RESEARCH PAPER

Effect of Curcumin and Arabic Gum Extracts in the Preparation of Nano Zinc Oxide and Investigation of Antimicrobial Activity

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ABSTRACT

The synthesis and characterization of ZnO NPs produced with gum Arabic and curcumin extracts are the main topics of this work. Plants and zinc nitrate are the precursors. ZnO has been described using UV, FTIR, SEM, and XRD. According to the XRD data, ZnO by Curcumin had a crystalline size of 38.92 when estimated using the Scherer equation; ZnO by Gum Arabic, on the other hand, was amorphous. According to SEM, the ZnO NP sample made with curcumin showed heterogeneity in size and shape, whereas the ZnO sample made with gum Arabic showed clumped particles that were entirely covered in proteins and some that appeared as bright protrusions. The absorption peak at 578 and 574 for ZnO using Curcumin and Gum Arabic respectively corresponds to metal-oxygen (ZnO stretching vibrations) vibration mode, which authenticated the presence of ZnO. UV absorption spectrum of ZnO nanoparticles show absorbance edge near 266 and 355 nm for ZnO by Curcumin extract and ZnO by gum Arabic extract, where the energy gap was 4.6 eV and 3.5 eV respectively. The antibacterial activity of ZnO nanoparticles was evaluated at different concentration (25,50 and75%).

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INTRODUCTION

Numerous bacteria frequently result in infectious diseases that are expensive for both the economy and public health. Treatment of such illnesses becomes challenging as a result of their resistance to numerous antibiotics. Thus, in order to benefit human society, new medications or methods for inhibiting these germs must be developed. As an emerging field, nanotechnology has shown that it is possible to produce nanoparticles (NPs) in any size or shape and use them as potent antibiotics [1-3]. At the atomic level, NPs are referred to as controlled or manipulated particles (1–100 nm). High surface reactivity is a result of nanostructured materials having a higher fraction of atoms at their surface. As a result, nanomaterials have become increasingly important in bio-nanotechnology as well as the basic and applied sciences in recent years. Their size-related characteristics differ greatly from those of bulk materials. Their unique characteristic makes them potentially useful in a variety of sectors, including biosensors, nano-medicine, and bio-nanotechnology Reducing them to the nano-scale can alter their optical, structural, mechanical, electrical, morphological, and chemical characteristics. The NPs can now interact with cell biomolecules in a unique way thanks to these changed properties, which

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facilitates their physical entry into the internal structures of cells. [4-6]. Recently, there has been a lot of interest in studies on nano-scale zinc oxide materials as antibacterial agents. In comparison to other antibacterial agents, ZnO NPs is used more in the fields of medicine, environmental sciences, packaging, and photochemical activity due to its non-toxic nature, long-lasting activity, low cost, high catalytic, large excitation binding energy, UV filtering properties, and high photo stability [8,9].

There are several sophisticated physical and chemical techniques for generating ZnO NPs, but they can be costly to implement and need capping agents, hazardous chemicals and solvents, as well as a large amount of energy. Thus, using plant extracts to produce ZnO NPs would be a superior, more economical, and environmentally friendly alternative to conventional techniques of synthesizing ZnO NPs. Studies on nano-scale zinc oxide materials as antimicrobial agents have garnered a lot of interest lately. Because of its non-toxic nature, long-lasting activity, low cost, high catalytic, large excitation binding energy, UV filtering properties, photochemical activity, biocompatibility, and high photostability, nano ZnO is used more than other antibacterial agents in the fields of medicine, environmental sciences, cosmetics, and packaging [8,9]. There are several sophisticated physical and chemical techniques for generating ZnO NPs, but they can be costly to implement and need capping agents, hazardous chemicals and solvents, as well as a large amount of energy. Thus, using plant extracts to produce ZnO NPs would be a superior, more economical, and environmentally friendly alternative to conventional techniques of synthesizing ZnO NPs. Through the use of safe and environmentally friendly solvents like water and natural extracts, green synthesis techniques enable us to create materials' nanostructures with non-polluting chemicals.[10]. Curcumin belongs to the Zingiberaceae family, which includes ginger. Curcumin can be used as a food coloring and preservative because of its vivid yellow hue (see

Fig. 1. Curcumin in cases Rhizomes and rhizome powder.

