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Silver Nanoparticles Synthesis by Green Method and Loading of the Enterosein to Study Its Antimicrobial Inhibition

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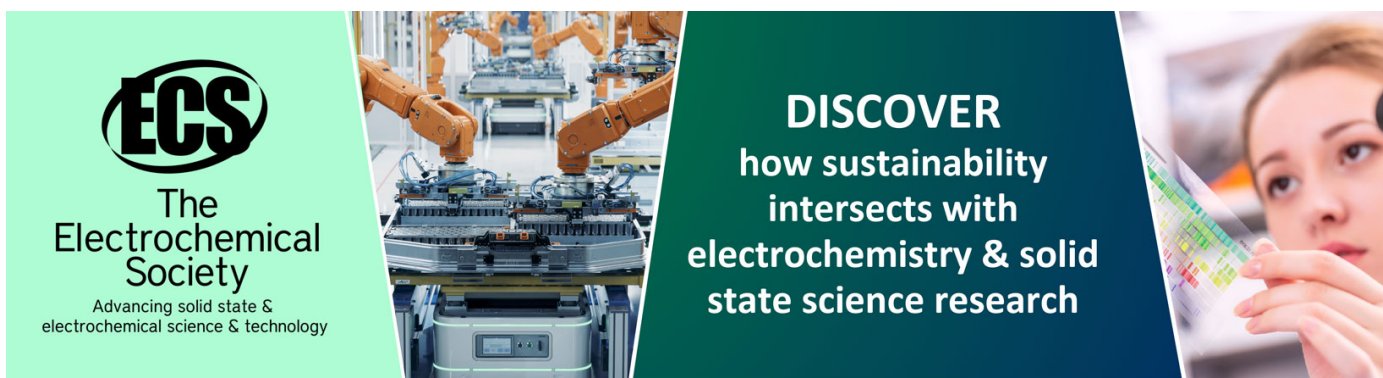
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SILVER NANOPARTICLES SYNTHESIS BY GREEN METHOD AND LOADING OF THE ENTEROSEIN TO STUDY ITS ANTIMICROBIAL INHIBITION

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ABSTRACT

This study aims to loaded the Enterocin produced from *Enterococcus faecalis* bacteria on silver nanoparticles(SNP+En) by using green synthesis ,to increase the effectiveness of Enterocin against some Gram-positive and negative bacteria *Escherichia coli*, *Pseudomonas aeruginos*, *Salmonella typhimurium* , *Staphylococcus aureus*, *Bacillus subtilis* and *Candida albicans* yeast. SNP was synthesized by using *Alettaria cardamomum* alcohol extract as a reducing agent, then it was loaded with Enterocin . The color change of the extract was preliminary evidence of the reduction process. The UV–Visible spectral analysis confirmed the synthesis of SNP and SNP+En showing a characteristic peak around 452-419 nm due to the absorption of the surface of the plasmon and SEM from 18-88 nm, analysis to the X-ray data indicated that SNP and SNP+En have four clear peaks were shown at the angle of Θ 38 °, 44 °, 64 ° and 77.5 °, and this is due to symmetry levels (111) and (200) (220) and (310) preferentially at the level (111) and zeta potential for SNP it reached 22.55 mV and it became 31.25 mV for SNP + En . demonstrated Inhibitory effect against Gram-positive and negative bacteria for SNP + En was more than SNP at the same ratio(0.1%).

keywords: UV , antibacterial activity, SEM , nanoparticles, Characterization

INTRODUCTION

Researches in the field of nanotechnology over the past two decades has opened the door to unlimited opportunities to solve many problems associated with a wide range of biological products and in the food sector. Interferences between nanoparticles and bacteriocin on high potentials to achieve benefit in increasing the spectrum inhibiting the microbes and the interaction may also lead to a decrease In the requirements for the high dose of bacteriocin and the extension of the shelf life, and when nanoparticles packaging the bacteria made in food preservation, it protects them from decomposition by digestive enzymes and can increase their commercial return and stability [1].Nanotechnology was used to solve the problems of using nisin as a food additive in food preservation as it was found that it may interfere with food ingredients such as fats and proteins [2]. Although nisin is widely used in the food industry, the effectiveness of nisin decreased due to the



development Bacterial resistance. For example, *Staphylococcus aureus* has degraded nicin as a result of its secretion of the nisinase enzyme, so it has been possible to improve the effectiveness of nicin by biocompatible with nanoparticle minerals [3]. The proposed working mechanism for metallic nanoparticles is a promising approach to solving the problem of antimicrobial resistance. Therefore, the mixture of bacteria and nanoparticles is expected to have a synergistic effect on antibacterial properties. In a recent study that stated the association between nanoparticles of gold with nicin or bacteriocin produced from *L. plantarum* ATM11 both showed higher antibacterial activity compared to bacteriocin alone, especially against the bacteria *M. luteus*, *B. cereus*, *E. coli*, *S. aureus* [4]. This demonstrates the efficacy of this pairing in extending the shelf life of food products by inhibiting a number of microorganisms that cause food spoilage. In a similar study, the association of bacteriocin produced from *L. acidophilus* CH1 with gold nanoparticles led to a composition with a strong activity against micro-intestinal microbes in immunocompromised mice. Moreover, it was found that these bacteriocin associated with nano were safe and non-toxic, as evidenced by During behavioral tests, biochemical analysis, and histological examination tests [5]. The antimicrobial efficacy of the silver nanoparticles increases by their association with antimicrobial agents, such as bacteriocin. When enveloping the nanoparticles with Enterocin (SNPs+En) has shown excellent efficacy against a wide range of Gram-negative and positive bacteria. It exhibited the highest level of activity against three of the most common food poisoning organisms, *E. coli*, *L. monocytogenes*, *S. aureus* [6]. The aim of this study is loading Enterocin produced from *Enterococcus faecalis* bacteria on silver nanoparticles SNP +En by using green method, to increase its effectiveness against some of Gram-positive and negative bacteria.

MATERIALS AND METHODS

Preparation of *Alettaria cardamomum* extract

The whole bobs dried cardamom were obtained from commercial market in Baghdad, they were medium in size, grounded by grind mill to obtain cardamom powder, according method [7].

Estimating the inhibitory efficacy of *Alettaria cardamomum* extract

1 gm of prepared *Alettaria cardamomum* alcohol extract powder was dissolved with 100 ml ion-free water, Then was added 2.5 ml of the extract to 100 ml of distilled water with continues stirring until thawing to obtain the same percentage of the extract in which the silver nanoparticles attended, then followed the method well diffusion according method [8] against a group of Gram-negative and positive bacteria (*Pseudomonas aeruginosa*, *E. coli*, *Salmonella typhimurium*, *Bacillus subtilis*, *Staphylococcus aureus*) as well as *Candida albicans* yeast.

