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PHYTO-SYNTHESIS, CHARACTERIZATION OF SILVER NANOPARTICLES USING AQUEOUS EXTRACT OF *MICONIA CRENATA* LEAF, AND ITS STRUCTURAL AND FUNCTIONAL ANALYSIS

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ABSTRACT

Utilizing *Miconia crenata* leaf aqueous extract as a bio-capping agent, the current study establishes an easy, sustainable process for manufacturing silver nanoparticles (Ag NPs). We investigated the possible activities of *M. crenata* leaf extract in converting silver ions. The UV demonstrated Surface Plasmon Resonance of Ag NPs, with a visible absorption peak at 400–410 nm and a band gap energy of 3.2 eV. The functional groups of silver oxide are correlated with the peaks found in the FT-IR spectrum, which range from 469.92 to 686.66 cm^{-1}. Using diffractogram sizes at 37.1°, 43.4°, 65.1°, and 76.8°, XRD spectra were used to identify the production of crystalline Ag Nps. SEM revealed a spherical nature with a diameter of 17.58 nm. The presence of elemental Ag was confirmed by EDX analysis, which showed a high absorption peak at 3 keV. The purity level of elemental silver was 30.24%, whereas that of Ag was 79.56%. Significant antibacterial activity was observed against *Escherichia coli*, *Streptococcus pyogenes*, and *Staphylococcus aureus* at 60 µg/mL. Similarly, antifungal activity against *Candida albicans* and MIC was observed at 40 µg/mL with a 1.2mm, respectively. Ag NPs mediated by *M. crenata* showed an IC_{50} value of 104 µg/mL and 95.90% scavenging activity at 200 µg/mL concentration. Additionally, the anti-inflammatory activity of Ag NPs was demonstrated by protein denaturation at the IC_{50} of 268.81 µg/mL. Additionally, the anti-arthritis activity decreased with increasing concentration. These studies revealed that *M. crenata*-derived Ag NPs contribute to the scientific knowledge of novel antimicrobial agents that combat drug-resistant microorganisms.

Keywords: *Miconia crenata*, Ag NPs, Nanoparticles, Green synthesis, biological activities

INTRODUCTION

Each research aims to provide a significant solution to an existing or anticipated challenge. Likewise, the application of various dynamic technologies and biological methods in biotechnology has had a profound impact on society for centuries. This research focuses on the remarkable use of nanoscale particles, particularly in the context of human health, through their characterization and application. We are familiar with nanoparticle applications, ranging from disease treatment to industrial usage. Yet, in many cases, certain limitations restrict the use of nanoscale particles across the full range. To maintain a sustainable ecosystem, it is wise to understand the importance of resources. Thus, nanotechnology emerged, combining hands with biology to uplift human health and the environment. Most techniques used to prepare nanomaterials are costly and require energy during synthesis, which is detrimental to human health and the environment **(Alsammarraie *et al*., 2018)**. Nowadays, hazardous compounds are removed using nanoparticles via green chemistry methods. In the green chemistry method, researchers aimed to reduce the use of chemicals and solvents, instead employing natural resources for nanoparticle synthesis **(Parida *et al*., 2011)**. The green synthesis approach uses biological materials, which are non-toxic, inexpensive, and ecologically benign, to synthesize nanoparticles. These materials include fruits, leaves, seeds, flowers, and microbes. Bio-nanotechnology has been utilized to create a range of nanoparticles, including silver, gold, zinc oxide, copper oxide, and iron oxide, for the prevention of cancer, cataracts, cardiovascular disease, and other conditions **(Elia *et al*., 2014; Anguraj *et al*., 2024)**.

Plants have immense potential for treating and healing diseases in all living organisms. One such plant species is *M. crenata*, a shrub that predominantly grows in wet tropical biomes. Some *Miconia* species possess therapeutic and pharmacological properties, including anti-inflammatory, anti-mutagenic, antibacterial, anticancerous, and antioxidant effects **(Gandhi *et al*., 2023; Subramaniam *et al*., 2025).** Meanwhile, *M. crenata* can remain more advantageous by producing nanoparticles from its extract through a green synthesis. This research was conducted to identify the potential benefits of nanoparticles derived from the plant species *M. crenata* (formerly known as *Clidermia hirta*), as shown in Figure 1. Biochemical and phytochemical analysis of the derived nanoparticles was carried out effectively *via* nanotechnology.