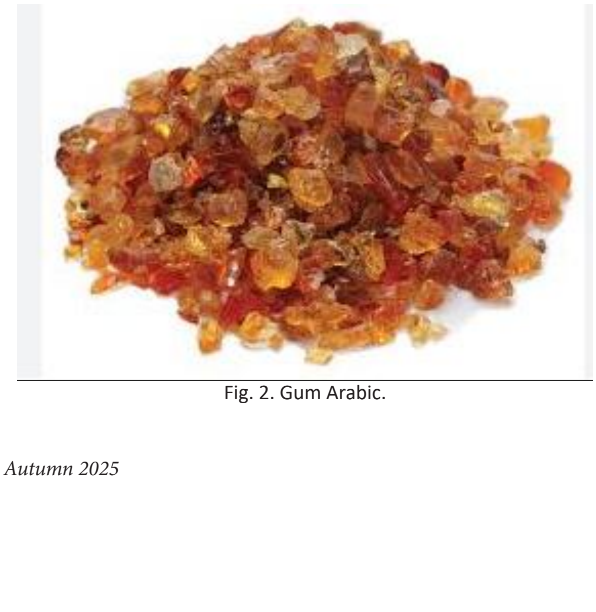

Fig. 2. Gum Arabic.

image 1). According to studies, Curcumin is longa L. has been used for a very long time in traditional medicine to treat a wide range of illnesses and conditions, such as rheumatism, sinusitis, cough, diabetic ulcers, hepatic diseases, biliary disorders, and anorexia. These benefits are due to the plant's many biological properties, which include antimicrobial, anticoagulant, anti-inflammatory, antioxidant, and immunomodulatory [11–15].

Gum Arabic, a dried exudate obtained from the stems and branches of Acacia senegal (L.) Willdenow or Acacia seyal (fam. Leguminosae), is depicted in Fig. 2. Chemically speaking, AG is a complex mixture of macromolecules, mostly proteins and carbohydrates, that vary in size and composition. Today, AG's properties and applications have been thoroughly researched and developed. It is used in many industrial sectors, such as food, encapsulating, textiles, ceramics, lithography, cosmetics, and pharmaceuticals. AG is used in pharmaceutical preparations and as a medication carrier in the pharmaceutical industry because it is thought to be a medically harmless substance. Recent research has brought attention to the antioxidant qualities of AG, its function in lipid metabolism, and its potential benefits in the treatment of a number of degenerative illnesses, including kidney failure, cardiovascular disease, and gastrointestinal disorders. Thus, there is compelling evidence that AG can have positive health-related impacts in addition to its well-known roles as an emulsifier and certain unique qualities of its antioxidant capacity against some reactive oxygen substances (ROS) and its antimicrobial activity (AMA) [16]. The purpose of this study is to examine the antibacterial properties of nano zinc oxide, which is made using gum Arabic and curcumin extracts.

MATERIALS AND METHODS

Preparation of samples

In this experiment, 0.5 M zinc nitrate was dissolved in distill water while being heated to 80C and stirred on a magnetic stirrer. The CGA sample and Curcumin were purchased from a local Baghdad, Iraqi market. 2 g of Curcumin was dissolved with stirring at 70 °C in 100 ml of distill water. After being cleaned of impurities using distillation water, the gum Arabic was allowed to air dry at room temperature. use a mortar and pestle to grind to a fine powder. AG dissolved (2g/100ml) at 70 °C using a hot plate magnetic stirrer, then filtered both solution (Curcumin and Cum Arabic) with Whatman filter paper to remove any impurities in these solutions. To create ZnONPs, as indicated in Fig. 3, Curcumin and Gum Arabic plant extract (25 mL for each 100 ml of zinc nitrate) were gradually added and continuously

