OPEN ACCESS
Advances in Animal and Veterinary Sciences

Research Article

Antimicrobial Action of Silver Nanoparticles Manufactured from Cinnamon Bark Extract Against Bacteria Isolated from Fresh Sheep Meat in Baquba City

Shaymaa Jabbar Hassoon[1*], Hiba Ibrahim Ali[2], Ayat Jasim Mohammed[3], Oras Salman[4]

[1,2]College of Veterinary Medicine, University of Diyala, Department of Microbiology, Iraq; [3]College of Veterinary Medicine, University of Diyala, Department of Internal and Preventive Veterinary Medicine, Iraq.

Abstract | This study was done to examine the antibacterial properties of silver nanoparticles synthesized from cinnamon extract against bacteria isolated from fresh sheep meat. Silver nanoparticles were synthesized by mixing 1ml of Cinnamon extract (0.025) % with (50ml) of silver nitrate solution (1.25)% and the ratio was (1:50) (v:v) at room temperature for (8hrs.) with pH(6.5-7) , later 8hrs, A higher pigment amount was seen. The physical features of AgNPs were proved by UV-VIS, Field Emission Scanning Electron Microscopy (FESEM) and Fourier-Transform Infrared Spectroscopy (FTIR), X-Ray Diffraction (XRD) and transmission electron microscope (TEM). The results showed the meat samples comprised *Staphylococcus aureus (14%), Escherichia coli(8%) and pseudomonas(2%)* , all isolated bacteria were confirmed by VITEK 2 system. The results of UV-Vis analysis showed a silver surface plasmon resonance band at 420 nm. AgNPs' spherical form and diverse diameters D1 (21.10) and D2 (21.39) were observed using SEM. While FT-IR spectrum noticed the existence of diverse efficient clutches accountable in order to reduction and stabilization Ag-NPs. The nanoparticles after XRD analysis were crystalline form with face-centered cubic structure of the bulk silver with wide beaks 37.80°, 44.0°, and 64.19°. TEM showed Ag-NPs spherical shape. Diverse concentrations of AgNPs were used in agar well diffusion test (1024, 512, 256 and 128µg/ml), different inhibition zones alongside bacterial were isolated with an rise in agent concentrations. The full inhibition zone for Ag-NPs biosynthesized showed a significant difference in the effectiveness of AgNPs-cinnamon extract compared to the cinnamon extract alone with p value (0.0032) , but the least zone was established alongside pseudomonas with clear significant difference in the effectiveness of AgNPs-cinnamon extract compared to the cinnamon extract alone with p value (0.0165), while the moderate zone showed *E.coli* with a clear significant difference in the effectiveness of AgNPs-cinnamon extract compared to the cinnamon extract alone Pvalue (0.051). From this study concluded the silver nanoparticles synthesized from cinnamon extract had antimicrobial properties against pathogenic isolated bacteria and offering a novel way in the combat alongside bacterial contagions.

Keywords | Silver nanoparticles, Cinnamon bark, Fresh sheep meat, Antimicrobial activity, *Staphylococcus aureus*, *Escherichia coli*

Received | July 05, 2024; **Accepted** | August 11, 2024; **Published** | October 23, 2024
***Correspondence** | Shaymaa Jabbar Hassoon, College of Veterinary Medicine, University of Diyala, Department of Microbiology, Iraq; **Email:** shymaa.j@uodiyala.edu.iq
Citation | Hassoon SJ, Ali HI, Mohammed AJ, Salman O (2024). Antimicrobial action of silver nanoparticles manufactured from cinnamon bark extract against bacteria isolated from fresh sheep meat in baquba city. Adv. Anim. Vet. Sci. 12(12): 2335-2344.
DOI | https://dx.doi.org/10.17582/journal.aavs/2024/12.12.2335.2344
ISSN (Online) | 2307-8316; **ISSN (Print)** | 2309-3331

INTRODUCTION

Nanotechnology in latest years has been a lot of concern in this technique. All particles having a diameter of one to one hundred nanometers that are composed of carbon, metal, metal oxides, or organic compounds (Bae *et al*., 2010). Nanoparticles have completely dissimilar or enhanced chattels comparison to larger components in bulk materials. (Srinivasan *et al*., 2014). Historically, antimicrobial agents have been formed expending silver in entirely of its forms, moreover alone or in assembling with diverse technological set. This metal has been investigated to take benefit of its capability to suppress bacterial growth through adding it as silver nitrate or silver sulfadiazine in food packaging to avoid contamination. Furthermore, it used to treat ulcers and burn, in home purposes like refrigerators, and in numerous industrial requests (Tong, 2009). Because of the information and indication present of the antibacterial action of silver, with the appearance of nanotechnology, the study of the antibacterial ability of silver nanoparticle was an obvious route (edziora *et al*., 2018). Silver nanoparticle are distinct as a nanomaterial with all its measurements in the array of 1–100 nm. These have revealed better capability and greater surface (area-to-volume ratio) associated to silver in its bulk formula. At the Nano scale, this material exhibitions exclusive optical, electrical and catalytic possessions, which has directed to the examination and manufacture of products for the distribution of specific drugs, finding, discovery, and imaging (Yaqoob *et al*., 2020). Also it is the excellent antibacterial action displayed by silver nanoparticles that has concentrated the devotion of investigators and productions on this nanomaterial. AgNPs have revealed antimicrobial action alongside a diversity of pathogenic and infectious microorganisms, comprising bacterium resilient to many drugs (Siddiqi *et al*., 2018). Plant-assisted nanoparticle production is extra productive than microbial nanoparticle production. Numerous metabolites and biochemicals found in plants, including polyphenols can be function as both reducing and stabilizing agents during creation of biogenic nanoparticles. Since plant-mediated NP synthesis does not entail the usage of hazardous chemicals, it is both economical and environmentally friendly. In the trials, plant-derived nanoparticles were significantly additional stable than those produced by bacteria and champignons. (Singh *et al*., 2016). The green creation of (NPs) required the utilization of natural constituents like vitamins, carbohydrates, plant extracts, biodegradable polymers, and microbes in combination with metal salts. Plant extracts can be utilized as a reducing agent and help maintain the stability of the system. (Carmona *et al*., 2017). The world knows cinnamon from the bark of a little, tropical evergreen tree named Cinnamomum zeylanicum. The bark of C. zeylanicum is profused in chemicals, such as resinous compounds and terpenoids such as linalool, eugenol, and methyl chavicol (Shan *et al*., 2005). As well as, caryophyllene, ethyl cinnamate, and cinnamonaldehyde (Lopez *et al*., 2005). Furthermore, there is some protein in the bark. (Verspohl *et al*., 2005). Terpenoids are thought to be crucial for the manufacture of silver nanoparticles by reducing silver ions (Shankar *et al*., 2003). Sturdy spices alike cinnamon has been exploited for thousands of years as medicine all across the world. One of the chief bioactive elements that has been exposed to have a diversity of biological possessions, including antibacterial, antibiofilm, anthelmintic, anticancer and antifungal activity is cinnamon extract. (Williams *et al*., 2015). So, due to its huge biological potential in the current study, Cinnamon bark extract was used for the green production of AgNPs and likewise the extract from cinnamon barks was used as a reducing agent and capping agent to creation AgNPs. The apparatus of cellular poisonousness demonstrated by metal nanoparticles is done the freedom of Reactive Oxygen Species (ROS) (Mallikarjuna et al., 2011). AgNPs are an brilliant biocidal instrument due to their late oxidation and freedom of Ag+ ions into the milieu, which contributed to their antibacterial possessions. Furthermore, because of their lesser size, these elements can be additional easily passed through cell membranes and effect intracellular procedures from inside (Premkumar *et al*., 2018). The goal of this study was to demonstrate the manufacture of silver nanoparticles by cinnamon bark. and evaluate the antibacterial action of the nanoparticle *in vitro.*