Figure 1 Leaf of *Miconia crenata*

The broad purpose of this research, which involves the green synthesis of Ag NPs from *M. crenata*, is to critically assess the capabilities of the biochemical product and apply them to address real-life issues, primarily specific medical conditions. In the current generation, most human cells are constantly but gradually deteriorating due to the influence of their lifestyle and present environment. Hence, we need treatments and solutions that enhance the function and lifespan of cells and tissues in our body. Along with treating unhealthy cells, it is vital to remain sustainable and eco-friendly while synthesizing beneficial products. Therefore, this research study aims to develop a solution that effectively addresses the statement mentioned earlier. Simultaneously, in this study, nanoparticles are analyzed to determine if they can effectively reduce the accumulation of heavy metals in water bodies. The novelty proposed here is that this is the first report to employ *Miconia crenata* leaf aqueous extract as a green reducing and biocapping agent for the synthesis of silver nanoparticles (Ag NPs). No previous studies have utilized this plant species for nanoparticle production. Moreover, it was the first report to characterize and evaluate the biological properties of *M. crenata*-derived Ag NPs. Developing a simple, cost-effective, and environmentally benign one-step method using only aqueous plant extract, avoiding hazardous chemicals or high-energy conditions, is a high impact. By

identifying a new plant-based nanoparticle system with strong bioactivity, the study contributes valuable knowledge toward the development of alternative agents against drug-resistant microorganisms.

MATERIALS AND METHODS

Materials and Reagents

Silver nitrate ($AgNO_3$) with 99.8% purity was procured from Sigma-Aldrich Chemicals, Mumbai, which is of analytical grade.

Collection of Plant material & Preparation of extracts

Fresh leaves were obtained from the plant specimen – *M. crenata*, grown at high altitudes in the moist, damp Valparai district, Tamil Nadu. Gently wash the leaves with running tap water to remove all dirt and excess macromolecules. Allow the leaves to dry in the shade and crush them into a fine powder. Then, they were subjected to extraction with 100mL of deionized water, heated to 100°C for 30 min. The resulting filter extracts were stored for further analysis **(Kumavat & Mishra, 2021; Begum *et al*., 2024)**.

Synthesis of silver nanoparticles (Ag NPs)

Ag NPs were synthesized using silver nitrate ($AgNO_3$) as a precursor. An aqueous solution containing 0.1 mM of silver nitrate was created. Ag NPs were prepared by mixing 25 mL of plant extract with 75 mL of $AgNO_3$, yielding a final concentration of 0.1 mL at room temperature. A noticeable color change from colorless to dark yellow suggested that Ag NPs were synthesized after 2 minutes. After 5 minutes, the hue deepened and became dark brown. The UV-Vis spectrum of the solution verified the reduction of silver ions. Centrifugation was performed for 20 minutes at 10,000 rpm to extract the nanoparticles produced from the mixture **(Jagtap & Bapat, 2013; Kiruba *et al*., 2023)**. Centrifugation was performed three or four times, dispersing the pellet in distilled water to extract the organic matter from the leaf. The pellet was gently removed from the bottom of the centrifuge tube using a watch glass, then dried at 60°C in a hot-air oven.

Ag NPs Structural and Functional Profile

Physicochemical properties of *M. crenata*-mediated Ag NPs were observed, including size, chemical bonding, elemental composition, purity, morphology, optical properties, crystalline nature, and thermal stability, using industry-standard methods and instruments, such as the UV-visible spectrophotometer, FT-IR, XRD, EDS, and FE-SEM **(Imani & Safaei, 2019; Al-Ajmi *et al*., 2018)**.

Determination of antibacterial & antifungal action

The antibacterial activity against *E. coli*, *Streptococcus pyogenes*, and *Staphylococcus aureus* was measured using the well-diffusion method **(Krishnamoorthy & Jayalakshmi, 2012)** using synthesized Ag NPs. 20 µg/mL, 40 µg/mL, and 60 µg/mL of the synthesized Ag NPs were suspended in sterile distilled water. Plates were incubated for 24 hours at 37°C with gentamycin (10 µg/mL) as a control. Following an incubation period, the zone of inhibition was measured in the well **(Kamer *et al*., 2024; Li *et al*., 2022)**.