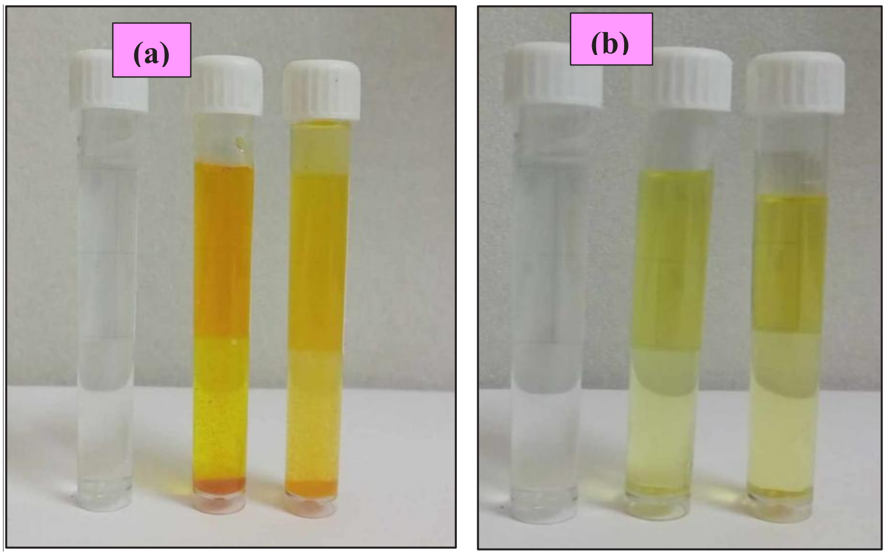

Fig. 3. Image illustration for the preparation of ZnONPs(a) from

stirred for two hours using a magnetic stirrer.

RESULTS AND DISCUSSION

Fig. 4 displays the results of an XRD examination of ZnO NPs produced by Curcumin and Gum Arabic, with 2θ ranging from 20° to 80° and Cu Kα radiation of 0.1540 nm. The (1 0 1),(201),(100),(101), and (102) reflections were found to be the XRD peaks at °22.9, 29.5, 31.9,39.0,43.0, and 48.03, respectively. Zinc, zinc hydroxide, and zinc oxide species (Zn (JCPDS 04-0831), Zn $(OH)^2$ (JCPDS 38-0385), and ZnO (JCPDS 036-1451)) were shown to be present [17, 18]. On the other hand, the ZnO sample produced using gum Arabic had an amorphous XRD pattern. There are no discernible crystalline ZnO or Zn (OH) diffraction lines. The incomplete oxidation and reduction process could account for the existence of OH and Zn.

The shape, size distribution, and morphology of ZnO nanoparticles produced by Curcumin, Gum Arabic, were further investigated using scanning electron microscopy (SEM). The SEM images of the particles from the Curcumin and gum Arabic preparations are displayed in Fig. 5a and 5b, respectively. The ZnO NP sample produced with Curcumin exhibited variability with respect to both form and size (Fig. 5a). The ZnO NPs that were obtained had a size range of 33.32 nm to 108.48 nm. On the other hand, the ZnO sample prepared by gum Arabic showed a picture of clumped particles entirely covered in proteins, with some particles showing as bright protrusions. Fig. 5b illustrates how some clumped particles can reach diameters of up to 422 nanometers.

The different distinctive functional groups connected to the generated nanoparticles were identified using FT-IR analysis of the synthesized ZnONPs, as illustrated in Fig. 6. The stretching vibration of hydroxyl compounds is responsible for the absorption peaks in the 3309 cm-1 range. The stretching vibration of C=C is the cause of the absorption peaks at 1634 and cm−1. Only in the sample Curcumin does the signal at 1350 cm-1 match to primary and secondary alcohol. The presence of ZnO was confirmed by the absorption peak for ZnO utilizing Curcumin and Gum Arabic, which correspond to the metal-oxygen (ZnO stretching vibrations) vibration mode at 578 and 574, respectively [19, 20].