MATERIALS AND METHODS

Samples Collection

Fifty fresh meat sheep samples were collected from the numerous marketplaces of Baqubah province After that, the samples were collected into hygienic plastic bags and kept at 4°C in freeze container then it carried to the lab for direct investigation. Entirely tasters were sent to the microbiology lab, where 3 gm. of the taster were mixed with 5ml of nutrient broth and hatched at 37°C for (18-24hr.). Subsequently, the broth was was taken and streaked on selective and differential media by a sterilized loop such as blood agar , MacConkey Agar, Salmonella-shigella agar, manitol salt agar, and Eosin-methylene blue agar. The shape of the bacterial colonies was used to assess the primary cultures then subcultured and stained with Gram stain.

Bacterial Identification

The identification of bacteria was accompanied via ordinary morphological and biochemical tests of isolation according to (Manual of Clinical Microbiology, 2002). In adding, VITEK 2 system was used to approve and determine the sensitivity test for each strain.

The Process of Biosynthesis Silver Nanoparticles using Cinnamon Bark Extract

Method for making powdered cinnamon bark: Cinnamon bark was bought from nearby marketplaces. It

Table 1: Biochemical features of bacteria isolated from samples of fresh, raw meat.

Isolates	Gram reactions	Biochemical test				
		catalase	Coagulase	Indole	Urease	Oxidase
Staphylococcus aureus	Positive	+	+	-	-	-
Escherichia coli	Negative	+	-	+	-	-
Pseudomonas aurogenosa	Negative	+	-	-	-	+

was washed with sterile D.W. to eliminate any contaminations and then it was let to naturally dry for a week at room temperature in the dark to get rid of some possible moisture. After that, the bark was chopped into lesser sections, converted into a well-ground powder with an electronic pounder, then the powder was sieved through a well mesh screen to yield elements in similar size as the bark that had been crushed. The completed powder was utilized in all ensuing research (Sathishkumar *et al*., 2009).

Method of making an extract from cinnamon bark: The extract was made by combing 100 milliliters of distilled water and 2.5 grams of cinnamon bark powder in a 500 milliliter Erlenmeyer flask. At 100° C, the mix was heated for 5 min. The mix was cooled, followed by filtration by Whatman No. 1 filter paper. and refrigerated until needed. (Gauthami *et al*., 2015).

Method of making 1mM silver nitrate solution: Silver nitrate (AgNO3) (1 mg) was prepared by dissolving 0.0421 g of AgNO3 in 100 ml of double-distilled water. In order to rest the silver from oxidizing on its own, the solution was well combined and kept in a yellow bottle. (Saleh *et al*., 2021).

Method of making silver nanoparticles using cinnamon barks extract: One milliliter (ml) of bark extract from Cinnamon (0.025) % was mixed with fifty milliliters (1 mM) of silver nitrate (AgNO3) solution (1.25)% with ratio (1:50) (v:v) and allowed to stand at room temperature for eight hours with pH(6.5-7) , the nitrate was reduced from silver Ag+ to free form, the solution's original yellowish hue changed to a black shade. Every hour, the color solution's change was recorded. Through an increase in reaction period, the color concentration altered following the reduction of Ag+ to silver nanoparticles by extracts from the bark of Cinnamon (Hamzah *et al*., 2018).

Description of AgNPs

Ag-NPS's important possessions have been determined by the usage of numerous tests, such as UV-Visible Spectroscopy, Fourier-Transform Infrared Spectroscopy,Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD) and Transmission electron microscopy (TEM), in order to assurance the manufacturing of silver nanoparticles. These characteristics included the size and form of the particles, the arrangement of the operating sets by the particles and the existence of a surface-specific plasmon resonance peak (Reyam and Ayad, 2021).

Antibacterial Property of Silver Nanoparticles

The well diffusion test technique was used to amount the inhibitory action. Wells were formed by a hygienic cork borer with like measurements and a 6 mm diameter on a Mueller Hinton agar that had previously been prepared. Subsequently covering the plate with 100 µl of the bacterial solution 1 x 10^8, 100 µl of Ag-NPs in diverse concentrations (1024, 512, 256, and 128). After that, the bacterial solutions were added to the equivalent wells. The inhibitory zone was measured after the plates were incubated for 18-24 hrs. at 37°C (Namasivayam *et al*., 2015).

Statistical Analysis

Entirely results were carried out and evaluated by the Spss version 17 program.