Antimicrobial activity and determination minimum inhibitory concentration (MIC) of Enterocin

Enterocin produced from *E. faecalis* bacteria followed the modified method according to [9] in the test of determining the minimum inhibitory concentration of Enterocin under study against microorganisms.

Synthesis of silver nanoparticles

The method was carried out according to [10] followed some modification, 100 ml of silver nitrate solution 0.1 M was put on the magnetic motor for 30 minutes to ensure solubility,

2.5ml of cardamom extract have been prepared was added gradually to the silver solution nitrate with stirring at 40 – 50 temp. until changes in color within 6 hours to yellow, clearly indicate for formation of silver nanoparticles, Solution were further centrifuged at 6 000 rpm for nearly 15 minutes and remove the majority of the leachate. Silver nanoparticles thus obtained were collected and resuspended in 2 ml of ionic water and in order to remove impurities, this process was repeated for twice time. The remains transferred in to abndorf tube was centrifuged under 12000 rpm for 10 min then washed by 1ml aqueous water. Dried under vacuum at 50° C for 24 hours. The powder obtained through the process described above was placed in a sterile container in refrigerator at 4C.

Preparation of SNP+En

It was carried out as method described above in addition to adding concentration minimum inhibition of Enterocin with silver nitrate was prepared before with more stirring for 24 hours on heating for 8 hours, then used the same steps described above.

characterization of SNP and SNP+En

The characterization process was done using UV-visible spectrometer (UV), Scanning electron microscopy (SEM) , X-ray diffraction (XRD) zeta potential for SNP and SNP+En , before and after washing

Antimicrobial activity of SNP and SNP+En

0.01g of the powder of SNP and SNP+En were dissolved in 10 ml of ion-free water. Agar well diffusion method was used according to the method mentioned above.

RESULTS AND DISCUSSION

Ethanollic *Alettaria cardamomum* extract not observed any inhibition effectance on Gram-negative , positive bacteria and yeast at the same concentration was used in the work although it is contain the compounds , alkaloids, tannins, volatile oils, soaps, soaps, turbines, flavonoids and coumarines that are considered anti-bacterial substances [53][11] . This is due to the low concentration of the extract used which is up to 1% due to the lack and quality of the active compounds in sufficient quantities to give the inhibitory efficacy of the used bacteria [12] reported That methylated red bean extract did not show any inhibiting result for the studied bacterium species, namely *S. aureus* and *S. epidermidis*. Many researchers explained the negative results to the active compounds may be present in insufficient quantities in the raw extracts to give inhibitory effectiveness, and even If the active ingredient is present in high quantities, then there are may be other components that show antagonistic effects of the positive effect of biologically active agents, or the extracts may be effective against other bacteria types not used in the current study. [13] indicated that the metallic alcohol extract of fenugreek seeds was effective with an inhibition diameter was 18 mm towards only one strain *E.coli* No. PTCC(1330), but it was not effective to strain No PTCC(1338) for the bacteria themselves [14] stated that the aqueous and alcoholic extracts of red bean seed showed no result in testing its efficacy with *E. coli*, *K. pneumoniae* and other bacteria. As for the study conducted by [15],), when used an alcoholic extract of piper nigrum, ther was no inhibition recorded to *S. aureus* bacteria, as was the case in *E. coli* bacteria. [16] reported that the ethyl alcohol extract of *P. guineense* had an inhibitory effect of *E. coli* and also conducted a study on the effect of black

and white pepper on 20 types of *salmonella* and 5 types of intestinal bacteria, but it did not record a significant result and this comes similar to the results of the current study . This is consistent with what [17] found when using alcoholic cardamom extract that high concentrations (240, 480) mg / ml are better by inhibiting positive and negative bacteria for a gram stain than low concentrations of (60-30) mg / ml.

minimum inhibitory concentration (MIC)

The results confirmed in Table (1) showed that the Enterocin didn't inhibit the growth of Gram-negative bacteria except *Pseudomonas aeruginosa* also not Inhibition Gram-positive bacteria except *Staphylococcus aureus* and did not inhibit *candida albicans* and the results of the test indicated that the lowest inhibitory concentration was 12.5 mg / ml against *Pseudomonas aeruginosa* bacteria. Where the diameter of the inhibition was 10 mm while the inhibition diameter was 13, 17, 25 mm respectively, for the concentrations used 25, 50, 100 mg / ml. [19] showed that Enterocin it characterized by inhibiting activity against many bacterial isolates, but the efficacy has not been shown in clear direction towards *Staphylococcus carnosus*, *Clostridium Sporogenes* and *Bacillus cereus*. [20] study indicated that bacteria isolated from different types of *Enterococcus faecalis* isolates didn't show any inhibitory spectrum toward Gram-negative and positive bacteria such as *Ecoli*, *Listeria innocua*, *Staphylococcus aureus*, *B. megaterium*, *B. cereus*, *Bacillus*, While the results we reached differed with several results [21]

Table (1) Antibacterial activity of minimal Enterocin concentration against some bacteria

organism		Diameter of Inhibition Zone (mm)			
		12.5	25	50	100
G-	<i>E.coli</i>	-	-	-	-
	<i>Pseudomonas aeruginosa</i>	10	13	17	25
	<i>Salmonella typhimurium</i>	-	-	-	-
G+	<i>Bacillus subtilis</i>	-	-	-	-
	<i>Staphylococcus aureus</i>	-	12	15	19
<i>Candida</i>		-	-	-	-

Data are mean of two replications

- No inhibition was observed

indicate its effect on sensitive isolates that may be caused by stimulation of some self-hydrolysis enzymes (Autolysine) that are under natural conditions linked to fatty acids that enter the wall and that work to break down the membranes of bacterial cells through the formation of ion channels It leads to the depolarization of cell membranes (Depolarization) [22]. Whereas the resistance of other isolates lies in their possession of a gene that encodes

immunity to introsin, or some minor changes in the structure of the membranes and walls of these cells or their lack of the specific receptors for this bacterium. Wossen [23]

Reaction chemistry

The results showed in Fig. (1-A) showed that the prepared SNP are yellow-brown. The appearance of SNP in a color other than silver particles is due to the phenomenon of surface plasmon resonance. As the property of surface plasmon resonance occurs in some metals such as silver as a result of the arrival of the diameter of their particles to the nanometer scale, and that color change is a preliminary evidence of the formation SNP [24]. The color change occurs to the presence of reducing agents in the plant extract used in the study [7]. When using the plant extract as a reducing agent and at temperatures between 40-30 m, and as it is known, the use of heat is one of the factors that accelerate the reduction process, as the heat dominates the formation SNP [25], due to the reason for the formation of nanoscale This indicates that adding the plant extract to the solution of silver salts works to reduce the yellowish-white color as a result of adding the extract to the solution and converting it to yellowish-brown colors passing through several color changes (form). SEM This result is consistent with the results of a number of researchers in this field [26]. This method is considered one of the safest methods of reduction compared to other methods of creation[27].

