ml	Strain
12	8	11 E	8	5	1 E
23	19	12 E	10	6	2 E
18	13	13 E	17	13	3 E
14	10	14 E	10	7	4 E
11	6	15 E	11	7	5 E
15	9	16 E	7	4	6 E
12	8	17 E	18	14	7 E
14	11	18 E	13	9	8 E
22	16	19 E	10	7	9 E
14	11	20 E	21	16	10 E

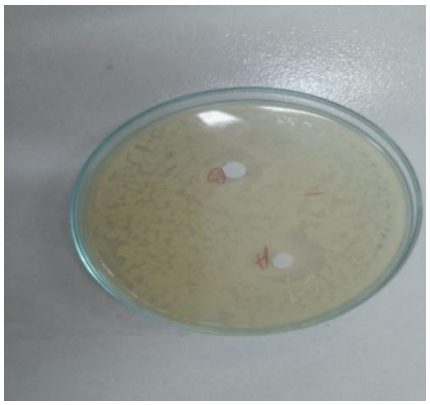

Fig. 4 Inhibition zone diameter at two different concentrations of zinc nanoparticles on Escherichia coli bacteria (a: concentration 1500 µg/ml) (b: concentration 750 µg/ml)

DISCUSSION

Bacterial infection during pregnancy has been very common, with the highest mortality rate observed between 2000 and 2008 [12]. The results of this study indicate that synthetic zinc nanoparticles have good antimicrobial effects on the pathogenic bacterium Escherichia coli. a

In a study that synthesized zinc nanoparticles in the medicinal plant Eucalyptus, the results showed that the diameter of the inhibitory zone at a concentration of 25 m b of nanoparticles against the bacteria E. coli, S. typhi, S. aureus, K. pneumonia, P. digitatum, and C. albicans [13].

In a study conducted on Escherichia coli samples from patients in Isfahan, the results showed that nanoparticles with a diameter of 20 nm caused very good inhibition of Escherichia coli bacteria, which is an effective treatment for patients [14].

Another researcher synthesized nanoparticles using the medicinal plant Eichhornia Crassipes. The results showed that the size of the produced nanoparticles was 22.89 nm, and this plant showed good antimicrobial activity against gram-positive and gram-negative bacteria [15].

In Chandra's study, zinc nanoparticles were synthesized using Berberis aristata. These nanoparticles were effective against a wide range of bacteria causing urinary tract infections [16].

The antimicrobial activity of zinc oxide nanoparticles on bacteria isolated from urinary tract infections in infants was investigated. Bactericidal effects were observed at a concentration of 0.8 mg/ml on E. coli (99%), Enterococcus faecalis (96%), and Klebsiella (90%) [17].

Kombucha extract showed the ability to make zinc nanoparticles from zinc salts and also had a minimum inhibitory concentration on Escherichia coli (25 µg/ml), Staphylococcus aureus (30 µg/ml), and Pseudomonas aeruginosa (35 µg/ml) [18].

CONCLUSION

The results of the study indicated that synthetic nanoparticles possess a significantly high capability to inhibit bacterial growth and may be applicable in the treatment of female infections.

Footnotes:

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Conflict of Interests Statement

The authors declare no conflict of interest.

Data Availability

All data analyzed are publicly available from the relevant study groups.

Ethical Approval:

The study was approved by the

Ethics Committee of Zabol University of Medical.

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