RESULTS AND DISCUSSION

The outcomes got from this study are existing in the tables below. Table 1, displayed the morphological appearances of bacteria isolated and acquired from raw meat. Their biochemical test arrayed from negative to positive. The existence of bacteria in meat has been broadly described from diverse portions of the world (Kinsella *et al*., 2008). *Staphylococcus aureus* was the utmost noticeable bacteria recovered from raw sheep meat samples, with *Escherichia coli* and *pseudomonas* subsequent in variable concentrations Table 2. This is consistent with previously reports that recognized *Staphylococcus aureus, Escherichia coli, and Klebsiella pneumonia* from the fresh and careless meat samples. (Oluwatobi *et al*., 2021). Other review mentioned by Fatima et al. (2023) they were discovered many bacteria present in sheep flesh, with varying percentages of *Salmonella* SPP (68%), *E. coli* (72%), and *Staphylococcus aureus* (48%). Confirmatory analysis the results of the VITEK 2 system indicated that the isolated bacteria had a 100 % identity with a probability of 99%.

Table 2: The rate of bacterial isolates originate in each sample of meat.

Isolates	Fresh samples	Ratio
Staphylococcus aureus	7	14%
Escherichia coli	4	8%
Pseudomonas aurogenosa	1	2%

Links Researchers

Table 3: Antibiotic susceptibility of *Staphylococcus aureus*.

Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
Ampicillin	>=64	R	Meropenem	<= 0. 5	S
Amoxicillin/clavulanic	16	R	Amikacin	16	R
Piperacillin/ Tazobactan	8	R	Gentamicin	<=2	S
Cefotaxime	>=32	R	Ciprofloxacin	1	S
Ceftazidime	16	R	Norfloxacin	<= 1	S
Cefepime	8	R	Fosfomycin	<= 16	S
Ertapenem	<= 0. 25	S	Nitrofurantion	64	R

Table 4: Antibiotic susceptibility of *E.coli*.

Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
Ampicillin	>=32	R	Ertapenem	<= 0. 25	S
Imipenem	8	R	Amikacin	<= 2	S
Piperacillin/ Tazobactan	<= 4	S	Gentamicin	>=16	R
Cefotaxime	>=64	R	Ciprofloxacin	>=4	R
Ceftazidime	16	R	Norfloxacin	>=16	R
Cefepime	<= 0. 5	S	Nitrofurantion	<= 16	S
Meropenem	<= 0. 25	S	Fosfomycin	<= 16	S
Amoxicillin/clavulanic	8	R	Trimethoprim/Sulfa methoxazole	>=320	R

***MIC:** Minimum Inhibitory Concentration (μg/ml); **S:** Sensitive; **R:** Resistan.

Antibiotic Sensitivity Test

The data from antibiotic susceptibility tests for the utmost public bacteria, *Pseudomonas aurogenosa, E. coli, and Staphylococcus aureus,* were included in (Tables 3,4 and 5). The finest antibiotics susceptibility were Ertapenem (<= 0. 25 μg/ml), Meropenem (<= 0. 5 μg/ml), when tested on *Staphylococcus aureus* while, it was resistant to Ampicillin(>=64) and Nitrofurantion (>=64) (Table 3), whereas the utmost operative antibiotics' susceptibility were meropenem and Ertapenem (<= 0. 25 μg/ml) and Cefepime (<= 0. 5 μg/ml) once tested on *E.coli* but, it was unaffected to Trimethoprim/Sulfa methoxazole (<=320 μg/ml) .Table 4 And the additional antibiotic faintness to *pseudomonas aeruginosa* was Imipenem (<= 0. 25) whereas, it was unaffected to Cefotaxime (>=64) and Norfloxacin (32) as in Table 5.

The Manufacture of Silver Nanoparticles by Extract from Cinnamon Bark

Cinnamon bark extracts were used to generate silver nanoparticles in a green process. One milliliter of the extract was added to 50 milliliters of a 1Mm solution of AgNO3. To yield silver nanoparticles from these extract, a simple process was employed. The dye of the reaction combination altered from yellowish to dark brown later 8 hr. of mixing the Cinnamon plant extract with the 1 mM silver nitrate resolution. This specifies the generation of silver nanoparticles is created by the dynamic molecules in the plant abstracts of cinnamon lead to reducing the silver metal ions Ag+ to silver nanoparticles. A prolonged cultivation time can be hasten the percentage of reduction and increase the quantity of nanoparticles formed.

Technique of manufacture diverse concentrations of SNPs: Standard solution of Ag-NPs was ready by combination 0.1 g of silver nanoparticles with ten ml of D.W. (10 mg/ml) and concentrations of (1024, 512, 256 and 128μg/ml) were ready by mix identified size from the standard solution with D.W.

Description of Nanoparticles

UV-VIS absorbance spectroscopy: A useful method for examining and researching Plasmon resonance in metallic nanoparticles ultraviolet-visible (UV-Vis) absorbance spectroscopy and using a spectrophotometer, the reduction of silver ions to nanoparticles was frequently appreciated. Outcomes signposted were made up the absorption spectra of the silver nanoparticles distinct sturdy surface plasmon resonance band at 420 nm (Figure 1). The utmost typical feature of silver solution is a narrow band of plasmon absorption visible in the 350–500 nm range. The noticeable peak was obviously apparent at 420 nm, representing a reduction of silver ion.

The ultraviolet absorption band of Ag-NPs exhibited in the (Figure 1) was determined via a single sharp beam at around 420 nm, which is nearby to (Reyam and Ayad, 2021) who is noted the explanation of the UV-Vis spectrum of the nanoparticle's manufacture from the cinnamon bark through formation of the surface plasmon resonance band at 435 nm. It likewise reaches agreement with (Sathishkumar *et al*., 2009) who saw that the absorption beak of nanoparticles manufacture from the cinnamon barks was documented at 429 and 435 nm, correspondingly.

Table 5: Antibiotic susceptibility of *pseudomonas aeruginosa*.

Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
Ampicillin			Meropenem	8	R
Amoxicillin/clavulanic			Amikacin	<= 2	S
Piperacillin/ Tazobactan	16	R	Gentamicin	2	s
Cefotaxime	>=64	R	Ciprofloxacin	16	R
Ceftazidime	4	s	Norfloxacin	32	R
Cefepime	8	R	Fosfomycin		
Ertapenem			Nitrofurantion		
Imipenem	<= 0. 25	S	Trimethoprim/Sulfa methoxazole		

Field emission scanning electron microscope (FE-SEM): Scanning electron microscopy was utilized to interpret the morphological characteristic (dimension and form) of the nanoparticles. The synthesis AgNPs' SEM pictures are showed in (Figure 2). The Ag-NPs SEM image at diverse magnifications displayed that the particles are agglomerated, through nearly all of the AgNPs appeared to be spherical. Moreover, (Figure 2) displayed that the biosynthesized Ag NPs ranged in size from 27.52 nm to 40.14 nm; this outcome was alike to that of (Supriya1 and Chaitanya, 2019) when they established the manufactured AgNPs had a sphere-shaped, fewer aggregated and a well-dispersed particle size range of 49–82 nm.