In vitro anti-inflammatory activity

Protein denaturation assay

The reaction mixture consisted of 50 mL of 1% BSA in phosphate buffer solution, and synthesized Ag NPs at concentrations of 50, 100, 150, and 200 µg/mL were added to various test tubes. The final volume was increased to 2 mL using PBS, and the mixture was incubated at room temperature for 15 minutes to denature BSA. The reaction mixture was heated to 70°C in a hot-water bath for 10 minutes. Using a colorimeter, the OD was determined at 660 nm. The following formula was used to determine the protein's denaturation percentage:

$$\%\ \boldsymbol{of\ denaturation} = \frac{[(\boldsymbol{Abs\ control} - \boldsymbol{Abs\ test})]}{\boldsymbol{Abs\ control}} \times \mathbf{100} \quad (1)$$

Abs is the absorbance of the control, and Abs test is the absorbance of the test sample

Antiarthritis activity

The final volume was brought to 0.5 mL by adding 0.05 mL of standard diclofenac sodium, plant extract, and Ag NPs at different concentrations to 0.45 mL of BSA. The samples were incubated for 20 minutes at 37°C, followed by 5 minutes at 72°C. Following cooling, 2.5 mL of phosphate buffer was added to each sample, and the absorbance was measured at 660 nm using a visible spectrophotometer. The control represents complete protein denaturation. The sample result was compared with the standard value for diclofenac sodium **(Amoolya *et al*., 2017)**. The inhibition percentage was calculated using the following formula:

$$\%\ \boldsymbol{of\ inhibition\ of\ denaturation} = \left(\mathbf{1} - \frac{\boldsymbol{A2}}{\boldsymbol{A1}}\right) \times \mathbf{100} \quad (2)$$

A1 is the absorption of the control sample, and A2 is the absorption of the test sample

Free Radical Scavenging activity using 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay

2, 2-diphenyl-1-picrylhydrazyl (DPPH), used for the antioxidant properties of Ag NPs, was ascertained. Ag NPs were prepared at concentrations of 25, 50, 100, 200, and 500 µg/mL. 0.1 mL of distilled water and 0.7 mL of methanol were used as a reference. The absorbance peak was measured using a 0.1 mL sample of de-ionized water and 0.7 mL of DPPH solution **(Baliyan *et al*., 2022)**. The capacity to reduce free radicals was computed using the following formula:

$$\mathbf{Aa} = \frac{[\boldsymbol{Ao} - \boldsymbol{Ai}]}{\boldsymbol{Ao}} \times \mathbf{100} \quad (3)$$

Ai is the average absorbance of the tested solution, and Ao is the average absorbance of the DPPH solution, where Aa represents the percentage (%) of antioxidant activity.

RESULTS AND DISCUSSION

The plant-based synthesis of nanoparticles appears to be significantly more efficient and convenient compared to many other approaches **(Mahmoodi Esfanddarani *et al*., 2018)**. The green synthesis of nanoparticles from *M. crenata* extract exhibits a broad range of biological and systemic activities, offering a sustainable and proactive solution to modern-day challenges. The primary abilities of the nanoparticles are anti-inflammatory, antimicrobial, and antioxidant, due to their critical structure and geometry. Several *in vivo* and *in vitro* studies have been conducted to evaluate the potential of the phytoconstituents of the *Miconia* genus. Likewise, the size distribution, morphology, molecular structure, and crystal configuration of the nanoparticles were ascertained from the patterns and bands observed in the structural analysis.

UV–Visible spectroscopic analysis

A reddish-brown color formed, and the Ag NPs aggregated as Ag0 ions. The silver surface plasmon resonance (SPR) band at 400 - 410 nm, which confirmed the biosynthesis of Ag NPs **(Giri *et al*., 2022; Khatun *et al*., 2023)** (Figure 2). A chitosan-mediated biogenic Ag NP nanoparticle exhibits a single peak at 400–480 nm **(Zaheer, 2018; Priya *et al*., 2020)**.

