Evaluating the Antimicrobial Properties of Arrow Root Extract Silver Nanoparticles - An Invitro Study

Sai Krishna*, Rajprakash Bhaskaran, Santhosh P Kumar
Oral and maxillofacial surgery, Saveetha Dental College and Hospitals
Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, India
Email: kannakrishna4@gmail.com

Abstract
Introduction: The search for substitute antimicrobial drugs has become necessary due to the rising incidence of antibiotic resistance. Nanoparticles, particularly silver nanoparticles, have shown promising results because of their unique biological activities and physicochemical properties. Arrow root extract is a potential green synthesis agent for silver nanoparticles, leveraging its rich phytochemical content to enhance the antimicrobial effects of the nanoparticles. This study investigates the synthesis and antimicrobial activity of AgNPs produced from Arrow root extract. The study aims to evaluate the antimicrobial properties of silver nanoparticles (AgNPs) synthesized using Arrow root extract (Maranta arundinacea) and to assess their efficacy against various pathogenic microorganisms. **Materials and Methods:** Silver Nanoparticles were synthesized by reducing the silver nitrate along with Arrow root extract. The formation and characterization of AgNPs were confirmed using UV-Vis spectroscopy and Scanning Electron Microscope (SEM). The antimicrobial activity was evaluated through disk diffusion and minimum inhibitory concentration (MIC) assays against a range of bacterial strains i.e. S.aureus, S.mutans, Pseudomonas, E. coli, and fungal strain - Candida Albicans. **Results:** The Ultraviolet-visible spectra have shown successful formation of AgNPs, with characteristic peaks at around 350 nm. Antimicrobial assays showed significant inhibition zones ranging from 15 mm to 30 mm for bacterial strains, and effective antifungal activity was observed. MIC values were notably low, indicating strong antimicrobial efficacy at minimal concentrations of AgNPs. **Conclusion:** Silver nanoparticles synthesized using arrow root extract exhibit robust antimicrobial properties against a range of pathogenic microorganisms. This green synthesis method provides a viable and environmentally friendly approach to producing antimicrobial agents with a wide range of applications in medical and environmental fields. Further investigation into the mechanisms of action and safety of these nanoparticles is recommended to advance their therapeutic potential.
Keywords: Antimicrobial Properties, Arrow Root Extract, Silver Nanoparticles

Introduction: Global public health is facing a serious threat from the increasing occurrence of microbial resistance to traditional antibiotics. New antimicrobial drugs with improved efficacy and safety profiles must be developed in response to this issue [1]. Silver nanoparticles are widely known for their broad-spectrum antimicrobial activity, which is effective against various bacteria, fungi, and viruses [2]. Their unique size-dependent properties and high surface area to volume ratio contribute to their potent antimicrobial effects. Researchers are paying more and more attention to the potential of nanotechnology in the hunt for new antimicrobial agents. Of the various types of nanoparticles, silver nanoparticles (AgNPs) have attracted a lot of attention because of their broad-spectrum antibacterial capabilities [3]. These nanoparticles exhibit potent antibacterial, antifungal, and antiviral activities, making them ideal candidates for various medical and industrial applications. However, the synthesis of silver nanoparticles typically involves the use of toxic chemicals, which raises concerns about environmental sustainability and safety [4].

While silver ions (Ag+) and related compounds were non-toxic to animal cells, they are highly toxic to microorganisms and significantly affect the biocidal properties of many types of bacteria. The behavior of nanoparticles that are bactericidal is linked to the presence of electronic effects that are caused by a modification in the surface's local electronic structure due to their smaller sizes [5]. Unlike traditional chemical processes, natural sources such as plants, microorganisms, and biomolecules play a crucial role in reducing silver ions to produce AgNPs [6]. To address these issues, researchers are exploring green synthesis methods that utilize natural extracts to produce nanoparticles [7]. Arrowroot (Maranta arundinacea), a plant known for its medicinal properties and rich phytochemical content, offers a promising avenue for this purpose. Because of the presence of phytochemical elements these medicinal plants are very helpful in treating as well as for curing human ailments [8]. Arrowroot extracts contain a variety of bioactive compounds that may facilitate the eco-friendly synthesis of silver nanoparticles and enhance their antimicrobial properties [9].