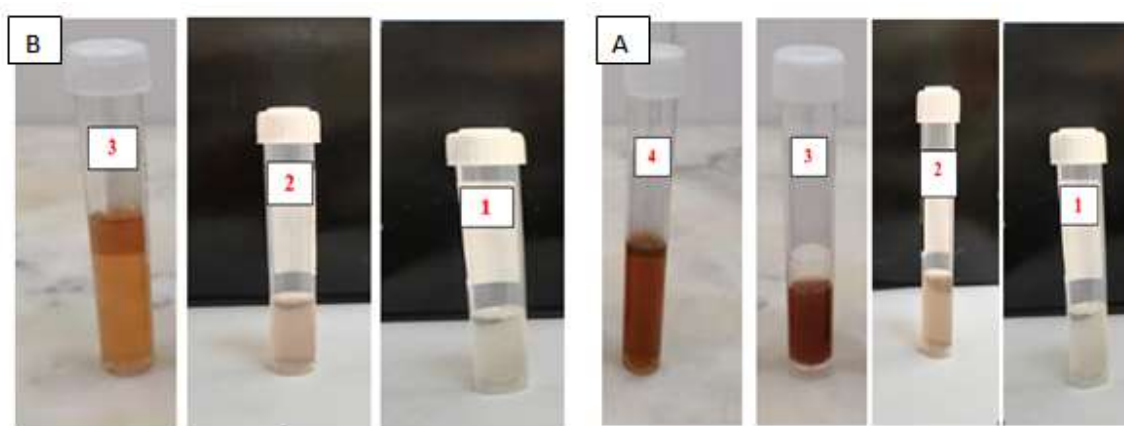


Figure (1) shows a color change during the formation SNP (A) and the formation SNP+En (B).

Whereas the color of the solution of SNP+En was a dark brown Fig. (1 -B), when mixing the silver nitrate with Enterocin and by adding the extract, the color turned to dark brown with the help of heat (50-40) m for 8 hours, while the color was turned to yellowish brown in the absence Interferin is about 6.30 hours, and this difference in time may be due to the process of converting silver salts into silver nanoparticles and conducting the process of linking to Enterocin by adding the extract as a reducing agent, and the appearance of dark color indicates the large size of the silver particles loaded with Enterocin and was proven through examination by the SEM device. This finding is consistent with the results of a number of researchers in this field [28]. The appearance of this color is also due to the surface plasmon resonance of the SNP formed, which in turn is due to the influence of the interaction between the fluctuation of the electric / magnetic fields of the electromagnetic waves, including visible light with the

surface electrons of the silver . The characteristic depends on distinguishing volume change [6].

characterization of SNP and SNP+En.

SEM measurement

SNP prepared before measured an electronic scanner (SEM), this examination helps in diagnosing nanoparticles and the effect of their size on the surface change of the plasmon, whose color has been changed. Fig. (2-A) appeared SNP spherically and in different sizes as in a rate of 42-18 nm and the difference in the size of the SNP formed due to the concentration of the extract as a reducing agent, temperature plays an important role in determining the size and shape of nanoparticles [29] , the difference in the particles size in the sample indicates that it was formed in different times [30]. Prepared particles bound to Enterocin, which became at a rate of 81.5-88nm Fig. (2-B) This result is consistent with what found Hadedee [31]

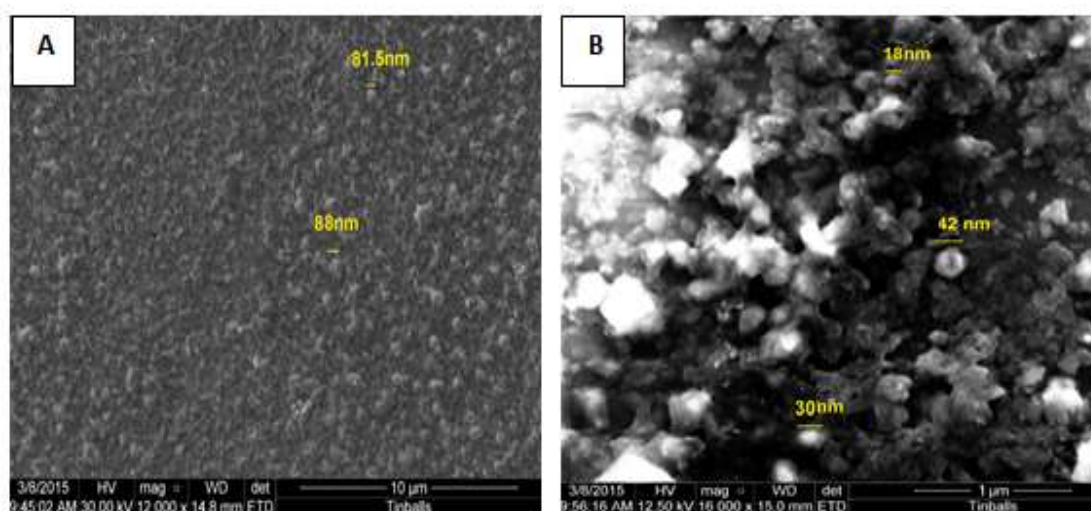


Figure (2) SEM Images of SNP (A) and SNP+En (B)

Measurement of the UV absorption spectrum:

the absorption spectrum of the prepared SNP represented by Fig. (3-C) where it was 424 nm, while the highest absorption spectrum of SNP + En represented by Fig. (3-D) was 452 nm before washing. After washing, the highest absorption spectrum of the prepared SNP was represented Fig.(4-A) where it was 419nm, while the highest absorption spectrum of SNP + En represented by Fig. (4-B) was 435 nm. Through the results of the analysis of the visible-ultraviolet spectrum of the sample under study, we confirmed the presence of SNP because the appearance of absorption peaks at wavelengths between 450-400 nm is a characteristic of the diagnostic properties of nanoparticles due to the absorption of the surface of the plasmon (SPR)[32]. This is a first indication of SNP formation compared to the absorption spectrum of cardamom extract represented by Fig. (3-B) and silver nitrate represented by Fig. (3-A) whose absorption spectrum did not appear at the top within these distinct limits of SNP.