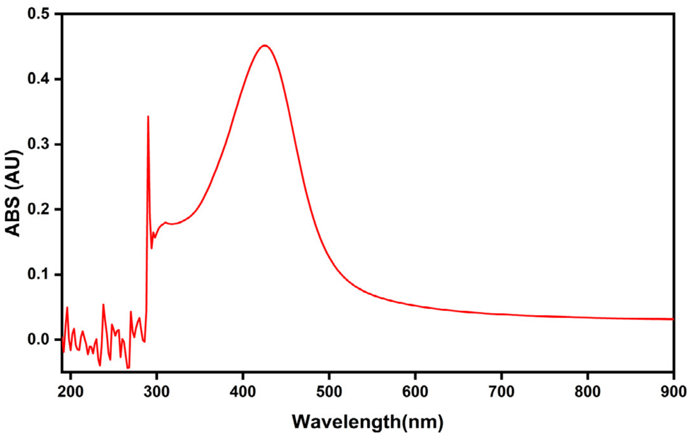

Figure 1: Surface plasmon resonance peak of silver nanoparticles at 420 nm.

Fourier transmission infrared spectroscopy (FTIR): The probable bioactive operative groups are existing in the extract and contributed to the formation and stability of AgNPs were identified using FT-IR investigation. AgNPs' FT-IR spectra were gotten in the 400–4000 cm−1 range. (Figure 3). The presence of a wide and strong absorption band of silver NPs round (3165.19 cm−1) was consigned to the N-H stretch (Amides). Whereas absorption peak at (2922.16 cm−1) was allotted to –C–H stretching of –CH2 of protein. The band at (1697.36 cm−1) displayed a nonlinear increase in the strength which was related with the stretching vibration of an aldehyde carbony1 C=O groups of alkenes. The peak at (1419.61.92 cm−1) is ascribed to the Nitro Compounds NO2 stretch. The peak at (1382.92 cm−1) is ascribed to the C–H bending in alkanes. Conversely, the peak at (1150–911 cm−1) of C–O–C group. Lastly, the band at (667.37 cm−1), and (617.22 cm−1) were due to C–N–C bending in amines. These outcomes were collected the incidence of operative groups in the synthesized Ag-NPs. The FT-IR outcomes displayed the existence of numerous operative groups in the cinnamon's (CZ) extract. These operative groups were going to phenols, alcohols, alkane, alkynes, and aldehydes (particularly, cinnamaldehyde). About FTIR investigation of biosynthesized Ag- NPs was an precise technique for description of AgNPs as described Salami *et al*. (2018) also agreed with the outcomes recorede by Yusof *et al*. (2020), who used FTIR to describe manufactured Ag-NPs.

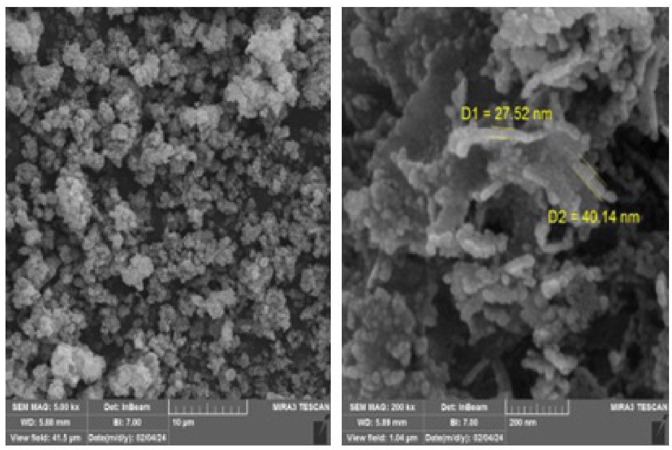

Figure 2: SEM image of manufactured silver nanoparticles the particle size at altered average diameters D1and D2.

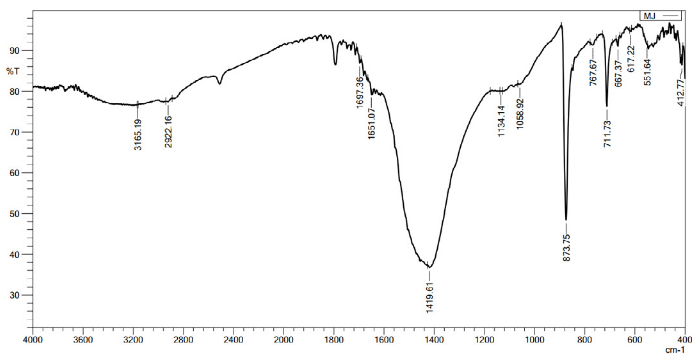

Figure 3: FTIR analysis of biosynthesized Ag-NPs.

X-Ray diffraction (XRD): Speedy methodical approaches like X-ray diffraction (XRD) can be used to rapidly describe and recognize crystalline constituents through of synthetic nanoparticles and can also produce evidence about the measurements of unit cells. The distinctive peaks seen in the XRD image (Figure 4) which is demonstrated and confirmed the X-ray diffraction pattern of the manufacture AgNPs. In the entire spectrum of 2θ values extended from 20 to 100, the XRD pattern 2θ revealed three sturdy peaks (37.80 °, 44.0 °, and 64.19 °), they are represented the structure of silver nanoparticles as face centered cubic (fcc). These patterns, in turn, parallel to (111), (200), and (311) respectively. This result is consistent with a study recoreded by Sekatawa *et al.* (2021) when they created AgNPs by an aqueous extract of Camellia sinensis bark. The AgNPS displayed perfect peaks of cubic levels at 38.0 (111), 44.3 (200), 64.5 (220), and 77.4 (311).

