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Original article

Biosynthesis of AgNPs by extract from waste leaves of *Citrullus lanatus sp*. (watermelon); characterization, antibacterial and antifungal effects

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Abstract. Silver nanoparticles (AgNPs) are valuable materials with a large number of sectors used. Green synthesis is very important for biomedical applications as they show biocompatible properties. In this study, AgNPs were easily synthesized using the environmentally friendly green synthesis approach using agricultural waste parts of Citrullus lanatus sp. plant grown in the Diyarbakır region. Characterization of synthesized AgNPs was made. Fourier Transform Infrared Spectroscopy (FTIR) analysis was used to evaluate the phytochemicals responsible for effective reduction in the formation of AgNPs. UV-visible spectrophotometer (UV-Vis.) Spectra were also used to determine the presence of AgNPs. X-Ray Diffraction Diffractometer (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope, Zeta potential analyzes were performed to define the crystal structures, dimensions and surface charges of AgNPs, respectively. In these data, it was determined that AgNPs showed maximum absorbance at 460 nm, spherical appearance, 21.27 crystal nano size and -30.05 mV zeta potential. Antimicrobial effects of AgNPs on gram-positive *Staphylococcus aureus* (*S. aureus*) and *Bacillus subtilis* (*B. subtilis*) bacteria, gram negative *Escherichia coli* (*E. coli*) and *Pseudomonas aeruginosa* (*P. aeruginosa*) bacteria, as well as on yeast *C. albicans* pathogenic microorganisms It was analyzed by specifying the Minimum Inhibition Concentration (MIC) by microdilution.

Key words: Antimicrobial, MIC, SEM, TEM, Zeta potential

Introduction

Metallic nanoparticles are valuable materials. Metallic nanoparticles such as Ag (silver) (1), zinc (Zn) (2), Au (gold) (3), palladium (Pd) (4), copper (Cu) (5) are used in many fields. It has uses as anticancer and antimicrobial agents in medical applications (6, 7), bioremediation studies (8, 9), cosmetics industry (10), electronics (11). Different methods are used to synthesize nanoparticles (12). These methods are biological, physical and chemical methods. Biological methods are more advantageous in the synthesis process as they do not contain harmful toxic chemicals and the cost is low (13, 14). Biological sources such as plants, fungi, bacteria, algae are used in the synthesis of nanoparticles (15, 16).

Synthesis of AgNPs by using plant sources, obtaining more in quantity, not requiring special conditions for synthesis, easy and simple application is advantageous in biological methods (17, 18). In addition, the stable structure of AgNPs synthesized using plant sources is the reason for the interest in this field. In the synthesis of AgNPs with plant sources, leaves (19), fruits (20), flowers (21), roots (22) of the plant are used. Phytochemicals found in the leaves, fruits, flowers and roots of the plant in the synthesis of AgNPs with plant sources are bioactive products. Bioactive compounds such as aromatic compounds, alcohols, phenolic compounds, flavonoids are involved in the reduction of AgNP synthesis by reducing Ag^+ ions in aqueous the environment and forming Ag^o (23, 24).

Watermelon is a plant that grows in the Diyarbakır region with its unique characteristics and creates a serious income source. In this study, *Citrullus lanatus sp.* (watermelon) is aimed to be environmentally friendly, easy synthesis and characterization of AgNPs and the antimicrobial effects of the obtained AgNPs on pathogenic strains with the extract created from the leaves of the plant that emerged as agricultural waste after harvesting the fruits of the plant.

Materials and Methods

Citrullus lanatus sp. Preparation of extract from plant leaves and 5 millimolar (mM) silver nitrate ($AgNO_3$) solution

Citrullus lanatus sp. The leaves of the plant were collected after harvest. After washing with tap water, it was washed with distilled water and dried in room conditions. 100 g of dried plant and 400 ml of distilled water were mixed, and heat treatment was applied until it boiled. It was then cooled and filtered. It was stored at +4 °C to be used for synthesis.

A solution with a concentration of 5 mM was prepared from the $AgNO_3$ salt for the Sigma Aldrich brand synthesis to obtain AgNPs in the Green synthesis.