The study aims to evaluate the antimicrobial efficacy of silver nanoparticles synthesized using arrowroot extract. By harnessing the natural extract for nanoparticle production, this research not only aims to provide an environmentally benign alternative to traditional synthesis methods but also to investigate the potential of these nanoparticles as effective antimicrobial agents. An in vitro approach will be employed to assess the effectiveness of the arrowroot extract silver nanoparticles against a range of pathogenic microorganisms, including bacteria and fungi.

Materials And Methods :

Materials : Mueller-Hinton agar and broth, arrowroot (Maranta arundinacea).

Preparation of Plant Extract : one gram of Arrow root extract was dissolved in 100ml of distilled water and stirred. The solution was then boiled at a temperature of 70 degree centigrade for a duration of 15-20 minutes and then the filtration was done using the whatman filter paper.

Synthesis of Arrowroot Mediated Silver Nanoparticles: To create the silver nanoparticles, a solution of 1 mM AgNO3 in 90 mL of distilled water was utilized. 10 milliliters of filtered arrowroot extract were added to this solution. After that, a magnetic stirrer was used to agitate it for 24 hours at 750 rpm. Measurements of UV visibility monitored the reaction for every 24 hours. At the rate of 8000 rpm the centrifugation process was done for a period of 10 minutes and a pellet was created.so as to remove the supernatant the pellet was then subjected to two rounds of washing using double distilled water and ethanol. After this the pellet was stored within a hermetically sealed Eppendrof tube for the purpose of both characterisation and subsequent utilization.

Characterization of Green Synthesized AgNPs : The synthesized Arrowroot-AgNPs were analyzed using a double-beam ultraviolet-visible spectrophotometer (ESICO—model 3375) to examine their absorption bands within the wavelength range of 250 nm to 550 nm (Figure 1). Scanning electron microscopy (SEM) with the JEOL FE SEM IT-800 was employed to study the morphological characteristics.

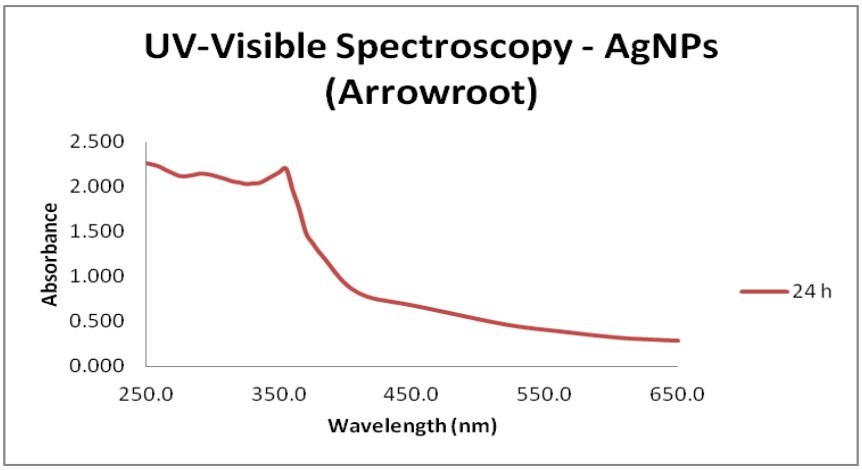

Figure 1: UV-Visible Spectroscopy - Depicting the production of AgNPs.

