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Evaluation of the Magnesium Oxide Nanoparticles Action Against Escherichia coli as Foodborne Bacteria

LUBNA ABDULAZEEM[1], ANAS SAJID ABBAS[2], ALI T.AL AARAJI[3], ALIAA SALMAN[4], SHAHAD ALI SAIB ALALLAWEP[5], KWTHAR ABD AL-HADI ABD AL-KARIM[6]

[1,6]DNA Research Center, University of Babylon, Iraq.
[2]Ministry of Education
[3]College of Dentistry, Al-Mustaqbal University, 51001, Babylon, Iraq
[4]Department of Microbiology Hammurabi College of Medicine, University of Babylon, Iraq
[5]Agriculture Collage Al-Qasim Green University Babylon 51013, Iraq

ABSTRACT

In food safety applications, magnesium oxide nanoparticles (MgO nanoparticles, which have an average of size of 35 nm) offer a great deal of promise as antibacterial agents because of their stability, surface characteristics, and structure. This study looked at the anti-bacterial properties and the mechanism of MgO nanoparticles action against a significant foodborne pathogen. E. coli were isolate and identify main bacteria caused foodborne infection, and trying to treatments by using nanoparticles. By measuring the antibacterial activity of the foodborne using the agar disc diffusion technique, MgO NPs demonstrated antibacterial properties against the E. coli, because Among the major foodborne pathogens, magnesium oxide nanoparticles have potent antibacterial action. Bacterial cells interact with nanoparticles to create oxidative stress, cell membrane leakage, and eventually cell death.

KEYWORDS: Foodborne Infections, MDR, MgO NPs and Anti-bacterial.

INTRODUCTION

Among the major foodborne pathogens, magnesium oxide nanoparticles have potent antibacterial action. Bacterial cells interact with nanoparticles to create oxidative stress, cell membrane leakage, and eventually cell death. These infections may spread from some animal excrement or from the different environment to the food, while food is being harvested, processed, distributed, and prepared. [1] Meat, dairy products, fresh vegetables, and ready-to-eat meals are among the many food items where pathogen contamination has been regularly discovered. The broad prevalence of different microbial pathogens in food, and increased many incidences of antibiotic resistant bacterial strains have posed serious concerns to public health. Hence, to effectively control microbial infections in food and the environment, new approaches must be developed. [2]

MgO nanoparticles have garnered a lot of interest as inorganic antibacterial agents due to their low cost, excellent stability, and non-toxicity. Narrow particles (NPs) are classified by European and other international committees as particles of matter that contain at least one phase with a single dimension (length, width, or thickness) between 1 and 100 nanometers (nm).[3] Other possible mechanisms for MgO NPs' antibacterial impact could include an electrostatic power contact between the bacterial surface and MgO NPs, which results in damage.[4] MgO NPs have been demonstrated to interact aggressively with a negatively charged bacterial surface due to their positive charge.[5,6] MgO NPs have demonstrated outstanding antibacterial properties against a range of harmful pathogens, including both Gram-positive and Gram-negative species. Because drug-resistant bacteria are becoming more and more common, it may be a useful antibiotic treatment. [6]. It has been stated that the generation of many types of reactive oxygen species (ROS), which may cause lipid peroxidation increase in bacteria, is responsible for the antibacterial action of MgO NPs. [6]

Metal oxide nanoparticles' mode of action on microbe is a complex and poorly understood process. It has been said that the generation many of ROS, which may cause lipid peroxidation inside microbe, is responsible for the effects of MgO NPs as antibacterial. [7] Cell death may occur through mechanisms other than oxidative stress, that mean the MgO nanoparticles were also shown to exhibit non-ROS-mediated bacterial toxicity. [8] In addition, the antibacterial effect varies depending on the bacterial species as well as the nanoparticles' sizes, shapes, chemical composition, and surface characteristics (such as hydrophobicity). [9,10]

This study sought to determine how MgO nanoparticles affected three important foodborne pathogens in terms of their antibacterial activity and mode of action.

MATERIALS AND METHODS

Bacterial Isolates

The bacterial isolates came from foodborne illnesses in several locations in Iraq's Hillah. For isolation and purification, all samples were put through the conventional bacteriological procedures of culture on different agar (blood and MacConkey's) agar plates for 24 to 48 hrs. at 37°C. All bacterial isolates were verified by using Biomérieux's (Vitek-2 compact system).

Solution and Media

Mueller-Hinton agar and media were obtained from Hi-Media- 9Mumbai, India). Different antibiotic disks Tetracycline (TE-30), Ciprofloxacin (CTP-10), Amoxicillin (AMC-30), Methicillin (ME-5), Gentamicin (CN-10) and Azithromycin (ATH-15) from (Bioanalyse, Turkey).