Synthesis of AgNPs

Citrullus lanatus sp. 200 ml of plant extract and 400 ml of 5 mM $AgNO_3$ solution were mixed and placed on the floor under room conditions without any special conditions. The color change was observed. After the reaction, the synthesis liquid was centrifuged at 9000 rpm for 10 minutes. The particles settle in the bottom part were dried after washing with distilled water and made ready for characterization processes.

Characterization of AgNPs

Characterization of the AgNPs Perkin Elmer One brand UV-vis. Spectrophotometer and FTIR device were determined by Rigaku Miniflex 600 model XRD device and RadB-DMAX II computer controlled EDX device data. Also EVO 40 LEQ brand SEM, TEM, Jeol Jem. 1010 Transmission Electron Microscopy (TEM) devices and Malvern brand zeta potential device data were also used for characterization.

The wavelength scans were performed to determine the presence of AgNPs with UV-vis spectrophotometer. Crystal structures were determined with XRD data and crystal nano sizes were determined by the Debye-Scherrer equation (25).

$$D = K\lambda / (\beta \cos\theta) \quad (1)$$

In the equation: D = particle size, K = constant value, λ = X-ray wavelength value, β = half of the FWHM value of the maximum peak, θ = Bragg angle of the high peak.

The functional groups responsible for reduction were evaluated with spectra of FTIR device. Morphology of AgNPs in SEM and TEM micrographs, element content in EDX profile and surface charge distributions with zeta potential values were determined.

Determining the antimicrobial effects of AgNPs

The antimicrobial effects of AgNPs obtained by Green synthesis on pathogenic microorganisms were evaluated by determining MIC by microdilution. Pathogenic strains were procured from Inonu University Medical Faculty Hospital Microbiology Laboratory and Mardin Artuklu University Microbiology Research Laboratory. Gram-positive *Staphylococcus aureus* (*S. aureus*) ATCC 29213, *Bacillus subtilis* (*B. subtilis*) ATCC 11774 bacteria and gram-negative *Escherichia coli* (*E. coli*) ATCC25922, *Pseudomonas aeruginosa* (*P. aeruginosa*) ATCC27833 bacteria were used in the experiment. In addition, AgNPs were also applied on fungus *Candida albican*s (*C. albicans*).

Bacteria in nutrient agar medium and yeast *C. albicans* in Sabora dextros agar medium were allowed to grow for one day at 37 °C. After the growth control the next day, suspensions were prepared from the cultured microorganisms according to the McFarland standard 0.5 (26) turbidity. Muller Hinton broth and Roswell Park Memorial Institute (RPMI) 1640 broths were prepared for microdilution application. A suitable medium prepared for microorganisms was added to the microplate wells. One well was set for sterilization control and another well for growth control. The solutions containing appropriate concentrations of the AgNPs were pipetted into the first wells of the microplate. A series of micro dilutions were applied to the other wells that followed. The microorganism suspension was then added to the wells. Plates were left to incubate at 37 °C for a day at the end of the application. The next day, the growth control was performed and the concentration of the well before the concentration at which the growth started compared to the control was determined as MIC.

Results and Discussion

UV-vis. Spectroscopy

After mixing watermelon plant extract and 5 mM $AgNO_3$ solution, the color change to dark brown was observed after 20 minutes. The color transformation occurred due to the formation of AgNPs as a result of the reduction of silver ions through functional groups found in phytochemicals (27, 28). Due to the excitation of free electrons in surface plasma resonance (SPR) bound UV-vis spectra, absorption bands at 460 nm are characteristic data regarding the presence and formation of AgNPs (29, 30) (Figure 1).

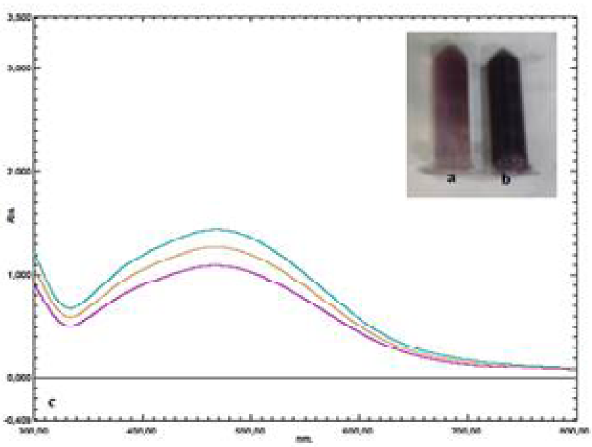

Figure 1. a. Watermelon plant extract b. The formation of AgNPs, the dark brown color change of the post-synthesis fluid, c. UV-vis. spectra showing the formation and presence of AgNPs