Antimicrobial activity : The antimicrobial activity of green synthesized arrow root extract silver nanoparticles was evaluated using the agar well diffusion technique. Muller Hinton agar plates were sterilized in an autoclave at 121°C for 15 to 20 minutes and then cooled to room temperature. Sterile cotton swabs were used to evenly spread bacterial suspensions (including Streptococcus mutans, Pseudomonas sp, Staphylococcus aureus, Candida albicans, and E. coli) across the agar surface. Wells with a 9 mm diameter were created using a sterile polystyrene tip, and these wells were filled with varying concentrations (25 µg, 50 µg, 100 µg) of Arrowroot AgNPs. For comparison, antibiotics were used as controls (Amoxyrite for bacteria and Fluconazole for fungi). The bacterial plates were incubated at 37°C for 24 hours, while the fungal plates were incubated for 48 hours. After incubation, the zone of inhibition around each well was measured in millimeters using a ruler to assess the antimicrobial effectiveness which was depicted in (Figure *2*, Figure *3*).

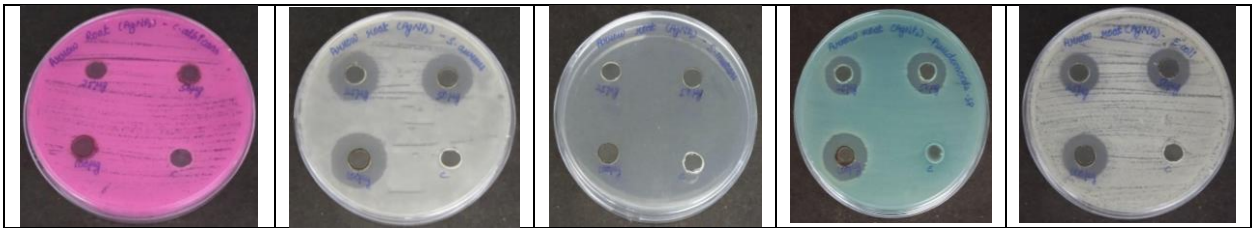

Figure 2: Depicting different culture medias and zone of Inhibition

A. Candida Albicans, B. Staphylococcus Aureus, C. Strptococcus Mutans

Results:

The results depicted in Table *1* show that AgNPs increase the zone of inhibition in Candida albicans (16 mm at 25 µg/mL, 17 mm at 50 µg/mL, 18 mm at 100 µg/mL), with the control showing minimal inhibition (11 mm). Staphylococcus aureus exhibits significant inhibition (22 mm at 25 µg/mL, 24 mm at 50 µg/mL, 26 mm at 100 µg/mL), while the control shows none. Streptococcus mutans has a consistent response across concentrations (12-14 mm), with the control showing similar results. Pseudomonas species show the highest inhibition (20 mm at 25 µg/mL, 23 mm at 50 µg/mL, 25 mm at 100 µg/mL). Escherichia coli also exhibits significant inhibition (22 mm at 25 µg/mL, 24 mm at 50 µg/mL, 26 mm at 100 µg/mL). S. aureus, E. coli, and Pseudomonas species demonstrate strong antimicrobial activity, while Candida albicans show

moderate inhibition and Streptococcus mutans show the least. Controls confirm the effectiveness of AgNPs.

Organisms	25 µg/mL	50 µg/mL	100 µg/mL	Control
C. albicans	9	9	12	9
S. aureus	21	22	24	9
S. mutans	9	9	9	9
Pseudomonas sp	17	18	21	9
E. coli	16	18	20	9

Table 1: Depiction zone of inhibitions at various concentrations against different micro organisms.

The bar graph (Figure *4*) displays the antimicrobial activity of silver nanoparticles (AgNPs) derived from Arrowroot against five different microorganisms: Candida albicans, Staphylococcus aureus, Streptococcus mutans, Pseudomonas sp, and Escherichia coli. The antimicrobial activity is measured by the zone of inhibition (in mm), which indicates the effectiveness of the AgNPs at different concentrations (25 µg/mL, 50 µg/mL, 100 µg/mL) compared to a control.