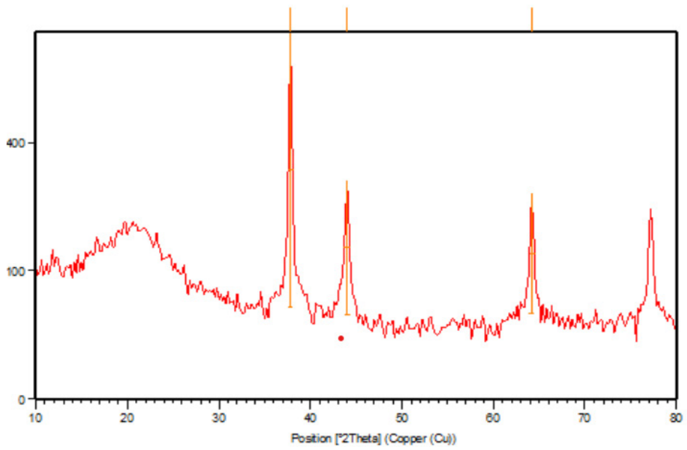

Figure 4: X-ray diffraction (XRD) pattern of obtained Ag nanoparticles.

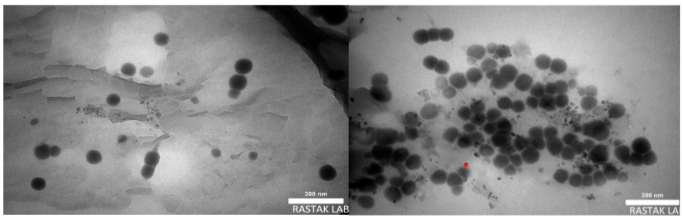

Figure 5: TEM images of silver nanoparticles.

Transmission electron microscope (TEM): The morphology of the chemically created silver nanoparticles was examined by using TEM. The resulting enlarged image confirmed the existence of minute, sphere-shaped and faceted nanoparticles in AgNPs. The fact that individual nanoparticles were not in direct interaction with one another. Alshareef *et al.* (2017) have stated that AgNPs in together sphere-shaped and rod- shaped exhibition sturdy antimicrobial possessions. In this regard, the existence of a mixture of varied forms of AgNPs-cinnamon, as understood in (Figure 5) could be proposal benefits in terms of bactericidal action. This result perhaps due to diverse forms of nanoparticles lead to interrelate with bacterial cells in varied methods, possibly resulting in numerous apparatuses of cell disturbance.

In Vitro Antibacterial Activity of Silver Nanoparticles

Silver nanoparticle have displayed extremely antibacterial action alongside numerous Gram-positive(G+) and Gram-negative(G-) bacteria. The current study examined the antibacterial properties of biosynthesized Ag-NPs alongside the following microorganisms: *Staphylococcus aureus, Escherichia coli and Pseudomonas aeruginosa.* The agar well diffusion assay was employed varying quantities of Ag-NPs, by using of different concentrations (1024, 512, 256 and 128μg/ml) resultant in changeable degrees of inhibition zones of alongside (*staphylococcus aureus, E.coli and pseudomonas*). The dimension of the inhibition zones various dependent on the Ag-NPs concentrations; the dimension of the inhibition zones enlarged proportionately as the agent concentration increased. The silver NPs' antibacterial action results revealed effect of alongside entirely microorganisms with variable inhibition zone sizes when compared with the chemically synthesized antibiotics , silver NPs antibacterial action was represented by the results of Vitek2 system which showed that every type of bacteria had resistance to many antibiotics, such as *Staphylococcus aureus* resistance to ampicillin, amoxicillin/clavulanic, piperacillin/tazobactan, cefotaxime, ceftazidime, cefepime, amikacin and nitrofurantion and this result was similar to *E.coli* and *Pseudomonas aurogenosa* which are resistance to Many antibiotics. Nonetheless, the biosynthesized Ag-NPs utilized important action alongside all tested bacteria by resulting in foundation of variable zone of inhibition dependent on the bacterial strain used. The full inhibition zone for Ag-NPs biosynthesized was detected with *Staphylococcus aureus* which it was around (25 mm) in diameter compared to the inhibitory zone created by plant extract only (10mm) at high concentration. There is a clear significant difference in the effectiveness of cinnamon extract alone compared to the effectiveness of the extract combined with AgNPs. with p value (0.0032) , but the least zone was established alongside *pseudomonas* which it is displayed an inhibitory zone diameter of (12mm) comparing through plant extract (0 mm) at high concentration with a clear significant difference in the effectiveness of cinnamon extract alone compared to the effectiveness of the extract combined with AgNPs with p value (0.0165) , while the moderate zone was saw with *E.coli* which it was about (20 mm) in diameter comparing through the inhibitory zone formed by plant extract only (13mm) at great concentration. There is a clear significant difference in the effectiveness of cinnamon extract alone compared to the effectiveness of the extract combined with AgNPs. with p value (0.051) (Figure 6 and 7), but in Table 6, demonstrated, there was no bacterial growing of any type is noticed in the wells having AgNPs-cinnamon and this result may be attributed to a

Table 6: Inhibition zones(mm) of synthesis nanoparticle used against pathogenic bacteria.

P value	Synthesis nanoparticle				Cinnamon extract				Isolates
	128	256	512	1024	128	256	512	1024	Conc.
0.0032	14	17	20	25	0	6	8	10	Staphylococcus aureus
0.051	10	14	18	20	0	10	11	13	Escherichia coli
0.0165	0	7	11	12	0	0	0	0	Pseudomonas aurogenosa

strong antibacterial resulting from totally of the studied microorganisms. This explanation was in agreement with result reported by Li *et al.* (2017), when they investigated AgNPs' action alongside *S. epidermidis, P. aeruginosa, and E. coli*; the results displayed that AgNPs are added operative alongside *E. coli* than against *S. epidermidis and P. aeruginosa*. Nevertheless, it is significant to consider the dependency of antibacterial action on the concentration of AgNPs. This fact was also proved by Parameswari *et al.* (2010), they demonstrated the inhibition zone grew as AgNP concentration increased from the numerous revisions on MDR bacteria, AgNPs are active alongside pathogenic bacteria such as *S. Typhi*, *E. coli, S. epidermidis*, and *S. aureus*, *P. aeruginosa* . (Li *et al.*, 2017; Ouda, 2014; Lara *et al.*, 2010).