Crystal structure and size analysis with XRD analysis data

To evaluate the crystal structures and sizes of the AgNPs obtained as a result of the synthesis, the data obtained with the XRD device at 2θ were evaluated. The peaks (111), (200), (220) and (311) showing the crystal structure of AgNPs show that these particles exhibit a cubic crystal structure (31-33). The values of these peaks showing the values of the spectra of these peaks at 2θ were read as 38.13, 44.30, 64.30 and 77.27, respectively (Figure 2). The highest peak value in (111) is 38.13. To determine the crystal nano sizes of AgNPs, calculations were made using the Debye-Scherrer equation from the data taken at 2θ.

As a result of the calculation, it was determined that the crystal nano size of AgNPs was at 21.27 nm. The crystal nano sizes of the AgNPs obtained as a result of green synthesis studies were calculated as 21 nm (32) and 23.66 (34) nm.

FTIR spectroscopy

Functional groups responsible for the reduction in synthesis were evaluated in reaction liquid both after extract and after synthesis by FTIR spectroscopy spectra. The frequency shift occurring in the spectra 3323.25-3311.83 cm^{-1} is associated with the hydroxyl groups (-OH) (35), the shift alkyne groups (C≡C) (36) at 2116.24-2129.01 cm^{-1}, and the frequency shift at 1635.07-1635.11 cm^{-1} is the I amine groups ($-NH_2$) (37) suggests that it can play a role in reduction (Figure 3).

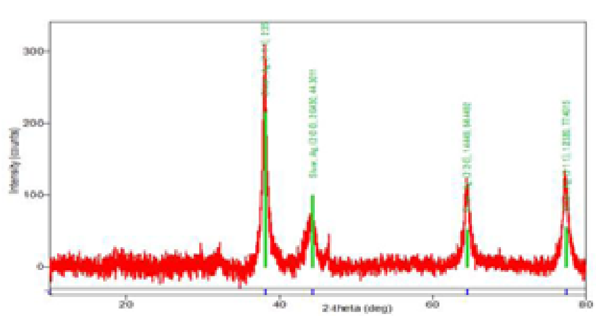

Figure 2. XRD pattern of the crystal structures of AgNPs

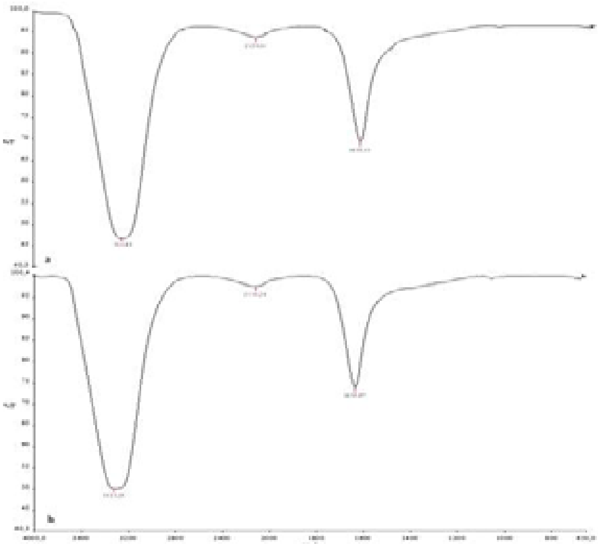

Figure 3. FTIR spectra, a. the reaction liquid after synthesis, b. extract

SEM and TEM micrographs of AgNPs and EDX elemental compositions of the particles obtained

In electron microscopy analyzes performed to determine the morphological structures of AgNPs, it was determined that AgNPs were in spherical appearance (Figure 4a and b) (38, 39).

The EDX profile of the particles obtained in Figure 4c was evaluated. Strong peaks of silver show the presence of AgNPs in the element content (40). In addition, weak peaks such as C and O are also due to residues of the extracted content (36, 41).

Zeta potential distributions of AgNPs

With the zeta potential analysis, it was determined that the surface loads of AgNPs showed a distribution of -30.5 mV (Figure 5). This result shows that AgNPs do not show aggregation and are stable (42, 43). In a study, it was stated that the zeta potential distributions of AgNPs were -30.4 mV in one study (44).