ZnO nanoparticles produced by gum Arabic extract and Curcumin underwent optical absorption and optical energy band gap studies. Fig. 7 illustrates how the optical absorbance varies between 200 and 1100 nm at wavelength. A shorter wavelength has been used to obtain the absorption edge. The nanoparticles' quantum confinement may be the cause of the absorption spectrum's widening. The ZnO nanoparticles exhibit strong blue emission and high crystallinity, making them suitable for use in optical systems.

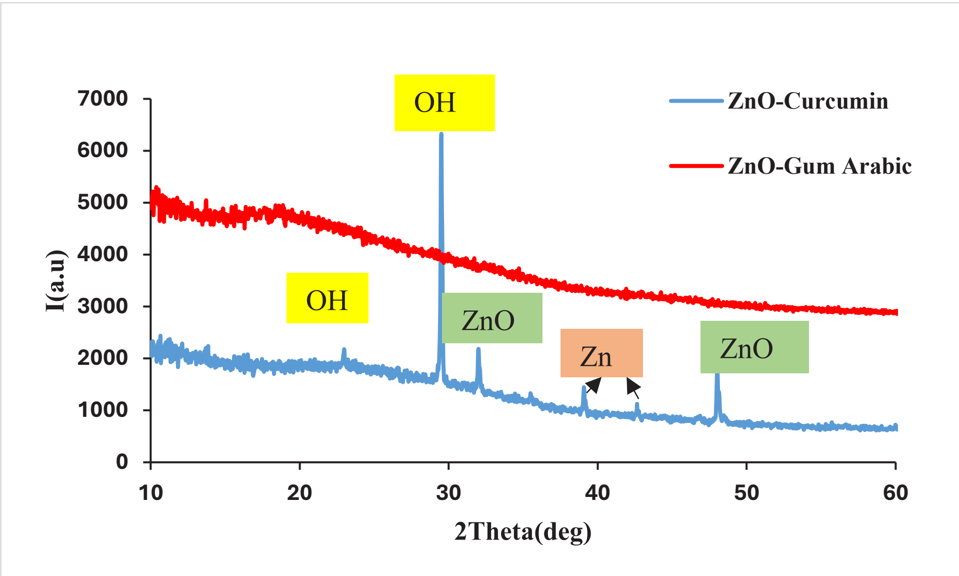

Fig. 4. XRD spectra of ZnO film.

ZnO nanoparticles' UV absorption spectra reveal an absorbance edge at about 266 and 355 nm for ZnO derived from Curcumin extract and ZnO derived from gum Arabic extract, respectively, with an energy gap of 4.6 eV and 3.5 eV[21–23]..

Using the agar disc diffusion method, the antimicrobial activity of ZnO NPs synthesized from Curcumin and gum Arabic extract was assessed based on the inhibition zones against a variety of organisms, including S. aureus and Streptococcus and E. coli and Klebsiella , at varying concentrations of 25, 50, and 75%. The findings verify that the various ZnO NP concentrations were successful in preventing the test pathogen from growing, as indicated by (Figs. 8, 9 and Table 1). It note that the control well by Curcumin and gum Arabic recorded an effectiveness of up to 10 mm, which indicates the possibility of using extracts against bacterial inflammation and increasing their effect in the presence of nanoparticles. The highest inhibition area for zinc oxide prepared using turmeric was recorded at a concentration of 75% was 17 mm for negative bacteria (Klebsiella Sp.). As for zinc oxide prepared with gum Arabic, the highest value was