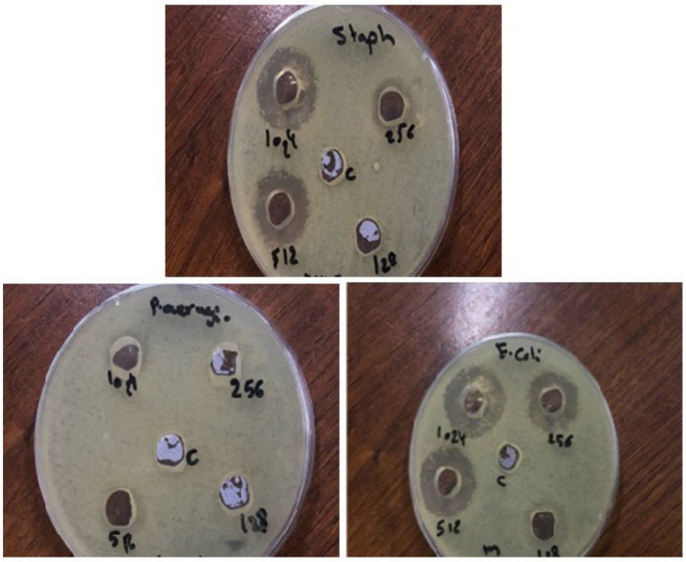

Figure 6: Antibacterial activity of cinnamon extract against *Staphylococcus aureus, Escherichia coli and Pseudomonas aeruginosa.*

The chief device by which silver nanoparticles exhibited antibacterial possessions was via attaching to and pungent the bacterial cell wall and regulating cell signaling through the dephosphorylation of potential important peptide substrates on trypsin residues. Once silver binded to plasma binding protein (PBP), it inhibited transpeptidation which forms the bacterial cell wall, which finally resulted in cell lysis and death. It is evident that treated bacteria exhibited an important alterations as well, comprising membrane destruction and the foundation of "pits" on their surfaces. A parallel result was defined by Stoimenov *et al.* (2002).

Figure 7: Antibacterial activity of AgNPS synthesized by cinnamon extract of plants against *Staphylococcus aureus, Escherichia coli* and *Pseudomonas aeruginosa.*

Silver nanoparticles destruction compounds made of sulfur and phosphorus, such as DNA, by binding to them. It is thought that cellular proteins became inactive and DNA fails its ability to duplicate. Furthermore, it was exposed that Ag+ attacked definite protein clutches lead to producing the denatured protein . (Ibrahim *et al.*, 2016). In study recoreded by Awais et al. (2023), displayed AgNPs offered the great inhibition alongside *E. coli* in a dose-dependent protocols (at 50 ug, produce 20 mm of zone inhibition and at 100 ug, 25 mm), then by *S. aureus* (13 mm and 17 mm for 50 ug and 100ug) and *S. typhimurium* (14 mm and 19 mm) correspondingly AgNP accessible a visible inhibition against both gram positive and gram negative bacteria. AgNPs' greater surface area and smaller size caused them to interrelate with bacterial cell walls, fix to the cell membrane and alteration penetrability by altering the membrane potential (Pal *et al.*, 2007). Ag-NPs transformed into silver ions upon arriving the cell and interrelated with biomolecules, causing harm to the cell because they bind to DNA and stop its replication. Furthermore, these ions attached to cell and membrane proteins, which aid in cell division (Singh *et al.*, 2020). AgNPs can be also penetrated bacterial membranes and walls, which rised the generation of reactive oxygen species (ROS) by blocking respiratory chain enzymes and encouraging their build-up within bacteria (Salas *et al.*, 2019). According to a prior study on the effectiveness of AgNPs against bacteria, AgNPs interacted with membrane components, changing and damaging their structure as well as causing cellular components to be excreted, which ultimately resulted in the death of the cell (Al-Dhafri and Ching, 2019). These findings indicated that silver nanoparticles (SNPs) exhibited a strong antibacterial activity against harmful bacteria.

CONCLUSIONS AND RECOMMENDATIONS

From this study concluded AgNPs was efficiently synthesized from cinnamon bark extract and acted as a reducing agent with bactericidal action by using disk diffusion. In divergence, the growth of bacteria was not expressively affected by cinnamon extract only. Silver nonparties-cinnamon's morphological variability played a key role in improving its effectiveness against numerous bacterial strains. (AgNPs) have special physical, chemical, and biological possessions that make them ideal, reliable, effective solutions for antimicrobial, drug-loading, and other usages based on nanoparticle feature such as dimensions, forms, and surface charge of (NPs). It is recommended by usages in the cancer immunotherapy as the carrier of immunotherapeutic agents and as the adjuvants to encourage immune systems to eliminate cancer.

ACKNOWLEDGMENTS

Many thanks to Professor Dr. Ali Ibrahim for his support and assistance me

NOVELTY STATEMENT

The originality of the work is dedicated on the creation of nanoparticles from herbal extract that can be used as inventive anti-bacterials that are hardy to artificial antibiotics.

AUTHOR'S CONTRIBUTIONS

Every author made an equal contribution.

Conflicts of Interest

The writers articulate nope conflict of interest.

REFERENCES

Al-Dhafri K, Ching CL (2019). Phyto-synthesis of silver nanoparticles and its bioactivity response towards nosocomial bacterial pathogens. Biocatal. Agric. Biotechnol., 18: 101075 https://doi.org/10.1016/j.bcab.2019.101075

Alshareef A, Laird K, Cross RBM (2017). Shape-dependent antibacterial activity of silver nanoparticles on Escherichia coli and Enterococcus faecium bacterium. Appl. Surf. Sci., 424: 310–315. https://doi.org/10.1016/j.apsusc.2017.03.176

Ahmad A, Mushtaq Z, Saeed F, Afzaal M, Al Jbawi E (2023). Ultrasonic-assisted green synthesis of silver nanoparticles through cinnamon extract: biochemical, structural, and antimicrobial properties Int. J. Food Prop., 26(1): 198. https://doi.org/10.1080/10942912.2023.2238920

Awais A, Zarina M, Farhan S, Muhammad A, Entessar AJ (2023). Ultrasonic-assisted green synthesis of silver nanoparticles through cinnamon extract: biochemical, structural, and antimicrobial properties.international journal of food properties. 26(1): 1984–1994. https://doi.org/10.1080/10942912.2023.2238920