Antimicrobial effects of AgNPs

AgNPs obtained as a result of the synthesis were effective on microorganisms in the concentration range 0.13-1.00 μg/mL. AgNPs showed lower concentrations than silver nitrate solution and antibiotics on all strains. It was determined that AgNPs were

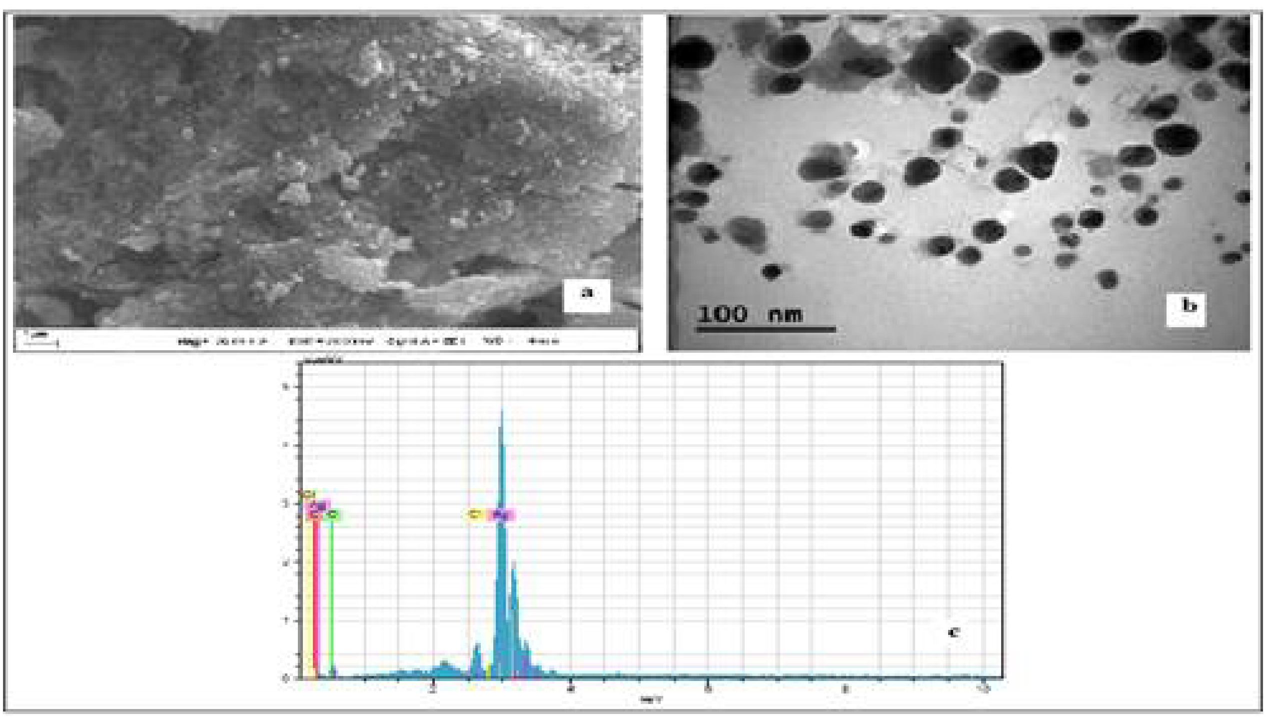

Figure 4. Micrographs of AgNPs a. SEM, b. TEM images, c. EDX profiles

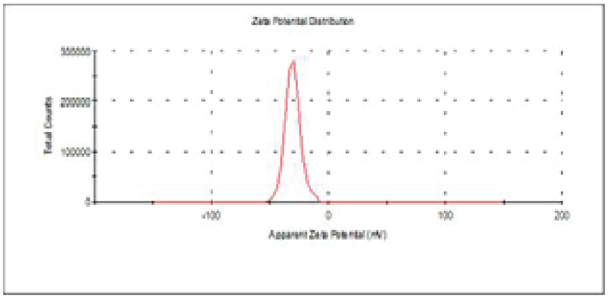

Figure 5. Zeta potential analysis data of surface charges of AgNPs

Table 1. MIC values where AgNPs, antibiotics and silver nitrate solution are effective on antimicrobial activity on pathogenic microorganisms(The used antibiotics (Fluconazole, Vancomycin, and Colistin) were obtained commercially).