The appearance of the highest absorbing value is due to the interaction between light and silver nanoparticles as nanoscale metals possess free electrons and give these electrons a surface plasmon resonance that depends on their size and this resonance is caused by the vibrations of metal electrons compared to light waves [33] This confirms our findings that the highest

absorption spectrum for the prepared SNP was less than the absorption spectrum SNP + En [34]. The location of the highest absorption (highest peak) depends on the size and shape of the nanoparticles [35], our results agreed with [3] when they synthesized the SNP using the *Cymbopogon citratus* extract and then the biological association of those nanoparticles with the silver nanoparticles nisin where SNP showed peak absorption at 432 nm and after the dynamic pairing of SNP with nisin the absorption spectrum reached 457 nm. Similarly to what was mentioned by [36] when synthesizing SNP+ Nisin in different conditions a peak of UV absorption for Nisin was 450 nm.

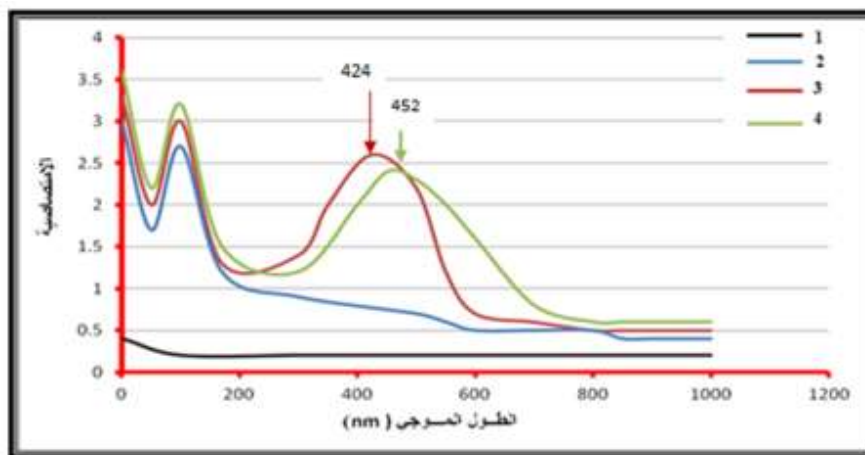


Figure (3) Spectral absorption UV visible

- A- Absorbance of silver nitrate salts
- B- Absorption of plant extract
- C- SNP absorbency prepared using cardamom extract after washing
- D- SNP + En absorbency prepared using cardamom extract after washing

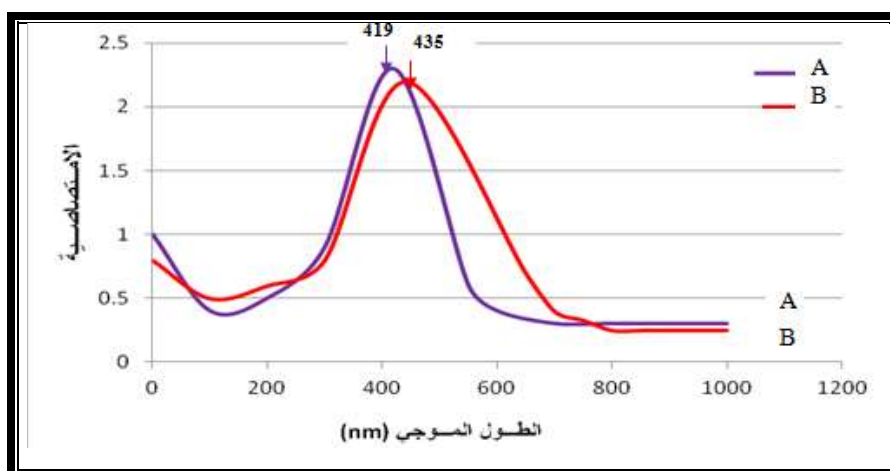


Figure (4) Spectral absorption UV visible

- A -Absorbency of SNP prepared using cardamom extract after washing
- B- Absorbance of SNP + En prepared using cardamom extract after washing

Zeta potential :

zeta potential was measured for the prepared SNP by using the extract, as The zeta potential for the prepared SNP was 41.55 mV while the (SNP + En) was 32.25 mV, this difference in the zeta potential may be due to the positive nature of the Enterocin [37] The magnitude of the zeta force is a prediction of colloidal stability, as nanoparticles with The zeta potential values greater than + 30 mV or less than -30 mV are characterized by high levels of stability [23] and represent a high value of zeta potential (I.e. the occurrence of strong repulsive forces between the particles) thus prevent agglomeration [38] These results coincide with what [3] found, that the potential of Zeta potential for SNP prepared from the *Cymbopogon citratus* extract was 27.7 mV, while the potential Zeta potential for the silver nanoparticle associated with Nicin was 23.3- mV. Likewise, with what [39] when linking the antimicrobial peptide (AMP) with the silver nanoparticles and found a measurement of the zeta potential -37 mV and explained in the reason the negative value of the Zeta potential is the presence of citrate , and the researcher found the positive peptide had a surface charge of 2.12 mV And when paired with SNP, A negative surface potential has decreased to -11.2 and this indicates that the negative charge of the SNP covered citrate is partially neutralized (removed) when interacting with the positively charged peptide. Whereas, the results differed with [40] when they attended the silver nanoparticles depending on the chemical method and then encapsulated them with bacteria to increase their activity towards pathogenic organisms in foods where they were SNP 23- mV and they became (SNP + En) 34.8- mV

X-ray diffraction

XRD technology is used to reveal information about the crystal structure and the physical properties of the studied material [41]. The X-ray diffraction form of *Alettaria cardamomum* extract appeared as a winding

line without tops Fig (5), and this indicates that there is no crystallization in the extract and when adding the silver salts and after completing the experiment, the diffraction patterns showed the sample to the presence of four clear peaks within the angular range (0 ° -100 °) where the peaks appeared at the angle of 2θ 38 ° and 44 ° and 64 ° and 77.5 ° Fig. (6) before washing ,and Fig. (7)after washing, this is due to the symmetry of levels (111), (200), (220), and (310) and towards my preferences at the level (111) This is consistent with the study by [31] when preparing the SNP in a dynamic way as patterns showed X-ray diffraction at the angle 2θ 78 ° 66 °, 44 ° 38 °, which is due to the contradiction of levels (111) (200), (220), (311) and also agrees with [3]

These indicators indicate the nature of the prepared SNP synthesis, which was a focal point cube (fcc), and this corresponds to the standard tables (JCPDS), as well as the appearance of

the peaks themselves in SNP+En Fig. (8) before washing and after washing Fig. (9) . Between the angle of 18 to 25 note that it does not belong to the distinct peaks of the SNP, but it can be attributed to its appearance as a result of the crystallization of Enterocin on the surface of the SNP and this is consistent with what proved [42]. It is one of the evidence for the success of the process of linking SNP with Enterocin.