Bae E, Park H J, Lee J, Kim Y, Yoon J, Park K (2010). Bacterialcytotoxicity of the silver nanoparticle related to physicochemical metrics and agglomeration properties. Env. Toxicol. Chem., 29(10): 2154-2160. https://doi.org/10.1002/etc.278

Balashanmugam P, Kalaichelvan P (2014). Biogenic synthesis of silver nanoparticles from Dodonaea viscosa Linn. and its effective antibacterial activity. J. Sci. Trans. Environ. Technovation., 8: 67- 71. https://doi.org/10.20894/STET.116.008.002.003

Carmona ER, Benito N, Plaza T, Recio-Sánchez G (2017). Green synthesis of silver nanoparticles by using leaf extracts from the endemic Buddleja globosa hope. Green Chem. Lett. Rev., 10(4): 250- 6. https://doi.org/10.1080/17518253.2017.1360400

Edziora K, Speruda A, Krzy˙zewska M, Rybka E, Łukowiak J, Bugla-Płosko A, ´nska G (2018). Similarities and differences between silver ions and silver in nanoforms as antibacterial agents. Int. J. Mol. Sci., 19: 444. https://doi.org/10.3390/ijms19020444

Fatima SA, Jassim MA, Nadhim SJ (2023). Incidence rate of some food borne pathogens bacteria from red meat and chicken meat in duhok prevalence. J. Univ. Duhok, 22(1): 201-206.

Gauthami M, Srinivasan NM, Goud N, Boopalan K, Thirumurugan K (2015). Synthesis of silver nanoparticles using Cinnamomum zeylanicum bark extract and its antioxidant activity. Nanosci. Nanotechnol. Asia, 5(1): 2-7. https://doi.org/10.2174/2210681205011507281 03209

Hamzah HM, Saleh RF, Maroof MN (2018). Fusarium mangiferae as New Cell Factories for Producing Silver Nanoparticles. J. Microbiol. Biotechnol., 28(10): 1654-1663 https://doi.org/10.4014/jmb.1806.06023

Hu B, Wang SB, Wang K, Zhang M, Yu SH (2008). Microwave-assisted rapid facile "green" synthesis of uniform silver nanoparticles: Self-assembly into multilayered films and their optical properties. J. Phys. Chem.,112: 11169- 11174. https://doi.org/10.1021/jp801267j

Ibrahim OMS, Saliem AH MSalih SI (2016). Antibacterial activity of silver nanoparticles synthesized by Cinnamon zeylanicum bark extract against Staphylococcus aureus. Al-Anbar J. Vet. Sci., 9 (1):45-90. https://doi.org/10.36326/kjvs/2016/v7i14294

Jacob IS, Ravikumar S, Manikandan N (2011). Antibacterial potential of silver nanoparticles against isolated urinary tract infectious bacterial pathogens. Appl. Nanosci., 1: 231-236. https://doi.org/10.1007/s13204-011-0031-2

Jahn W (1999). Chemical aspects of the use of gold clusters in structural biology. J. Struct. Biol., 127(2):106-12. https://doi.org/10.1006/jsbi.1999.4123

Khan M, Tareq F, Hossen M, Roki M (2018). Green synthesis and characterization of silver nanoparticles using Coriandrum sativum leaf extract. J. Eng. Sci. Technol., 13(1): 158-66.

kinsella KJ, Prendergast DM, McCann MS, Blair IS, McDowell DA, Sheridan JJ (2008). The survival of Salmonella enterica serovar Typhimurium DT104 and total viable counts on beef surfaces at different relative humidities and temperatures. J. App. Microbiol., 106: 171–180. https://doi.org/10.1111/j.1365-2672.2008.03989.x

Lara HH, Ayala-Núñez NV, Ixtepan LDC, Rodríguez C (2010). Bactericidal Effect of Silver Nanoparticles against Multidrug-Resistant Bacteria. World J. Microbiol. Biotechnol., 26: 615–621. https://doi.org/10.1007/s11274-009-0211-3

Li WR, Sun TL, Zhou SL, Ma Y K, Shi Q S, Xie ZB, Huang XM (2017). A comparative analysis of antibacterial activity, dynamics, and effects of silver ions and silver nanoparticles against four bacterial strains. Int. Biodeterior. Biodegrad., 123:304–310. https://doi.org/10.1016/j.ibiod.2017.07.015

Lopez P, Sanchez C, Batlle R, Nern C (2005). Solid–vapor-phase antimicrobial activities of six essential oils: susceptibility of selected foodborne bacterial and fungal strains. J. Agric. Food Chem., 53: 6939-6946. https://doi.org/10.1021/jf050709v

Mallikarjuna K, Narasimha G, Dillip GR, Praveen B, Shreedhar B, Sree lC, Reddy BV, Deva PR (2011). green synthesis of silver nanoparticles using ocimum leaf extract and their characterization. Digest Journal of Nanomaterials and Biostructures. 6(1): 181 – 186.

Manual of Clinical Microbiology (MOCM) (2002). 7th edition. Washington DC USA American Society for Microbiology Press, 442-631.

Namasivayam SJ, Jayakumar D, Kumar R, Bharani RS (2015). Antibacterial and anticancerous biocompatible silver nanoparticles synthesized from the cold-tolerant strain of Spirulina platensis. J. Coastal Life Med., 3(4): 265-262.

Oluwatobi FB, Stephen-Amzat B, Fabulous-Fabowale TA (2021). Isolation and Identification of Pathogenic Bacteria Associated with Raw Meat from Different Locations in Ado-Ekiti. Int. J. Res. Innov. Appl. Sci., 6(3): 2454-6194.

Ouda M (2014). Some Nanoparticles Effects on Proteus sp. and KLebsiella sp. Isolated from Water. AJIDM., 2: 4–10. https://doi.org/10.12691/ajidm-2-1-2

Pal S, Tak YK, Song JM (2007). Does the antibacterial activity of silver nanoparticles depend on the shape of the nanoparticle? A study of the gram-negative bacterium Escherichia coli. Appl. Environ. Microbiol.,73(6):1712-20. https://doi.org/10.1128/AEM.02218-06

Parameswari E, Udayasoorian C, Paul Sebastian S,Jayabalakrishna RM (2010). The bactericidal potential of silver nanoparticles. Int. Res. J. Biotechnol., 1: 44-49.