ORGANISM	**AgNPs** µg/mL	**Silver Nitrat** µg/mL	**Standarts Antibiotic** µg/mL
S. aureus ATCC 29213	0.25	2.65	2.00
B.subtilis ATCC 11774	0.13	1.32	1.00
E. coli ATCC25922	0.50	0.66	2.00
P. aeruginosa ATCC27833	1.00	1.32	4.00
C. albicans	0.13	0.66	2.00

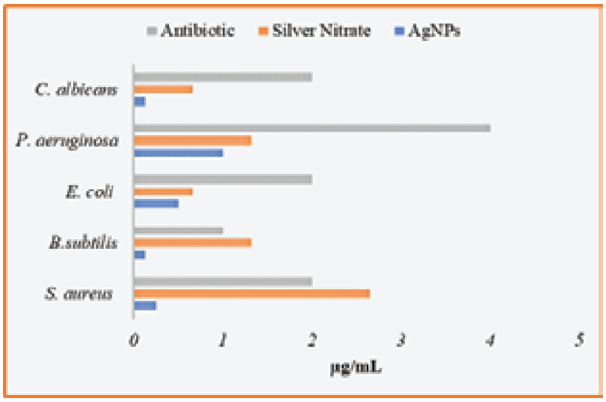

Figure 6. Comparison of MIC values effective on microorganisms

effective on the growth of *B. subtilis* and *C. albicans* strains with the lowest concentration of 0.13 µg/mL. The highest concentration was detected on gram negative *P. aureuginosa* with a concentration of 1.00 µg/mL (Table 1 and Figure 7).

AgNPs are ionized in the liquid in which an show very high reactivity and contact microorganisms with electrostatic attraction force (21,33,45). After this interaction, it causes an increase in Reactive Oxygen Species (ROS). Some biomolecules have affinity for these species such as DNA, RNA and life enzymes. As a result, these biomolecules become incapable of functioning and cell death occurs (34, 35).

AgNPs obtained in a green synthesis study were reported as 10 µg/mL MIC on gram negative *E. coli* growth (46). In another study, a concentration of 250 µg/mL was effective on gram positive *S. aureus*, and a concentration of 30 µg/mL was effective on gram negative *P. aeruginosa* bacteria (47). It was also stated in one of the studies that AgNPs were effective on *B. subtilis* and *C. albicans* strains at a concentration of 25 µg/mL (48). In another environmentally friendly study, a concentration of 0.33 µg/mL showed an inhibition effect on *E. coli* (49).

Conclusion

AgNPs were successfully synthesized in an environmentally friendly manner with the extract prepared from above-ground plant parts in the form of the agricultural waste remaining in the soil after the watermelon harvest. Various analyzes were made to determine their characteristics. AgNPs were characterized by using XRD, FTIR, UV-vis., Zeta potential, TEM, SEM, and EDX analysis data. The antimicrobial effects of the synthesized AgNPs were examined, and it was found that they showed lower concentrations of antimicrobial effects against antibiotics and silver nitrate solution. By developing the application steps, they can be used as an antimicrobial agent against the problem of antibiotic resistance.

References

1. Baran MF. Synthesis and Antimicrobial Applications of Silver Nanoparticles From artemisia absinthium plant. Biological and Chemical Research 2019; 6: 96–103.
2. Doğaroğlu ZG, Eren A, Baran MF. Effects of ZnO Nanoparticles and Ethylenediamine- N, N ′ - Disuccinic Acid on Seed Germination of Four Different Plants. Global challanges 2019; 1800111: 1–5.