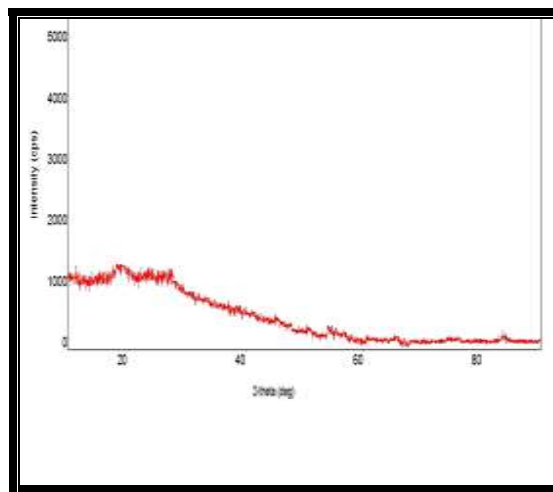


Figure (5) XRD for the extract

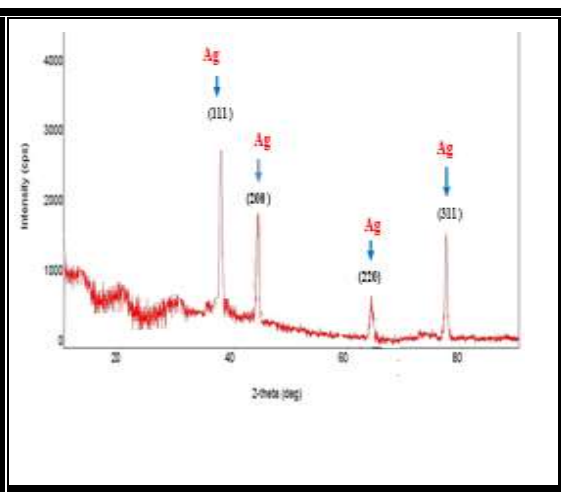


Figure (6) XRD for SNP

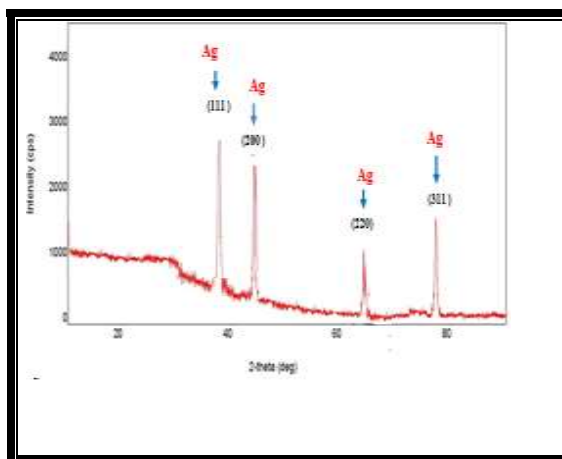


Figure (7) XRD for SNP after washing

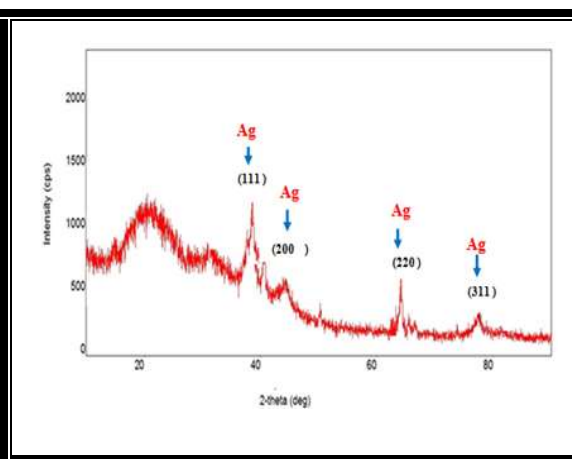


Figure (8) XRD for SNP+En before washing

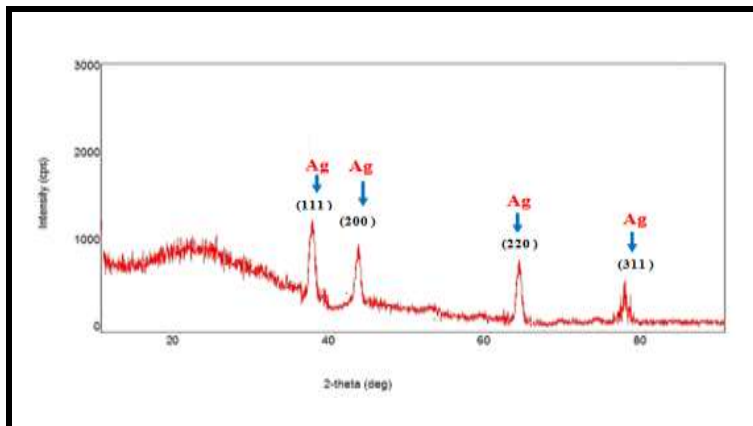


Figure (9) XRD SNP+En after washing

Antimicrobial activity of SNP and SNP+En:

Through Fig. (10-A) follow us the SNP prepared using the extract has a clear inhibiting effect on the group of microorganisms used in the study where the inhibition diameters were 10 mm for *E. coli* , 9 mm for *Pseudomonas aeruginosa* , 7 mm for *Salmonella typhimurium* and 13 mm for *Bacillus subtilis* , 12 mm for *Staphylococcus aureus*. and *candida albicans* yeast was 30 mm when using SNP. From this results, we note SNP has a more negative effect on the negative bacteria than that positive, and this phenomenon can be explained by the difference in the thickness of the cell wall between the Gram-positive and negative bacteria, which mainly consists of peptidoclecans [43]. The inhibition diameter of SNP on microorganisms depends on the size and concentration of the nanoparticles created using the extract [44]. The surface area of the SNP increases with a small size of minutes and thus accumulates in larger numbers on the surface of cells, which leads to an increase in its toxicity to microorganisms as it will affect the permeability of the plasma membrane of bacteria and thus cell death [45], and the mechanism in which nanoparticles interact with bacteria is that microscopic organisms carry a negative charge while nanoparticles carry a positive charge which creates an electromagnetic attraction between bacteria and the surface of nanoparticles and that silver nanoparticles will release ions that interact with the thiol group (-SH) of the proteins that transport the substances Food that protrudes from the bacterial cell membrane, thereby reducing the permeability of the membrane and thus cell death [46]. As for the effect of SNP against DNA, it will affect the multiplication and gene expression of proteins and enzymes necessary for ATP production and thus become ineffective [47] SNP affects cell respiration or interference with components of the electronic transmission system for bacteria [48]. Whereas become increase in the inhibition areas when used SNP +En Fig. (10-B), where it reached 14 mm *E. coli* and 20 mm for *Pseudomonas aeruginosa* , 14 mm for *Salmonella typhimurium* , 17 mm for *Bacillus subtilis* , 23 mm for *Staphylococcus aureus* and *Candida* yeast was 55 mm.

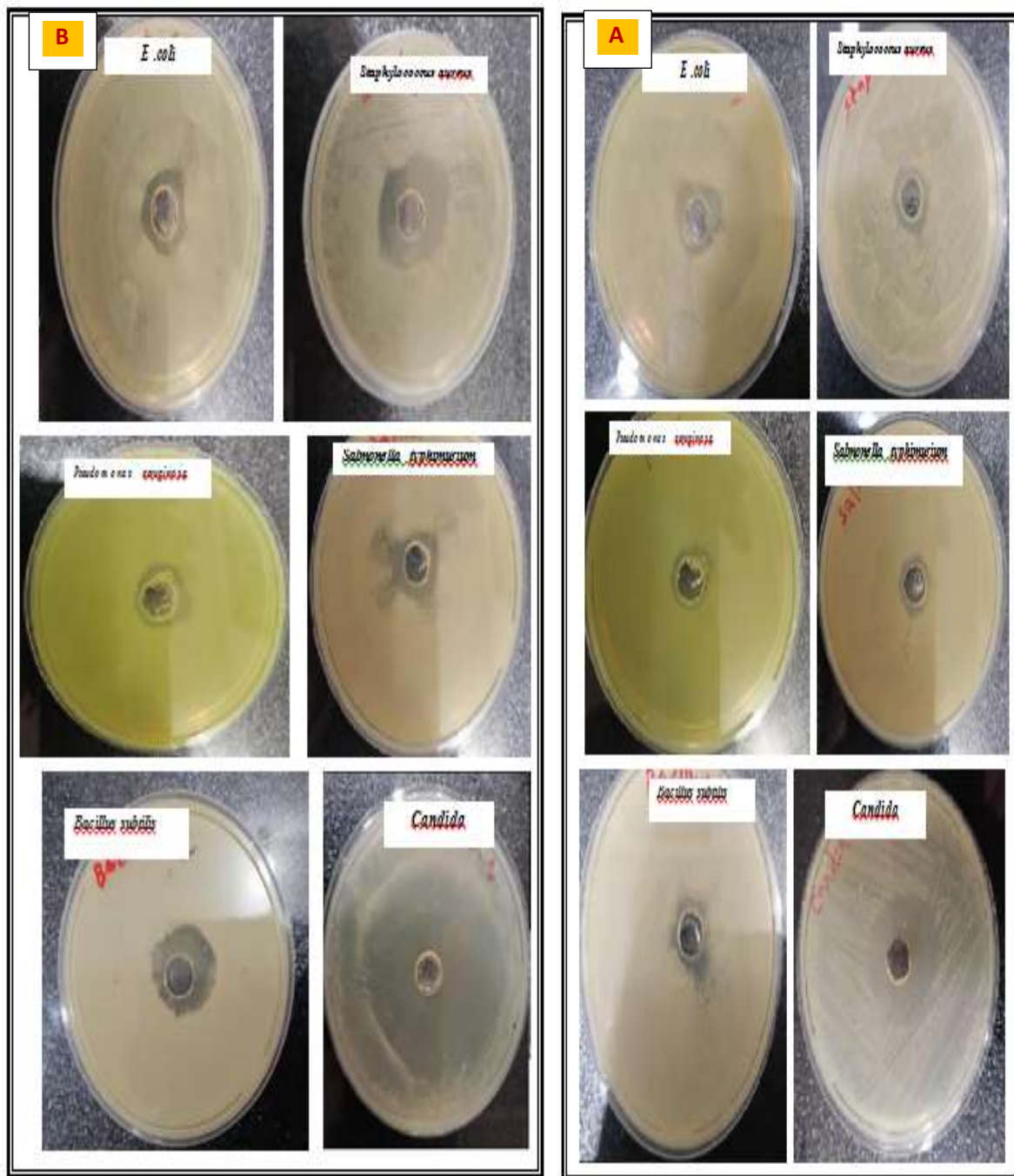


Figure (10) Inhibitory effect of SNP (A) and SNP+En(B) against of some microorganisms