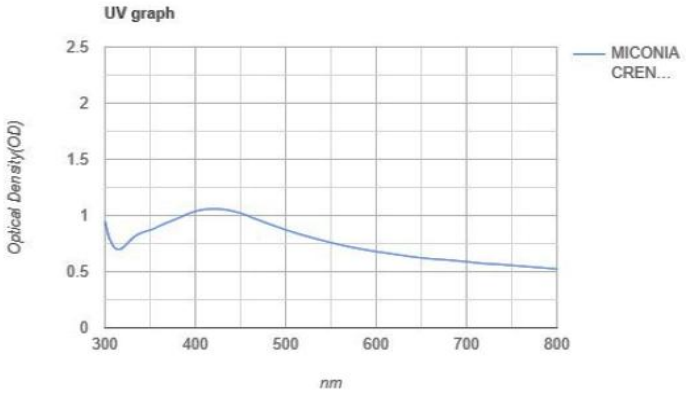


Figure 2 UV- Visible spectroscopy analysis of *M. crenata* leaf extract-mediated Ag NPs

FTIR analysis

There were no visible peaks between 2000 and 3000 cm^{-1}, indicating the absence of triple bands in the sample. The peak intensity indicates the presence of distinct functional groups. In the double-bond region, a small peak was observed, indicating the presence of alkene and imine functionalities. The presence of aromatic rings was confirmed by strong signals between 700 and 1400 cm^{-1}. The FTIR spectrum of the Ag NPs derived from *M. crenata* leaf extract showed bands at 3703.33, 2345.44, 1527.62, 1064.71, 686.66, 648.08, 601.79, and 469.92cm^{-1}. Correspondingly, the COOH stretching vibration and other functional groups. Additionally, a minimum of flavonoids and other residual organic substances was

detected around the nanoparticles, appearing as small bands at 1311.59, 1041.56, 686.86, and 601.79 (Figure 3 and Table 1).

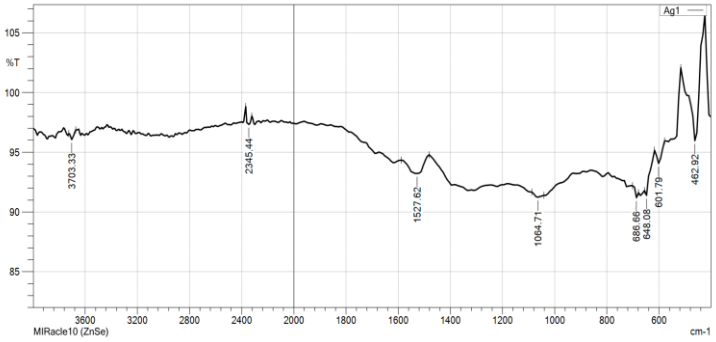


Figure 3 FTIR analysis of *M. crenata–mediated* Ag NPs

Table 1 Functional groups of *M. crenata* leaf extracted and adhered to Ag NPs.

1.1.1. **Absorption Band**	1.1.2. **Functional group**
1.1.3. 3703.33	1.1.4. NH stretching group, COOH groups, and water molecules.
1.1.5. 2345.44	1.1.6. Cyanide groups C=C, N-C=S
1.1.7. 1527.62	1.1.8. -C=C-, C=N
1.1.9. 1064.71	1.1.10. Ether groups, C-F, C-I
1.1.11. 686.66	1.1.12. Aromatic C-H, Phenyl C-H (Disubstituted, meta-positioned), C-Br
1.1.13. 648.08	1.1.14. C-Br, alkyne, C-H bend, C-Cl
1.1.15. 601.79	1.1.16. C-Br
1.1.17. 469.92	1.1.18. Finger print region

XRD analysis

The XRD analysis of the *M. crenata*-assisted Ag NPs is shown in Figure 4, demonstrating the absence of impurities. Firm peaks at 2θ = 37.1°, 43.4°, 65.1°, and 76.8° were assigned to the planes (111), (200), and (311) facets of silver crystal, respectively (JCPDS Card File No. JCPDS No. 87–0717). The synthesized Ag NPs are crystalline, as shown by XRD. The average size of Ag NPs synthesized from *M. crenata* extracts was calculated using Scherrer's equation, with an average of 23.21 nm. The XRD spectra of marine algae-based Ag NPs showed the presence of planes of (311), (220), (200), and (111), indicating that the NPs were face-centered cubic **(Mahyoub, 2021; Sahayaraj *et al*., 2012)**. Using Scherrer's equation, the average grain size of Ag NPs was determined to be 17.8 nm **(Nandana *et al*., 2025; Kingslin *et al*., 2023)**.