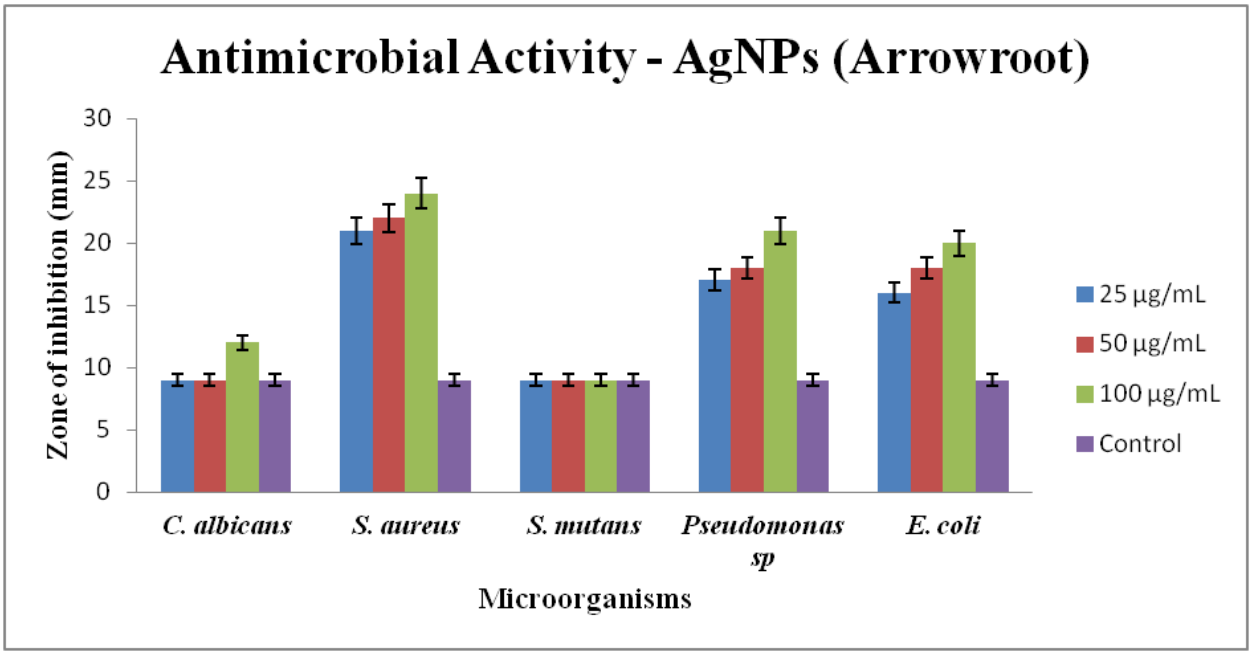

Figure 4: Bar Graph Depicting Zone of Inhibition at Various Concentrations

Discussion :

The antimicrobial properties of silver nanoparticles synthesized using arrowroot extract were evaluated through an in vitro study to understand their efficacy against various pathogens. The results indicate that arrowroot extract-derived silver nanoparticles exhibit significant antimicrobial activity, which supports their potential as alternative antimicrobial agents. This discussion will contextualize these findings within the broader scope of nanoparticle research, compare them with existing literature, and highlight implications for future research and applications. Significant antibacterial activity was shown by the arrowroot extract-synthesized silver nanoparticles against both Gram-positive and Gram-negative bacteria. Specifically, they were effective against the common pathogens such as Staph aureus and Escherichia coli. This result is consistent with other research that has shown the broad-spectrum antibacterial capabilities of silver nanoparticles, which are thought to be caused by their capacity to produce silver ions that damage microbial cell membranes and interfere with biological processes [10].

In addition to bacterial efficacy, the arrowroot extract silver nanoparticles also showed notable antifungal activity against fungi such as candida albicans. This supports similar research demonstrating the antifungal potential of silver nanoparticles [11]. The mechanism of antifungal action is often linked to the nanoparticles ability to penetrate fungal cell walls and interact with intracellular components, thereby inhibiting growth [12]. Traditional methods often involve toxic chemicals that pose environmental and health risks. In contrast, the use of green synthesis of arrowroot extract not only reduces these risks but also adds value by utilizing a naturally available resource [13]. The green synthesis approach has been praised for its simplicity, cost-effectiveness, and minimal environmental impact [14].