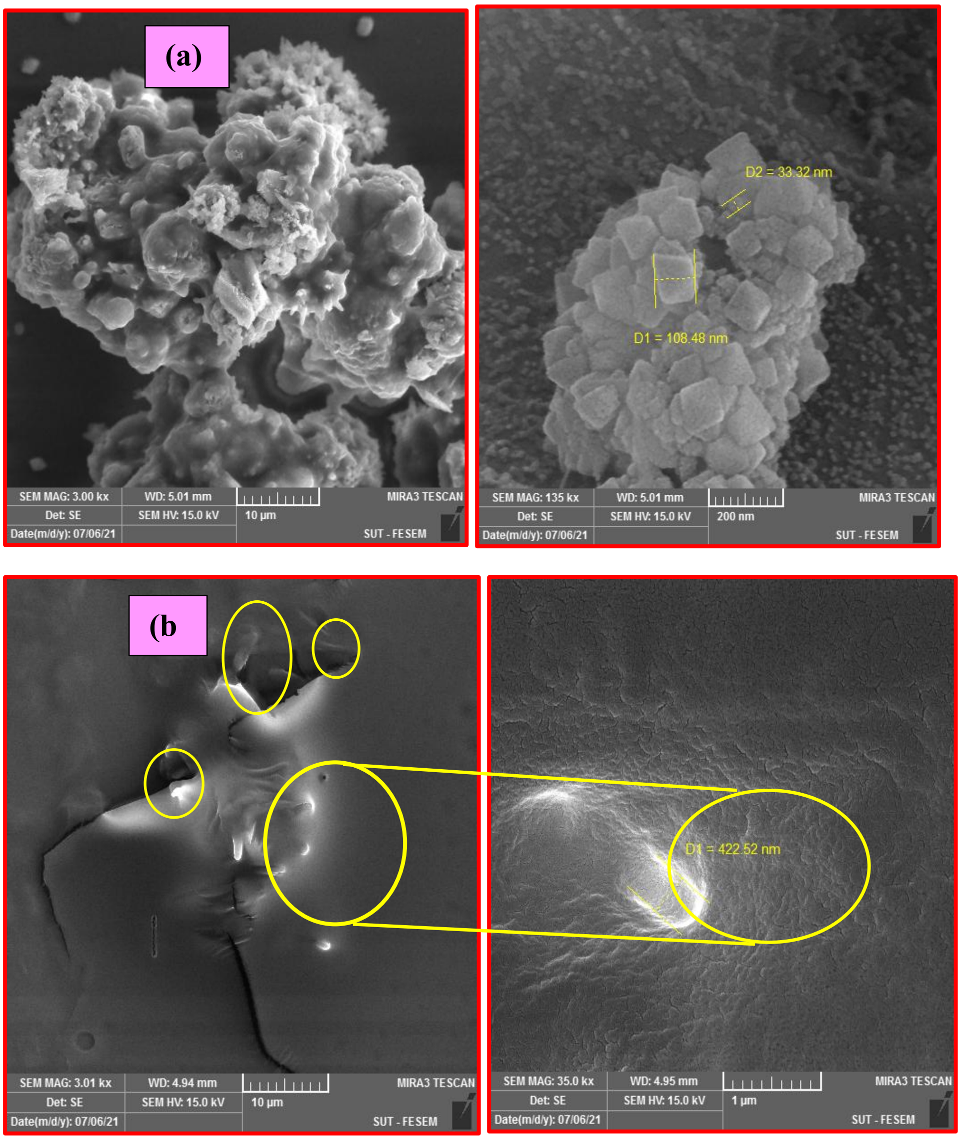

Fig. 5. a,b) SEM of ZnO film.

also recorded at a concentration of 75%, which is 16 mm for negative bacteria (Klebsiella Sp.). Furthermore, it is shown that negative bacteria (Klebsiella Sp.) are more vulnerable to ZnO NPs than positive gram-negative bacteria, and that the inhibitory areas expand with increasing