Antibiotic sensitivity determination

Each identified bacterial isolates of under study to determined their antibiotic sensitivity profiling against 6-antibiotic disk Tetracycline (TE-30), Ciprofloxacin (CTP-10), Amoxicillin (AMC-30), Methicillin (ME-5), Gentamicin (CN-10) and Azithromycin (ATH-15). Using the disk-diffusion of Kirby-Bauer technique, all tests were carried out on Mueller-Hinton media (agar) plates (Carl Roth from Germany). To compare each bacterial isolate identified with the standard tube of 0.5 McFarland turbidity, which is equivalent approximately to 1.5×10^{8} colony forming units/millilitre (cfu/ml), the isolates were re-suspended. Prior to conducting antibiotic sensitivity tests, each disc's surrounding zones of inhibition were measured 9by Vernier) and categorized as sensitive (S), intermediate (I), and

resistant (R) in compliance with the recommendations set out by the Clinical Laboratory and Standards Institute (CLSI) [11,12].

Antibacterial Activity of MgO NPs

MgO NPs antimicrobial activity was tested against bacterial isolates under study, that were maintained on nutrient agar slants. The Clinical and Laboratory Standards Institute provided a description of the antibacterial activity. To assess the effectiveness of MgO NPs against the bacteria being studied, sterile deionized water is used to dilute the 5-concentration MgO NPs (500, 250, 125, 62.5, and 31.25 µg/ml). Prior to being incubated at 37°C at night, the isolates were initially incubated for 15 minutes at room temperature. When, after a period of incubation, the inhibition zone was seen surrounding the well, positive findings were noted. A digital Vernier calliper was then used to quantify the inhibition zone diameter in millimetres [11,12].

RESULTS AND DISCUSSION

Pathogenic bacteria isolated from foodborne

A total of ten Escherichia coli pathogen isolates were isolated and identified from foodborne samples collected from ten distinct locations. Following confirmation of each isolate by biochemical testing, the Vitek-2 compact system (Biomérieux) was used.

Table 1 *(Biochemical tests to identified E. coli.)*

Biochemical test of *E.coli*	MR	KIA Medium				OX	MOT	Cit	Ind	Urea	Vp
		slope	Butt	H2S	Gas						
Result	+	Y	Y	-	+	-	-	-	+	-	-

[Ivd=indol test], [Cit= citrate utilization test], [Mot= motility test], [Ox oxidase test], [H2s= hydrogen sulphide], [MR= methyl-red test], [VP=voges – proskaure test], [Y= yellow]

Susceptibility profiles of E. coli

patterns of susceptibility to common antibiotics used to treat E. coli that were isolated from foodborne illnesses. Various antibiotic discs Tetracycline (TE-30), Ciprofloxacin (CTP-10), Amoxicillin (AMC-30), Methicillin (ME-5), Gentamicin (CN-10) and Azithromycin (ATH-15) are used. According to the CLSI, all ten bacterial isolates are resistant to every antibiotic disc utilized in the test, and the chosen antibiotic discs were ineffective against every bacterial isolate under investigation., as in Table (1).

Table 2 *(pattern of antibiotic susceptibility of E. coli isolated from foodborne illness (N=10) in Hilla City.)*

Bacterial isolate	Antibiotic Disk					
	TE-30	CTP-10	AMC-30	ME-5	CN-10	ATH-15
*E. coli*1	Resis.	Resis.	Inter.	Resis.	Resis.	Sens.
E. coli 2	Resis.	Resis.	Resis.	Resis.	Sens.	Sens.
E. coli 3	Resis.	Resis.	Resis.	Resis.	Resis.	Sens.
E. coli 4	Resis.	Resis.	Resis.	Resis.	Resis.	Sens.
E. coli 5	Resis.	Resis.	Resis.	Resis.	Resis.	Resis.
E. coli 6	Resis.	Resis.	Resis.	Sens.	Resis.	Resis.
E. coli 7	Resis.	Resis.	Resis.	Resis.	Resis.	Inter.

***E. coli* 8**	**Resis.**	**Resis.**	**Resis.**	**Resis.**	**Sens.**	**Resis.**
***E. coli* 9**	**Resis.**	**Resis.**	**Resis.**	**Resis.**	**Sens.**	**Resis.**
***E. coli* 10**	**Resis.**	**Resis.**	**Resis.**	**Resis.**	**Sens.**	**Resis.**

I= Intermediate ***R= Resistant*** ***S= Sensitive***

TE =Tetracycline, CTP =*Ciprofloxacin, AMC =Amoxicillin, ME =Methicillin, CN =Gentamicin and ATH= Azithromycin*

Agar disc diffusion test for MgO NPs' as antibacterial power against MDR bacteria