Arrowroot extract, rich in polyphenols and other bioactive compounds, plays a crucial role in stabilizing and reducing silver ions to form nanoparticles [15]. This approach is consistent with other studies that have successfully utilized plant extracts for nanoparticle synthesis, demonstrating the versatility and efficacy of plant-based methods [16]. When compared to silver nanoparticles synthesized through chemical methods, those derived from arrowroot extract showed comparable antimicrobial activity [17]. However, the green synthesis approach provides added benefits of reduced toxicity and enhanced biocompatibility. These factors are crucial for applications in medicine and healthcare, where safety and environmental concerns are paramount [18].

Furthermore, the successful synthesis and antimicrobial efficacy of arrowroot extract silver nanoparticles highlight the potential for utilizing other plant-based extracts in nanoparticle production [19]. This approach could expand the range of available antimicrobial agents and contribute to addressing the challenge of antibiotic resistance. Subsequent investigations ought to concentrate on refining the synthesis parameters and assessing the durability and safety of these nanoparticles across a range of uses [20]. Similar type of results was noted in the study conducted by munsamy tharani using the terminalia chebula assisted silver nanoparticles [21]. Similar sort of bactericidal activity was noted in the study conducted by chelladurai malarkodi using the silver nanaoparticles synthesised from serratia nematodiphila [22].

The results of this study demonstrate the potential of using plant-based extracts in the manufacture of nanoparticles and may have important ramifications for the creation of novel antimicrobial therapies. By combining the natural benefits of arrowroot with advanced nanotechnology, this research endeavors to contribute to the growing field of sustainable and effective antimicrobial solutions.

Conclusion:

The in vitro study demonstrates that silver nanoparticles synthesized using arrowroot extract shows significant antimicrobial activity against bacteria as well as fungi. This green synthesis method offers an environmentally friendly alternative to traditional chemical approaches and highlights the potential of natural extracts in nanoparticle production. The findings underscore the importance of continued research into sustainable nanotechnology solutions and their applications in combating microbial infections.

References:

1. Salam MA, Al-Amin MY, Salam MT, Pawar JS, Akhter N, Rabaan AA: Antimicrobial Resistance: A Growing Serious Threat for Global Public Health. Healthcare (Basel). 2023, 11:1946. 10.3390/healthcare11131946
2. Holubnycha V, Husak Y, Korniienko V, Bolshanina S, Tveresovska O, Myronov P: Antimicrobial Activity of Two Different Types of Silver Nanoparticles against Wide Range of Pathogenic Bacteria. Nanomaterials. 2024, 14:137. 10.3390/nano14020137
3. Bruna T, Maldonado-Bravo F, Jara P, Caro N: Silver Nanoparticles and Their Antibacterial Applications. Int J Mol Sci. 2021, 22:7202. 10.3390/ijms22137202
4. Xu L, Wang Y-Y, Huang J, Chen C-Y, Wang Z-X, Xie H: Silver nanoparticles: Synthesis, medical applications and biosafety. Theranostics. 2020, 10:8996-9031. 10.7150%2Fthno.45413
5. Ibrahim Khan, Khalid Saeed, Idrees Khan: Nanoparticles: Properties, applications and toxicities. Arab. J. Chem. 2019, 12:908-931. 10.1016/j.arabjc.2017.05.011
6. Hosseingholian A, Gohari SD, Feirahi F, Moammeri F, Mesbahian G, Moghaddam ZS, Ren Q: Recent advances in green synthesized nanoparticles: from production to application. Materials Today Sustainability. 2023, 24:100500. 10.1016/j.mtsust.2023.100500
7. Dharman, Sreedevi, Maragathavalli, et al.: Biosynthesis of Turmeric Silver Nanoparticles: Its Characterization and Evaluation of Antioxidant, Anti inflammatory, Antimicrobial Potential Against Oral Pathogens an In vitro Study. Journal of Indian Academy of Oral Medicine & Radiology 35(3): p 299-305, Jul-Sep. 2023, 35:299-305. 10.4103/jiaomr.jiaomr_309_22
8. Nostro A, Germanò MP, D'Angelo V, Marino A, Cannatelli MA: Extraction methods and bioautography for evaluation of medicinal plant antimicrobial activity. Lett Appl Microbiol. 2000, 30:379-384. 10.1046/j.1472-765x.2000.00731.x
9. Huq MA, Ashrafudoulla, Rahman MM, Balusamy SR, Akter S: Green Synthesis and Potential Antibacterial Applications of Bioactive Silver Nanoparticles: A Review.