3. Baran, MF., Keskin, C., Atalar, MN., Baran A. Environmentally Friendly Rapid Synthesis of Gold Nanoparticles from Artemisia absinthium Plant Extract and Application of Antimicrobial Activities. Journal of the Institute of Science and Technology 2021; 11(1): 365–75.
4. Ismail E, Khenfouch M, Dhlamini M, Dube S, Maaza M. Green palladium and palladium oxide nanoparticles synthesized via Aspalathus linearis natural extract. Journal of Alloys and Compounds 2017; 695: 3632–8.
5. Asghar MA, Zahir E, Shahid SM, Khan MN, Asghar MA, Iqbal J, Walker G. Iron, copper and silver nanoparticles: Green synthesis using green and black tea leaves extracts and evaluation of antibacterial, antifungal and aflatoxin B1adsorption activity. LWT - Food Science and Technology 2018; 90: 98–107.
6. Morais M, Teixeira AL, Dias F, Machado V, Medeiros R, Prior JAV. Cytotoxic Effect of Silver Nanoparticles Synthesized by Green Methods in Cancer. Journal of Medicinal Chemistry 2020; 63(23): 14308–35.
7. Wongpreecha J, Polpanich D, Suteewong T, Kaewsaneha C, Tangboriboonrat P. One-pot, large-scale green synthesis of silver nanoparticles-chitosan with enhanced antibacterial activity and low cytotoxicity. Carbohydrate Polymers 2018; 199: 641–8.
8. Baran. MF. Synthesis, Characterization and Investigation Of Antimicrobial Activity of Silver Nanoparticles From Cydonia Oblonga Leaf. Applıed Ecology and Envıronmental Research 2019; 17(2): 2583–92.
9. Francis S, Joseph S, Koshy EP, Mathew B. Green synthesis and characterization of gold and silver nanoparticles using Mussaenda glabrata leaf extract and their environmental applications to dye degradation. Environmental Science and Pollution Research 2017; 24: 17347–17357.
10. Arroyo G V., Madrid AT, Gavilanes AF, Naranjo B, Debut A, Arias MT, Angulo Y. Green synthesis of silver nanoparticles for application in cosmetics. Journal of Environmental Science and Health - Part A Toxic/Hazardous Substances and Environmental Engineering 2020; 55(11): 1304–20.
11. Sampaio S, Viana JC. Production of silver nanoparticles by green synthesis using artichoke (Cynara scolymus L.) aqueous extract and measurement of their electrical conductivity. Advances in Natural Sciences: Nanoscience and Nanotechnology 2018; 9(4): 1–10.
12. Baran M. Synthesis of silver nanoparticles (AgNP) with Prunus avium cherry leaf extract and investigation of its antimicrobial effect. Dicle University Journal of Engineering 2019; 10(1): 221–7.
13. Das G, Shin H, Kumar A, Vishnuprasad CN. Photo-mediated optimized synthesis of silver nanoparticles using the extracts of outer shell fibre of Cocos nucifera L. fruit and detection of its antioxidant, cytotoxicity and antibacterial potential. Saudi Journal of Biological Sciences 2021; 28(1): 980–7.
14. Singh J, Mehta A, Rawat M, Basu S. Green synthesis of silver nanoparticles using sun dried tulsi leaves and its catalytic application for 4-Nitrophenol reduction. Journal of Environmental Chemical Engineering 2018; 6: 1468–74.