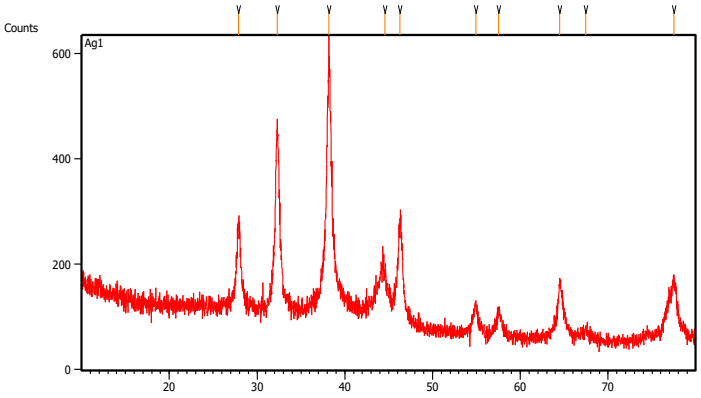


Figure 4 X-ray diffraction analysis of *M. crenata–mediated* Ag NPs

Field Emission – Scanning Electron Microscopy analysis

The shape and surface morphology of the green-synthesized Ag NPs were observed, and it was revealed that the synthesized nanoparticles were spherical (Figure 5). An average Ag NP diameter of 1 - 100 nm **(Almatroudi, 2020)**, and the clustered particles derived from the plant extract are about 17.58 nm in size. 15–25 nm with an average diameter of 21 nm in *Trigonella foenum-graecum* L leaf extract was reported **(Moond *et al*., 2023).**

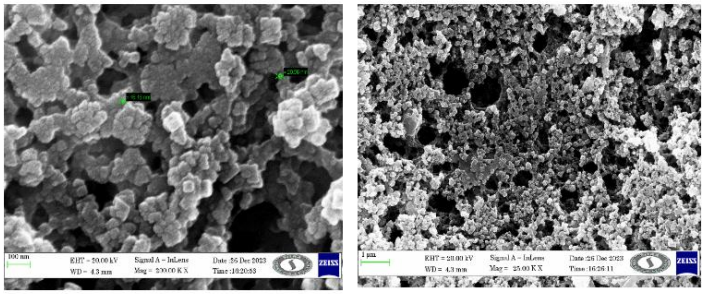


Figure 5 SEM analysis for *M. crenata*-derived Ag NPs

EDX analysis

The purity level of Ag NPs is determined by EDX elemental analysis. Based on the spectra, the purity level was 30.24%, with silver accounting for 79.56%, and the error shown was less than 5%. Based on the peak level, the purity of Ag NPs was determined (Figure 6 and Table 2).

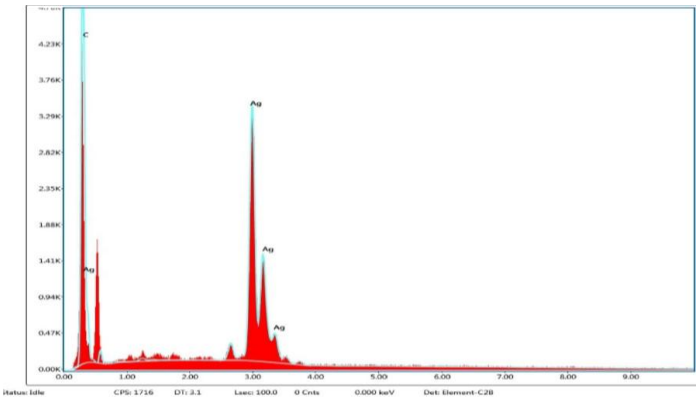


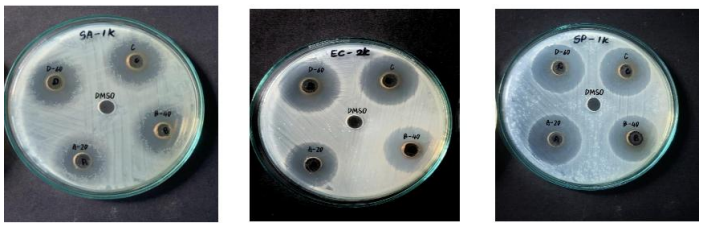
Figure 6 EDX analysis of Ag NPs derived from *M. crenata* plant leaf extract