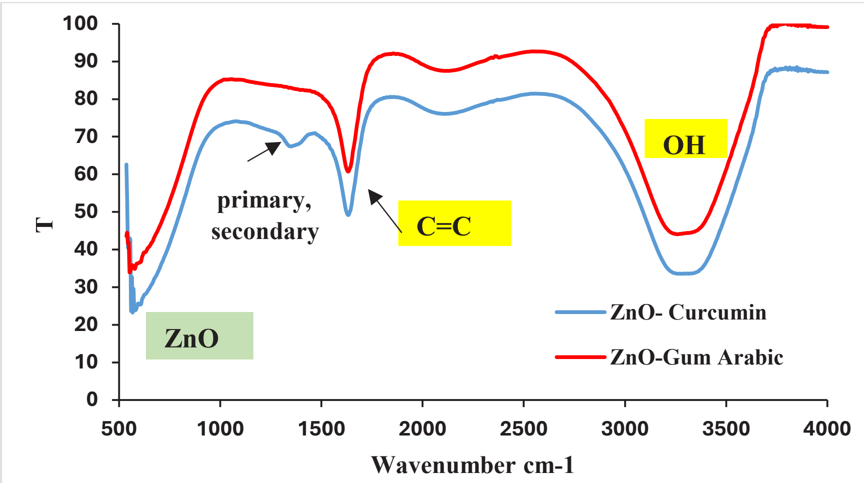

Fig.6. FTIR of ZnO colloidal.

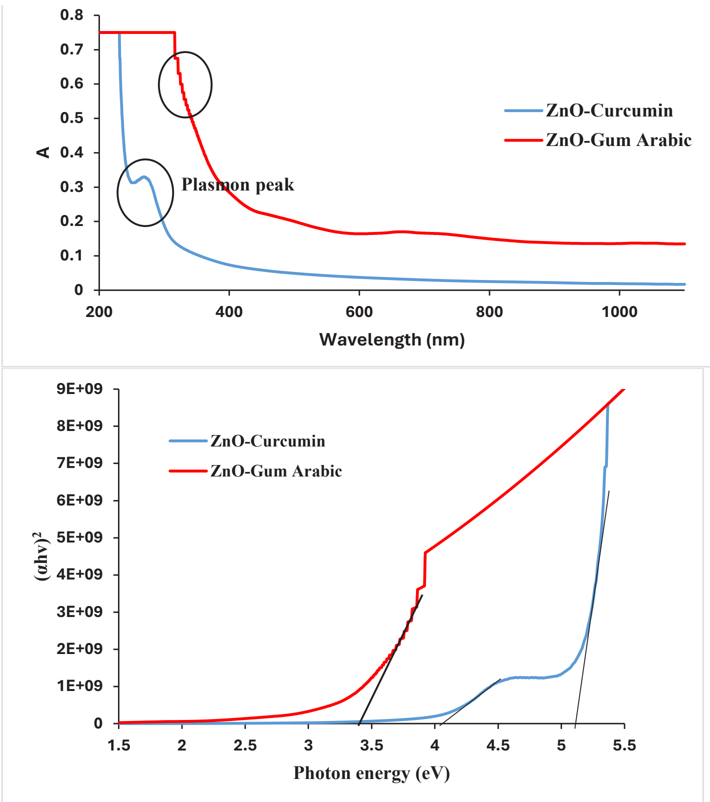

Fig. 7. Optical properties of ZnO colloidal.

concentration. The thick coating of peptidoglycan surrounding the cell walls of positive bacteria may account for their resistance to ZnO NPs [46]. Because ZnO NPs emit reactive oxygen species (ROS) from their surface, including hydroxyl radicals (OH-), peroxide (O_2^{2-}), and hydrogen peroxide (H_2O_2), they have potent antibacterial effects. In addition, Zn^{2+} ions bind to the bacterial cell wall's surface, disrupt the permeability of the bacterial cell membrane, and influence the metabolism of amino acids. Furthermore, Zn^{2+} ions inhibit the growth of microbes by reacting with some of the recognized energy groups of proteins, nucleic acids, and biological enzymes.