15. Patra S, Mukherjee S, Kumar A, Ganguly A, Sreedhar B, Ranjan C. Green synthesis, characterization of gold and silver nanoparticles and their potential application for cancer therapeutics. Materials Science & Engineering C 2015; 53: 298–309.
16. Kobashigawa JM, Robles CA, Martínez Ricci ML, Carmarán CC. Influence of strong bases on the synthesis of silver nanoparticles (AgNPs) using the ligninolytic fungi Trametes trogii. Saudi Journal of Biological Sciences 2018; 26(7): 1331–7.
17. Ojo, O.A., Oyinloye, B.E., Ojo, A.B., Afolabi, O.B., Peters, O.A., Olaiya, O., Fadaka, A., Jonathan, j., Osunlana O. Green Synthesis of Silver Nanoparticles (AgNPs) Using Talinum triangulare (Jacq.) Willd. Leaf Extract and Monitoring Their Antimicrobial Activity. Journal of Bionanoscience 2017; 11: 292–6.
18. Eren, A., Baran MF. Synthesis, Characterization and Investigation of Antimicrobial Activity of Silver Nanoparticles (AgNPs). Turkey Agricultural Research Journal 2019; 6(2): 165–73.
19. Baran MF. Synthesıs, Characterızatıon And Investıgatıon Of Antımıcrobıal Actıvıty Of Sılver Nanopartıcles From Cydonıa oblonga Leaf. 2019; 17(2): 2583–92.
20. Kumar B, Smita K, Cumbal L, Debut A. Green synthesis of silver nanoparticles using Andean blackberry fruit extract. Saudi Journal of Biological Sciences 2015; 24(1): 45–50.
21. Karunakaran G, Jagathambal M, Venkatesh M, Suresh, Govindan, Suresh Kumar, Evgeny, Kolesnikov, Arkhipov, Dmitry, Alexander, Gusev, Denis K. Hydrangea paniculata fl ower extract-mediated green synthesis of MgNPs and AgNPs for health care applications. Powder Technology 2017; 305: 488–94.
22. Sudhakar C, Selvam K, Govarthanan M. Acorus calamus rhizome extract mediated biosynthesis of silver nanoparticles and their bactericidal activity against human pathogens. Journal of Genetic Engineering and Biotechnology 2015; 13(2): 93–9.
23. Srikar SK, Giri DD, Pal DB, Mishra PK, Upadhyay SN. Green Synthesis of Silver Nanoparticles : A Review. Green and Sustainable Chemistry 2016; 6: 34–56.
24. Song JY, Kim BS. Rapid biological synthesis of silver nanoparticles using plant leaf extracts. Bioprocess and Biosystems Engineering 2009; 32(1): 79–84.
25. Baran, M. F., Saydut A. Gold nanomaterial synthesis and characterization. Dicle University Journal of Engineering 2019; 10(3): 1033–40.
26. Emmanuel R, Palanisamy S, Chen S, Chelladurai K, Padmavathy S, Saravanan M, Prakash P, Ajmal AM, Al-Hemaid F. Antimicrobial ef fi cacy of green synthesized drug blended silver nanoparticles against dental caries and periodontal disease causing microorganisms. Materials Science & Engineering C 2015; 56: 374–9.
27. Kumar, R., Ghoshal, G. Jain A and GM. Rapid Green Synthesis of Silver Nanoparticles (AgNPs) Using (Prunus persica) Plants extract: Exploring its Antimicrobial and Catalytic Activities. Journal of Nanomedicine & Nanotechnology 2017; 8(4): 1–8.