References

- [1] H. A. Fahim, A. S. Khairalla, and A. O. El-Gendy, "Nanotechnology: a valuable strategy to improve bacteriocin formulations," *Frontiers in microbiology.*, vol. 7, , pp. 1385, 2016
- [2] E. Chollet, I. Sebti, A. Martial-Gros, and P. Degraeve "Nisin preliminary study as a potential preservative for sliced ripened cheese: NaCl, fat and enzymes influence on nisin concentration and its antimicrobial activity," *Food Control.*, vol. 19, no. 10, pp. 982–989, 2008
- [3] R. Pandit, M. Rai, and C. A. Santos, "Enhanced antimicrobial activity of the food-protecting nisin peptide by bioconjugation with silver nanoparticles," *Environmental Chemistry Letters .*, vol.15, no. 3, pp. 443–452, 2017
- [4] A. Thirumurugan, S. Ramachandran, and A. Shiamala Gowri , "Combined effect of bacteriocin with gold nanoparticles against food spoiling bacteria-an approach for food packaging material preparation," *International Food Research Journal.*, vol. 20, no. 4, 2013
- [5] S. F. Mossallam, E. I. Amer, and R. G. Diab, "Potentiated anti-microsporidial activity of Lactobacillus acidophilus CH1 bacteriocin using gold nanoparticles," *Experimental parasitology.*, vol. 14, no. 4, pp. 14–21, 2014
- [6] S. C. Hayden, G. Zhao, K. Saha, R. L. Phillips, X. Li, and U. H. Bunz, "Aggregation and interaction of cationic nanoparticles on bacterial surfaces," *Journal of the American Chemical Society.*, vol. 134, no. 16, pp. 6920–6923, 2012
- [7] M.Elmastas, S. Cinkilic, and H.Y. Aboul-Enein , "Antioxidant Capacity and Determination of Total Phenolic Compounds in Daisy (Matricaria Chamomilla,Fam.Asteraceae .," *World Journal of Analytical Chemistry.*, vol. 3, no. 2, pp. 9–14, 2015
- [8] A.G.Oliveira, L.S. Murate, F.R. Lopes,L.D.P. Beranger, and G. Andrade , "Evaluation of the antibiotic activity of extracellular compounds produced by the pseudomonas strain against the Yanthomonas citri PV.Citri .," *Biol. Control.*, vol. 56, no. 2, pp. 125–131, 2011
- [9] M. Hassan; Y. Javazadeh, F. Lotfipour, and A . Badomchi , "Determination of comparative minimum inhibitory concentration (MIC) of bacteriocins produced by enterococci for selected isolates of multi-antibiotic resistant Enterococcus spp," *Adv Pharm Bull Published online.*, vol. 1, no. 2, pp. 75–79, 2011
- [10] E.R. Carmona, N. Benito,T . Plaza, andG. Recio-Sánchez , "Green synthesis of silver nanoparticles by using leaf extracts from the endemic *Buddleja globosa* hope," *Green Chemistry Letters and Reviews.*,vol.10,no.4,pp250–256,2017
- [11] L. TH. AL-Hadedee, T.H. AL Sadoon, and R.A. Chechan, "BIOCOMPATIBILITY OF NANOPARTICLES AND SOME OF IT'S APPLICATIONS," *Biochem. Cell. Arch.*, vol. 20, no. 1, pp. 131-136, 2020, doi: 10.1103/PhysRevLett.91.037401.

- [12] H. Jouad, M. Haloui, H. Rhiauani, and J. Elhilaly, "Ethnobotanical survey of medicinal plants used for the treatment of diabetes, cardiac and renal diseases in the North centre region of Morocco (Fez–Boulemane)," *Journal of Ethnopharmacology*, vol. 77, pp. 1175–182, 2001
- [13] G. H. S Bonjar, , "Screening for antibacterial properties of some Indian plants against two strains of *Escherichia coli*," *Asian J. Sci.*, vol. 3, no. 3, pp. 310–314, 2004 b
- [14] J. Parekh, and S. Chanda, "In vitro screening of antibacterial activity of aqueous and alcoholic extracts of various Indian plant species against selected pathogens from *Enterobacteriaceae*," *African J. Microbiol. Res.*, vol. 1, no. 6, pp. 92–96, 2007
- [15] W.S Abdel Gadir, F. Mohamed, and A. O. Bakhiet, "Antibacterial activity of *Tamarindus indica* fruit and *Piper nigrum* seeds," *Res. J. Microbiol.*, vol. 2, no. 11, pp. 824–830, 2007, doi:
- [16] O. C. Nwinyi, N. S. Chinedu, O. O. Ajani, C. O. Ikpo, and K. O. Ogunniran, "Antibacterial effects of extracts of *Ocimum gratissimum* and *Piper guineense* on *Escherichia coli* and *Staphylococcus aureus*," *African J. Food Sci.*, vol. 3, no. 3, pp. 77–81, 2009
- [17] Z. S. N Mahmoud, and M. A. Khalil, "The effect of aqueous and alcoholic extracts of the *Elettaria cardamomum* on the growth of some bacteria isolated from middle ear infections," *Al-Mustansiriya c.*, vol. 21, no. 6, , 2010
- [18] A. Laukova, S. Czikkova, Z. Vasilkova, P. Juris, and I. Krupicer, "Antimicrobial effect of enterocin ccm 4231 in the Cattle slurry environment. *Cytobios*," *Cytobios.*, vol. 94, pp. 73–79, 1998
- [19] W. Jennes, L.M. Dicks, and D.J. Verwoerd, "Enterocin 012, a bacteriocin produced by *Enterococcus gallinarum* isolated from the intestinal tract of Ostrich," *J. Appl. Microbiol.*, vol. 88, no. 2, pp. 349–357, 2000
- [20] S. Arokiyaraj, V. D. Kumar, T. Kamala, S.K. Park, M. Saravanan, M. ououdina, and S. Vincent, "Biosynthesized silver nanoparticles using floral extract of *Chrysanthemum indicum* L. potential for malaria vector control," *Environmental Science and Pollution Research*, vol. 22, no. 2, p. 9759–9765, 2005
- [21] H. S. Owaid, and H. M. Khammas, "The effect of enterocin produced by enterophageal stool bacteria on diarrheal bacteria in children and young sheep," *Al-Qadisiyah Journal of Veterinary Medicine Sciences.*, vol. 2, no. 21, pp. 2, 2013
- [22] A. Gálvez, M. Maqueda, M. Martínez-Bueno, and E. Valdivia, "Bactericidal and bacteriolytic action of peptide antibiotic AS-48 against Gram-positive and Gram-negative bacteria and other organisms," *Research in microbiology.*, vol. 140, no. 1, pp. 57–68, 1989
- [23] G. Fimland, R. Jack, G. Jung, I. F. Nes, and J. Nissen-Meyer, "The bactericidal activity of pediocin PA-1 is specifically inhibited by a 15-mer fragment that spans the bacteriocin from the center toward the C terminus," *Appl. Environ. Microbiol.*, vol. 64, no. 12, pp. 5057–5060, 1998
- [24] K. B. Narayanan, and N. Sakthivel, "Green synthesis of biogenic metal nanoparticles by terrestrial and aquatic phototrophic and heterotrophic eukaryotes and biocompatible agents," *Advances in Colloid and Interface Science.*, vol. 169, no. 2, pp. 59–79, 2011