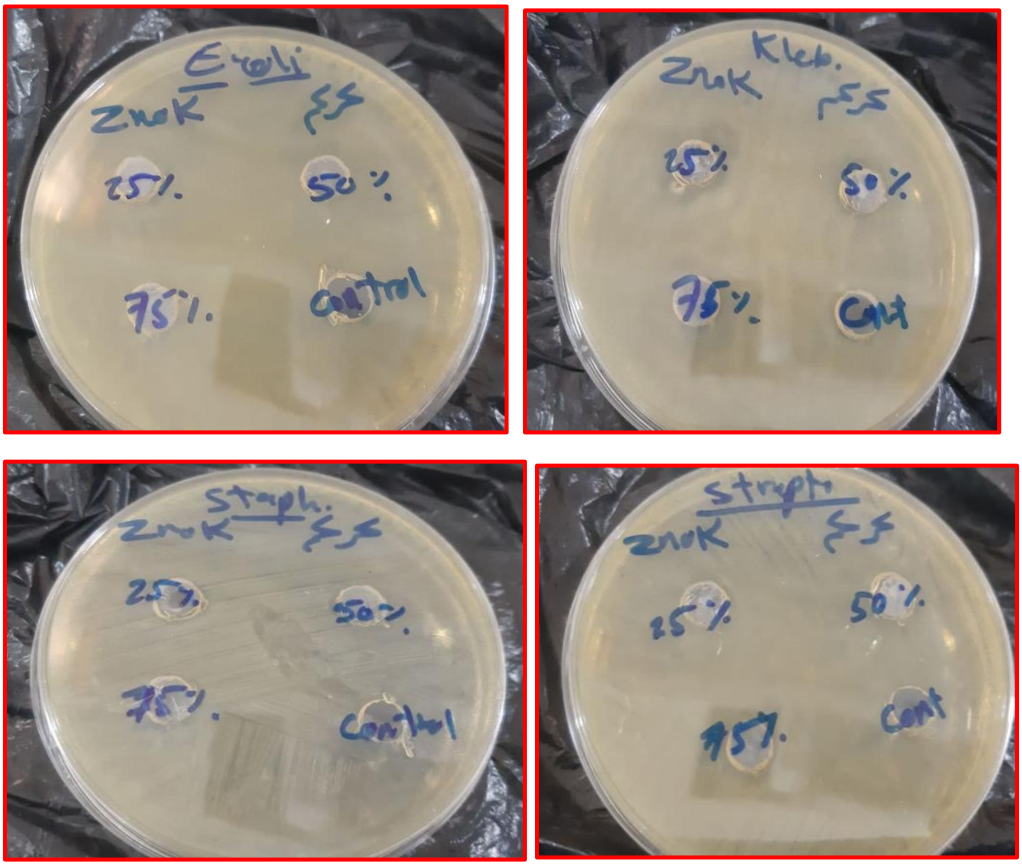

Fig. 8. Inhibitory Zones at different concentrations (25,50 and 75%) of ZnO that prepared by Curcumin extract.

Table 1. Summary of the IZ values at different concentrations (25,50 and 75 %) obtained for ZnO (Curcumin and Gum Arabic)

ZnO-Curcumin	*E.coli*	*Klebsiella*	*Staphylococcus*	*Streptococcus*
control	10	10	10	10
25%	10	15	11	11
50%	12	14	11	12
75%	13	17	11	13
ZnO-Gum Arabic	*E.coli*	*Klebsiella*	*Staphylococcus*	*Streptococcus*
control	10	10	10	10
25%	11	12	10	10
50%	12	14	10	10
75%	13	16	10	10