28. S, Majeed., Mohd, S. A., Gouri K. D., Mohammed, T.A., Anima N. Biochemical synthesis of silver nanoprticles using filamentous fungi Penicillium decumbens (MTCC-2494) and its efficacy against A-549 lung cancer cell line. Chinese Journal of Natural Medicines 2016; 14(8): 615–20.
29. Dwivedi AD, Gopal K. Biosynthesis of silver and gold nanoparticles using Chenopodium album leaf extract. Colloids and Surfaces A: Physicochemical and Engineering Aspects 2010; 369(1–3): 27–33.
30. Some S, Bulut O, Biswas K. Effect of feed supplementation with biosynthesized silver nanoparticles using leaf extract of Morus indica L. V1 on Bombyx mori L. (Lepidoptera: Bombycidae). Scientific Reports 2019; 9(1): 1–13.
31. Ali ZA, Yahya R, Sekaran SD, Puteh R. Green synthesis of silver nanoparticles using apple extract and its antibacterial properties. Advances in Materials Science and Engineering 2016; 2016: 1–6.
32. Khan AU, Yuan Q, Khan ZUH, Ahmada A, Khan FU, Tahir K, Shakeel M, Ulla S. An eco-benign synthesis of AgNPs using aqueous extract of Longan fruit peel: Antiproliferative response against human breast cancer cell line MCF-7, antioxidant and photocatalytic deprivation of methylene blue. Journal of Photochemistry and Photobiology B: Biology 2018; 183: 367–73.
33. Rouhollah, H., and Marzieh R. Biosynthesis of silver nanoparticles using extract of olive leaf : synthesis and in vitro cytotoxic effect on MCF-7 cells. International Journal ofBreast Cancer 2014; 2015: 1–7.
34. BARAN A. Eco- friendly, rapid synthesis of silver nanomaterials and their use for biomedical applications. Dicle University Journal of Engineering 2021; 12(2): 329–36.
35. Gopinath V, Priyadarshini S, Loke MF, Arunkumar J, Marsili E, MubarakAli D, Velusamy P, JVadivelu J. Biogenic synthesis, characterization of antibacterial silver nanoparticles and its cell cytotoxicity. Arabian Journal of Chemistry 2017; 10(8): 1107–17.
36. Alkhulaifi MM, Alshehri JH, Alwehaibi MA, Awad MA, Al-Enazi NM, Aldosari NS, Hatamleh AA, Raouf NA. Green synthesis of silver nanoparticles using Citrus limon peels and evaluation of their antibacterial and cytotoxic properties. Saudi Journal of Biological Sciences 2020; 27(12): 3434–41.
37. Thomas B, Vithiya BSM, Prasad TAA, Mohamed SB, Maria Magdalane C, Kaviyarasu K, Maaza M. Antioxidant and Photocatalytic Activity of Aqueous Leaf Extract Mediated Green Synthesis of Silver Nanoparticles Using Passiflora edulis f. flavicarpa. Journal of Nanoscience and Nanotechnology 2018; 19(5): 2640–8.
38. Premkumar J, Sudhakar T, Dhakal A, Shrestha JB, Krishnakumar S, Balashanmugam P. Synthesis of silver nanoparticles (AgNPs) from cinnamon against bacterial pathogens. Biocatalysis and Agricultural Biotechnology 2018; 15: 311–6.
39. Butola BS, Gupta A, Roy A. Multifunctional fi nishing of cellulosic fabric via facile, rapid in-situ green synthesis of AgNPs using pomegranate peel extract biomolecules. Sustainable Chemistry and Pharmacy 2019; 12: 100135.
40. Kumar V, Gundampati RK, Singh DK, Bano D, Jagannadham M V., Hasan SH. Photoinduced green synthesis of silver nanoparticles with highly effective antibacterial and hydrogen peroxide sensing properties. Journal of Photochemistry and Photobiology B: Biology 2016; 162: 374–85.
41. Arumai Selvan D, Mahendiran D, Senthil Kumar R, Kalilur Rahiman A. Garlic, green tea and turmeric extracts-mediated green synthesis of silver nanoparticles: Phytochemical, antioxidant and in vitro cytotoxicity studies. Journal of Photochemistry and Photobiology B: Biology 2018; 180: 243–52.
42. Al-ogaidi I, Salman MI, Mohammad FI, Aguilar Z, Al-Ogaidi M, Hadi YA, Al-Rhman RM. Antibacterial and Cytotoxicity of Silver Nanoparticles Synthesized in Green and Black Tea. World Journal of Experimental Biosciences 2017; 5(1): 39–45.
43. Patil MP, Singh RD, Koli PB, Patil KT, Jagdale BS, Tiparee AR, Kim GD. Antibacterial potential of silver nanoparticles synthesized using Madhuca longifolia flower extract as a green resource. Microbial Pathogenesis 2018; 121: 184–9.
44. Satpathy S, Patra A, Ahirwar B, Delwar Hussain M. Antioxidant and anticancer activities of green synthesized silver nanoparticles using aqueous extract of tubers of Pueraria tuberosa. Artificial Cells, Nanomedicine and Biotechnology 2018; 46(S3): S71–85.
45. Ahmed KBA, Raman T, Veerappan A. Future prospects of antibacterial metal nanoparticles as enzyme inhibitor. Materials Science and Engineering C 2016; 68: 939–47.
46. Krishnaraj C, Jagan EG, Rajasekar S, Selvakumar P, Kalaichelvan PT, Mohan N. Synthesis of silver nanoparticles using Acalypha indica leaf extracts and its antibacterial activity against water borne pathogens. Colloids and Surfaces B: Biointerfaces 2010; 76(1): 50–6.
47. Rolim WR, Pelegrino MT, de Araújo Lima B, Ferraza LS, Costa FN, Juliana Bernardes S, Rodiguesa T, Brocchic M. Green tea extract mediated biogenic synthesis of silver nanoparticles: Characterization, cytotoxicity evaluation and antibacterial activity. Applied Surface Science 2019; 463: 66–74.
48. Remya RR, Rajasree SRR, Aranganathan L, Suman TY. An investigation on cytotoxic effect of bioactive AgNPs synthesized using Cassia fistula flower extract on breast cancer cell MCF-7. Biotechnology Reports 2015; 8: 110–5.
49. Baran MF. Green Synthesıs of Sılver Nanopartıcles (AGNPs) Usıng Pıstacıa Terebınthus Leaf Extract: Antımıcrobıal Effect And Characterızatıon. International Journal on Mathematic, Engineering and Natural Sciences 2018; 5(2): 67–75.

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