When MgO NPs are tested against ten isolates of multidrug-resistant E. coli Gram-negative bacteria, they demonstrate strong broad-spectrum antibacterial action. The results of test are compared to the activity of other drugs on the E. coli isolates. According to Table [1] results, not all 10 bacterial isolates could be killed by the chosen medicines. A definite inhibitory zone width was demonstrated by MgO NPs as the concentration of NPs increased, even surpassing the action of some antibiotics. The concentration of 500 µg/ml demonstrated the strongest zone of inhibition against all 10 bacterial isolates, with a maximum zone of inhibition of 20 mm appearing against E. coli 10. In comparison to other bacterial isolates, E. coli 7 was the least susceptible to MgO NPs. The results show that synthesized MgO NPs suppress the development of all the microorganisms under investigation in a dose-dependent manner (Figure 1). Numerous processes influence MgO NPs' antimicrobial activity. Bacterial genetic material (DNA) and protein chemical damage are caused by oxidative stress and ROS generation, respectively. Another search revealed that the tiny size of the nanoparticles might aid MgO NPs' antibacterial activity. Second, electrostatic interactions between MgO NPs and cell membrane proteins may cause physical damage to bacterial cell membranes, which in turn may result in bacterial cell death [13-16].

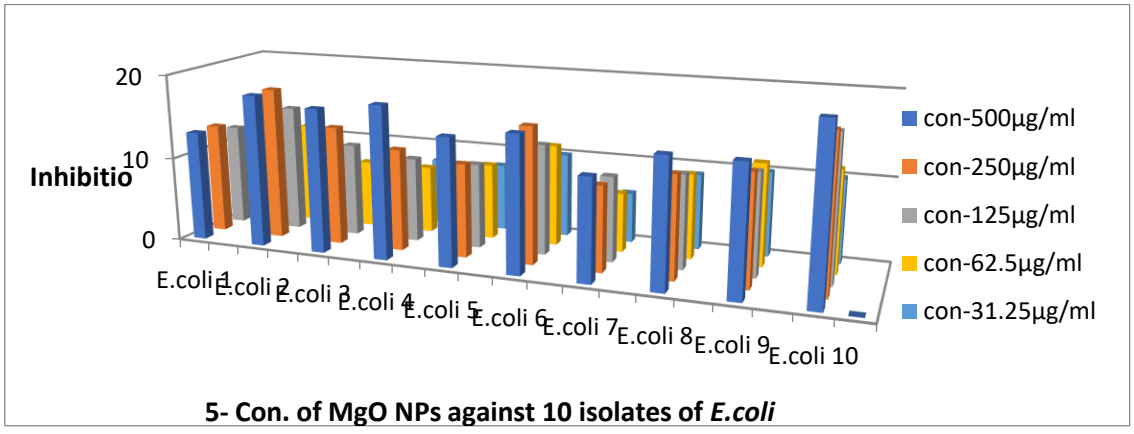

Figure (1)*: Antibacterial activity of MOg NPs against 10-isolates of E. coli isolates (by mm)*

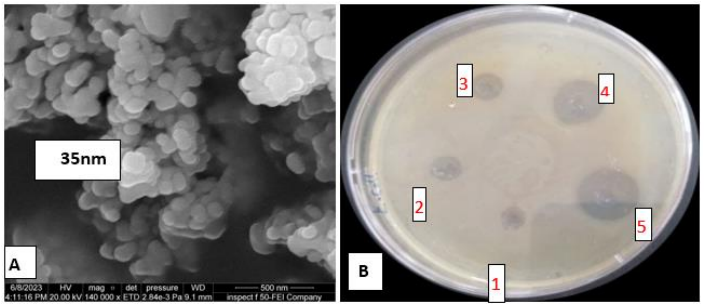

Figure (2): A/ size of MgO NP, B/Inhibition zone of E. coli growth as a result of activity of MgO NPs as antibacterial with different concentrations.

According to the results, because of their ability to combat harmful bacteria and their safe use in pharmaceutical and medical settings, MgO NPs production might be utilized as an alternative treatment for poultry infections (in vivo) in place of antibiotics [17-19].

CONCLUSIONS

Against three significant foodborne pathogens, this study showed that MgO NPs have potent antibacterial activity. It also examined the mechanisms behind the harmful effects of MgO nanoparticles on bacteria. The antibacterial activity mechanism of MgO NPs is likely caused by the increase in production of oxidative stress inside bacterial cells and then this ROS disruption of intact membrane that surrounds bacterial cells. This is corroborated by clear evidence of hydrogen peroxide (H2O2) generation in MgO nanoparticle solution, changes in cell shape, membrane leakage, and increase expression of oxidative stress deference genes caused by nanoparticles.

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