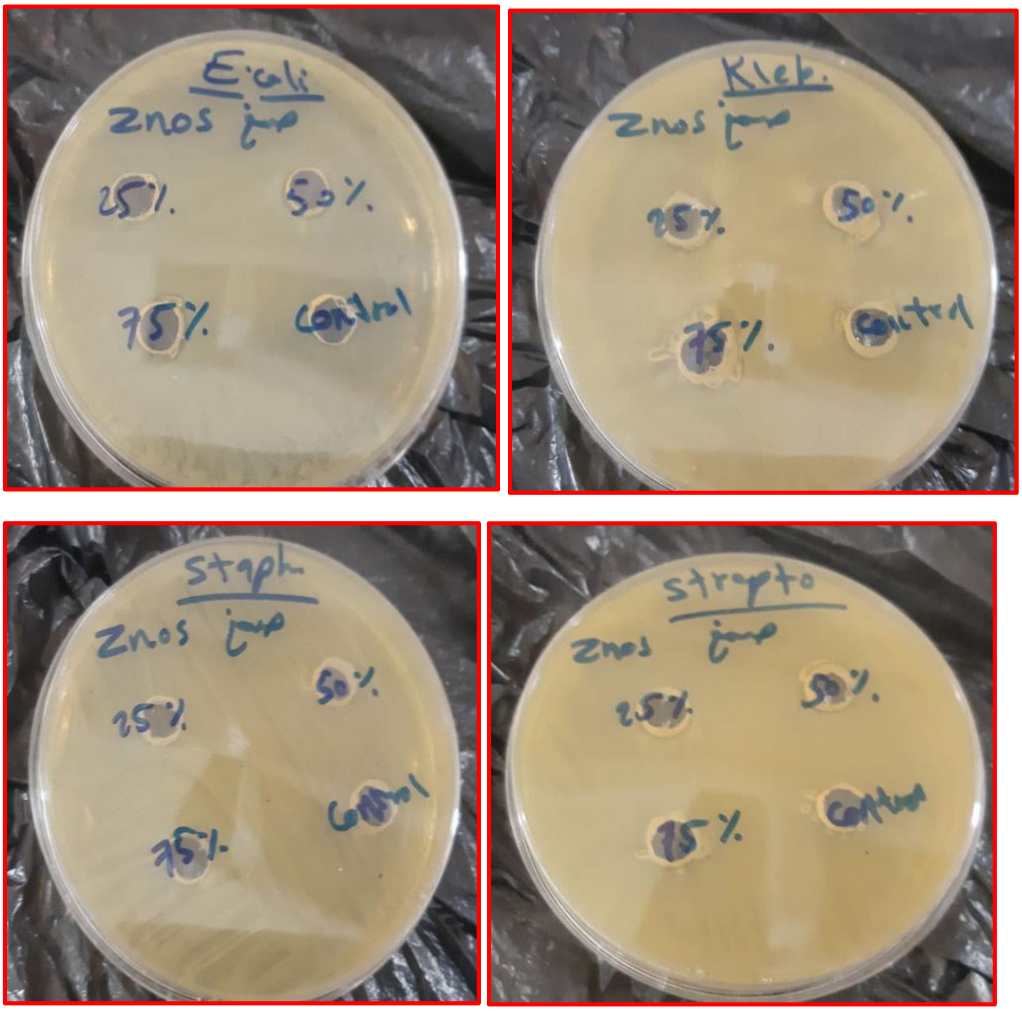

Fig. 9. Inhibitory Zones at different concentrations (25,50 and 75%) of ZnO that prepared by Gum Arabic extract.

The term "contact antibacterial mechanism" describes how antibacterial agents, like zinc oxide (ZnO), interact with lipids or proteins found in cell walls to destroy cell membranes. Sharp-edged micro ZnO materials can rupture the cell membrane, releasing phospholipids and other components from the cell [24–28].

CONCLUSION

In this work, we successfully synthesized ZnO NPs utilizing a green synthesis process that involved the use of gum Arabic and an aqueous extract of curcumin. Zinc oxide exhibited antibacterial properties. ZnO NPs over less expensive and safer alternatives to traditional treatments. They are a prospective option for a number of applications relating to the environment and human health because of their green synthesis and promising qualities. However, compared to the control, the antibacterial activities of zinc oxide in this work were not as powerful. This could be because the concentration of these ZnO nanoparticles is low, which could lead to a slower or less effective suppression.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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