- [25] M. M. Kadhum, and N. N. Hussein, "ANTIMICROBIAL ACTIVITY OF SILVER NANOPARTICLES BIOSYNTHESIZED BY STREPTOCOCCUS PYOGENES BACTERIA," *Iraqi Journal of Agricultural Sciences.*, vol. 51, no. 2, pp. 500–507, 2020
- [26] J. Karthikeyan, K. M. Nila, G. Thooyavan, and E. Vimalkumar, "Larvicidal and antibacterial efficacy of green synthesis silver nanoparticles using *Mella dubia*," *International Journal of Pharmacy and Pharmaceutical Sciences.*, vol. 6, pp. 395–399, 2014
- [27] V. V. Makarov, A. L. Love, O. V. Sinitsyna, S. S. Makarova, I. V. Yaminsky, and N. O. Kalina, " "Green" Nanotechnologies: Synthesis of Metal Nanoparticles Using Plants. *Acta Naturae*," *Acta Naturae.*, vol. 6, no. 1, pp. 35–44, 2014
- [28] A. N. Shipway, E. Katz, and I. Willner, "Nanoparticle arrays on surfaces for electronic, optical, and sensor applications," *ChemPhysChem.*, vol. 1, no. 1, pp. 18–52, 2000
- [29] K. S. Tapan, A. Pal, N. R. Jana, Z. L. Wang, and T. Pal, "Size controlled synthesis of gold nanoparticles using photochemically prepared seed particles," *Journal of Nanoparticle Research.*, vol. 3, no. 4, pp. 257–261, 2001
- [30] R. Geethalakshmi, and D. V. L. Sarada, "Gold and silver nanoparticles from *Trianthema decandra*: synthesis, characterization, and antimicrobial properties," *International journal of nanomedicine.*, vol. 7, no., pp. 5375, 2012
- [31] L. T. H. Hadedee, A. A. Taha, A. A. Suleiman, "Detection and Killing of Food Poisoning *Salmonella Typhimurium* in Cheese by Using Monoclonal Antibody and Nanoparticles Complex," *Research & Reviews: Journal of Food Science and Technology.*, vol. 1, no. 5, pp. 2278–2249, 2016
- [32] A. Gade, S. Gaikwad, N. Duran, and M. Rai, "Green synthesis of silver nanoparticles by *Phoma glomerata*," vol. 59, pp. 52–59, 2014
- [33] P. Kouvaris, A. Delimitis, V. Zaspalis, D. Papadopoulos, S. A. Tsipas, and N. Michailidis, "Green synthesis and characterization of silver nanoparticles produced using *Arbutus Unedo* leaf extract," *Materials Letters.*, vol. 76, no. 2, pp. 18–20, 2012
- [34] G. Li, D. He, Y. Qian, B. Guan, S. Gao, and L. Wang, "Fungus-mediated green synthesis of silver nanoparticles using *Aspergillus terreus*," *International journal of molecular sciences.*, vol. 13, no. 1, pp. 466–476, 2014
- [35] N. V. Harihar, P. Singh, and R. M. Chavan, "Gold nanoparticle: synthesis and characterization," *Veterinary World.*, vol. 7, no. 2, pp. 72–77, 2014
- [36] Q. J. Rasheed, "Synthesis and Optimization of Nisin-Silver Nanoparticles at Different Conditions," *Engineering and Technology Journal.*, 33(2 Part (A) Engineering) pp. 331–341, 2015

- [37] S. Sadiq, M. Imran, H. Habib, S. Shabbir, A. Ihsan, and F. Y. Hafeez, "Potential of monolaurin based food-grade nano-micelles loaded with nisin Z for synergistic antimicrobial action against *Staphylococcus aureus*," *LWT-Food Science and Technology*, vol. 71, pp. 227–233, 2016
- [38] R. Sankar, A. Karthik, A. Prabu, S. Karthik, and V. Ravikumar, "Origanum vulgare mediated biosynthesis of silver nanoparticles for its antibacterial and anticancer activity," *Colloids and Surfaces B: Biointerfaces*, vol. 108, pp. 80–84, 2013
- [39] I. Pal, V. P. Brahmkhatri, S. Bera, D. Bhattacharyya, Y. Quirishi, and H. S. Atreya, "Enhanced stability and activity of an antimicrobial peptide in conjugation with silver nanoparticle," *Journal of colloid and interface science*, vol. 4, no. 2, pp. 385–393, 2016
- [40] T. K. Sharma, M. Sapra, C. Aradhana, S. Rekha, D. P. Supriya, "Interaction of Bacteriocin-Capped Silver nanoparticles with Food Pathogens and Their Antibacterial Effect," *International Journal of Green Nanotechnology*, vol. 4, no. 2, pp. 1943–0892, 2012
- [41] P. J. P. Espitia, N. D. F. Soares, J. S. dos Reis Coimbra, N. J. de Andrade, R. S. Cruz, and E. A. Medeiros, "Zinc oxide nanoparticles: synthesis, antimicrobial activity and food packaging applications," *Food and bioprocess technology*, vol. 5, no. 5, pp. 1447–1464, 2012
- [42] A. M. Oda, H. Abdulkadhim, S. Jabuk, H. Fadhil, I. Alaa, D. Kareem, "Green Synthesis of Silver Nanoparticle by Cauliflower Extract: Characterization and Antibacterial Activity Against Storage. IET Nanobiotechnol The Institution of Engineering and Technology," pp. 1–7, ISSN 1751-8741, 2019, doi: 10.1049/iet-nbt.2018.5095 www.ietdl.org
- [43] T. Chatterjee, B. K. Chatterjee, D. Majumdar, P. Chakrabarti, "Antibacterial effect of silver nanoparticles and the modeling of bacterial growth kinetics using a modified Gompertz model," *Biochim Biophys Acta*, vol. 1850, no. 2, pp. 299–306, 2015
- [44] S. Maiti, D. Krishnan, G. Barman, and J. K. Laha, "Antimicrobial activities of silver nanoparticles synthesized from *Lycopersicon esculentum* extract," *Journal of Analytical Science and Technology*, vol. 5, no. 40, 2014
- [45] X. Lin, J. Li, S. Ma, and K. Yang, "Toxicity of TiO₂ Nanoparticles to *Escherichia coli*: Effects of Particle Size, Crystal Phase and Water Chemistry," *PLOS ONE*, vol. 9, no. 10, pp. e110247, 2014
- [46] D. Mandal, D. S. Kuma, and B. Das, "Bio-fabricated silver nanoparticles preferentially targets Gram positive depending on cell surface charge," *Biomed Pharmacother*, vol. 83, pp. 548–558, 2016
- [47] H. Gandhi, and S. Khan, "Biological Synthesis of Silver Nanoparticles and Its Antibacterial Activity," *J Nanomed Nanotechnol*, vol. 7, no. 2, 2016, DOI: 10.4172/2157-7439.1000366.
- [48] Y. M. Long, L. G. Hu, and X. T. Yan, "Surface ligand controls silver ion release of nanosilver and its antibacterial activity against *Escherichia coli*," *Int J Nanomedicine*, vol. 12, pp. 3193–3206, 2017