Premkumar J, Sudhakar T, Abhishek Dhakal, JeshanBabu Shrestha, Krishnakumar S, Balashanmugam P (2018). Synthesis of silver nanoparticles (AgNPs) from cinnamon against bacterial pathogens. Biocatal. Agric. Biotechnol., 15: 311-316. https://doi.org/10.1016/j.bcab.2018.06.005

Reyam FS, Ayad MG (2021). Biosynthesis and characterization of silver nanoparticles using Cinnamomum zeylanicum extract and a study of antibacterial effect against multi-drug resistance Gram-negative bacteria. Biomedicine, 41(2): 249-255. https://doi.org/10.51248/.v41i2.791

Singh P, Kim YJ, Zhang D, Yang DC (2016). Biological synthesis of nanoparticles from plants and microorganisms. Trends Biotechnol., 34(7): 588-99. https://doi.org/10.1016/j.tibtech.2016.02.006

Sathishkumar M, Sneha K, Won SW, Cho CW, Kim S, Yun YS (2009). Cinnamon zeylanicum bark extract and powder mediated green synthesis of nano-crystalline silver particles and its bactericidal activity. Colloids Surf. B., 73(2): 332-338. https://doi.org/10.1016/j.colsurfb.2009.06.005

Salami E, Karami M, Dehkordi AJ, Nadoushan MJ, Hajnorouzi A (2018). Protective effect of silver nano particles against ovarian polycystic induced by morphine in rat. Nanomedicine Res. J., 3: 229–235.

Sathishkumar M, Sneha K, Won SW, Cho CW, Kim S, Yun YS (2009). Cinnamon zeylanicum bark extract and powder mediated green synthesis of nano-crystalline silver. Appl. Nanosci., 34-56. https://doi.org/10.1016/j.colsurfb.2009.06.005

Saleh RF, Gaidan AM, Al-Mayah QS (2021). Green Synthesis of silver nanoparticles using aqueous leaf extract of Ocimum basilicum and investigation of their potential antibacterial activity. Trop. J. Nat. Prod. Res., 5(1): 94- 99. https://doi.org/10.26538/tjnpr/v5i1.12

Shan B, Cai Y Z, Sun M, Corke H (2005). Antioxidant capacity of 26 spice extracts and characterization of their phenolic constituents. J. Agric. Food Chem., 53: 7749- 7759. https://doi.org/10.1021/jf051513y

Shankar SS, Ahmad A, Sastry M (2003). Geranium leaf assisted biosynthesis of silver nanoparticles, Biotechnol. Prog., 19: 1627–1631. https://doi.org/10.1021/bp034070w

Supriya1 G, Chaitanya Sk (2019). Green synthesis of silver nanoparticles using Aloe vera extract and assessing their antimicrobial activity against skin infections. Int. J. Sci. Res. Biol. Sci., 6(1): 31.

Srinivasan P, Sudhakar S, Sengottaiyan A, Subramani P, Sudhakar C, Thiyagarajan KMP (2014). Green synthesis of silver nanoparticles using Cassia auriculata flower extract and its antibacterial activity. 42-46.

Siddiqi KS, Husen A, Rao, RAK (2018). A review on biosynthesis of silver nanoparticles and their biocidal properties. J. Nanobiotechnol., 16: 1–28. https://doi.org/10.1186/s12951-018-0334-5

Singh A, Gautam PK, Verma A, Singh V, Shivapriya PM, Shivalkar S (2020). Green synthesis of metallic nanoparticles as effective alternatives to treat antibiotics resistant bacterial infections: A review. Biotechnol. Rep., 25: e00427. https://doi.org/10.1016/j.btre.2020.e00427

Salas-Orozco M, Niño-Martínez N, Martínez-Castañón GA, Méndez FT, Jasso MEC, Ruiz F (2019). Mechanisms of resistance to silver nanoparticles in endodontic bacteria: a literature review. J. Nanomater., (35):1-11. https://doi.org/10.1155/2019/7630316

Stoimenov P K, Klinger R L, Marchin, G L, Klabunde K J (2002). Langmuir, 18. 6679. https://doi.org/10.1021/la0202374

Sekatawa K, Byarugaba D, Kato C, Nakavuma J, Wampande E, Ejobi F (2021). Physiochemical properties and antibacterial activity of silver nanoparticles green synthesized by Camellia sinensis and Prunus africana extracts. Res sq., 21. https://doi.org/10.21203/rs.3.rs-143995/v1

Tong JW (2009). Case reports on the use of antimicrobial (silver impregnated) soft silicone foam dressing on infected diabetic foot ulcers. Int. Wound J., 6: 275–284. https://doi.org/10.1111/j.1742-481X.2009.00610.x

Verspohl EJ, Baeur K, Neddermann E (2005). Antidiabetic effect of Cinnamomum cassia and Cinnamomum zeylanicum in vivo and in vitro. Phytother. Res., 19: 203- 206. https://doi.org/10.1002/ptr.1643

Williams AR, Ramsay A, Hansen TV, Ropiak HM, Mejer H, Nejsum P, Mueller-Harvey I, Thamsborg SM, (2015). Anthelmintic activity of trans - cinnamaldehyde and A- and B-type proanthocyanidins derived from cinnamon (*Cinnamomum verum*) .Sci. Rep., 5:14791. https://doi.org/10.1038/srep14791

Yaqoob AA, Ahmad H, Parveen T, Ahmad A, Oves M, Ismail I MI, Qari HA, Umar K, Mohamad Ibrahim MN (2020). Recent Advances in Metal Decorated Nanomaterials and Their Various Biological Applications: A Review. Front. Chem., 8: 341. https://doi.org/10.3389/fchem.2020.00341

Yusof HM, Rahman A, Mohamad NR, Zaidan UH (2020). Microbial mediated synthesis of silver nanoparticles by *Lactobacillus plantarum* TA4 and its antibacterial and antioxidant activity. Appl Sci., 10:6973. https://doi.org/10.3390/app10196973

Zhang XF, Liu ZG, Shen W, Gurunathan S (2016). Silver nanoparticles: synthesis, characterization, properties, applications, and therapeutic approaches. Int. J. Mol. Sci., 17(9): 1534. https://doi.org/10.3390/ijms17091534