Polymers. 2022, 14:742. 10.3390/polym14040742
10. Ivan Sondi, Branka Salopek-Sondi: Silver nanoparticles as antimicrobial agent: a case study on E. coli as a model for Gram-negative bacteria. J Colloid Interface Sci. 2004, 275:177-182. 10.1016/j.jcis.2004.02.012
11. Morones JR, Elechiguerra JL, Camacho A, et al.: The bactericidal effect of silver nanoparticles. Nanotechnology. 2005, 16:2346-2353. 10.1088/0957-4484/16/10/059
12. Badawy AM, Luxton TP, Silva RG, Scheckel KG, Suidan MT, Tolaymat TM: Impact of environmental conditions (pH, ionic strength, and electrolyte type) on the surface charge and aggregation of silver nanoparticles suspensions. Environmental science & technology. 2010, 44:1260-6. 10.1021/es902240k
13. Mikhailova EO: Selenium Nanoparticles: Green Synthesis and Biomedical Application. Molecules. 2023, 28:8125. 10.3390/molecules28248125
14. Sharma VK, Yngard RA, Lin Y: Silver nanoparticles: green synthesis and their antimicrobial activities. Advances in colloid and interface science. 2009, 30:83-96. 10.1016/j.cis.2008.09.002
15. Zuhrotun A, Oktaviani DJ, Hasanah AN: Biosynthesis of Gold and Silver Nanoparticles Using Phytochemical Compounds. Molecules. 2023, 28:3240. 10.3390/molecules28073240
16. Vanlalveni C, Lallianrawna S, Biswas A, Selvaraj M, Changmai B, Rokhum SL: Green synthesis of silver nanoparticles using plant extracts and their antimicrobial activities: a review of recent literature. RSC Adv. 2021, 11:2804-2837. 10.1039/D0RA09941D
17. Marinescu L, Ficai D, Ficai A, Oprea O, Nicoara AI, Vasile BS: Comparative Antimicrobial Activity of Silver Nanoparticles Obtained by Wet Chemical Reduction and Solvothermal Methods. Int J Mol Sci. 2022, 23:5982. 10.3390/ijms23115982
18. Almatroudi A: Silver nanoparticles: synthesis, characterisation and biomedical applications. Open Life Sciences. 2020, 15:819-839. 10.1515/biol-2020-0094
19. Ahmed S, Ahmad M, Swami BL, Ikram S: A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: A green expertise. J Advert Res. 2016, 7:17-28. 10.1016/j.jare.2015.02.007
20. Osman AI, Zhang Y, Farghali M, et al.: Synthesis of green nanoparticles for energy, biomedical, environmental, agricultural, and food applications: A review. Environ Chem Lett. 2024, 22:841-887. 10.1007/s10311-023-01682-3
21. Tharani, M.; Rajeshkumar, S.; Al-Ghanim, K.A.; Nicoletti, M.; Sachivkina, N.; Govindarajan, M: Terminalia chebula-Assisted Silver Nanoparticles: Biological Potential, Synthesis, Characterization, and Ecotoxicity. Biomedicines. 2023, 11:1472. 10.3390/biomedicines11051472
22. Chelladurai Malarkodi, Shunmugam Rajeshkumar, Kanniah Paulkumar, Mahendran Vanaja, Gnana Dhas Gnana Jobitha: Bactericidal activity of bio mediated silver nanoparticles synthesized by Serratia nematodiphila. Drug Invention Today. 2013, 5:119-125. 10.1016/j.dit.2013.05.005