Table 2 Purity and error levels of Ag NPs

1.1.19. **Element**	1.1.20. **Weight**	1.1.21. **Atomic**	1.1.22. **Error**
1.1.23. Silver (Ag)	1.1.24. 79.56%	1.1.25. 30.24%	1.1.26. 2.58%
1.1.27. Carbon (C)	1.1.28. 20.24%	1.1.29. 69.76%	1.1.30. 4.50%

Analysis of antimicrobial activity of Ag NPs

Ag NPs synthesized using *M. crenata* leaf extracts were evaluated for their antibacterial activity using the agar well diffusion assay. Our results were identical to those of the previous study; *Cestrum nocturnum*–mediated Ag NPs demonstrate bacteriostatic and bactericidal activity against *E. coli*, *E. faecalis*, and *S. typhi* **(Bhowmick *et al*., 2020; Murugesan *et al*., 2025)**. The highest zone of inhibition was observed at 60 µg/mL concentration, indicating the high efficacy against *Escherichia coli* and *Streptococcus pyogenes* (2.7 mm) (Figure 7 and Table 3). The antibacterial activity of Ag NPs depends on the composition and thickness of microorganisms' cell walls. Because of this, the structural makeup of the cell wall of gram-positive bacteria, specifically the peptidoglycan layer, made S. aureus (2.0 mm) more resistant to Ag NPs than *E. coli*, the gram-negative bacterium **(Dakal *et al*., 2016; Sindhura *et al*., 2025)**. *M. albicans*, *M. ligustroides*, *M. salicifolia*, and *M. latecrenata* have proven to have remarkable antibacterial action. In *Miconia*, urolic acid, oleanolic acid, phenolics, and triterpenes are the secondary metabolites typically associated with antibacterial activity. Specifically, the derivatives of *Miconia* can inhibit bacteria such as *Staphylococcus aureus* and *Escherichia coli* **(Gandhi *et al*., 2023)**. Several studies have examined the effects of *Miconia albicans* extract on both Gram-positive and Gram-negative bacteria. This synergistic approach against MRSA (Methicillin-Resistant *Staphylococcus aureus*) did not exhibit any negative inhibitory effects on biofilm formation. The MRSA MIC (Minimum Inhibitory Concentration) values ranged from ≥500 to 250 µg/mL, indicating a moderate to poor impact of biochemicals extracted from *M. albicans* stem and leaves **(de Jesus *et al*., 2023).** The MIC (Minimum Inhibitory Concentration) and MBC (Minimum Bactericidal Concentration) of green-produced Ag NPs against *Escherichia coli*, *Klebsiella pneumoniae*, *Salmonella typhimurium*, and *Salmonella enteritidis* were determined in a study specifically focused on the antimicrobial effects of these particles. Here, the MIC and MBC values were 7.5 µg/mL, and the zone of inhibition for the *E. coli* cell measured 15 mm in diameter **(Loo *et al*., 2018)**. Ag NPs have predominantly demonstrated strong antibacterial activity against both Gram-positive and Gram-negative microorganisms.



(A) (B (C)

Figure 7 Antibacterial activity of Ag NPs against *Staphylococcus aureus* (A), *E. coli* (B), and *Streptococcus pyogenes* (C)

Table 3 Antibacterial activity of Ag NPs of different concentrations on three different bacterial strains.

1.1.31. **Pathogenic strains**	1.1.32. **20 µg/mL**	1.1.33. **40 µg/mL**	1.1.34. **60 µg/mL**	1.1.35. **Control**	1.1.36. **DMSO**
1.1.37. *Escherichia coli*	1.1.38. 2.4mm	1.1.39. 2.5mm	1.1.40. 2.7mm	1.1.41. 2.7mm	1.1.42. -
1.1.43. *Staphylococcus aureus*	1.1.44. 1.7mm	1.1.45. 1.9mm	1.1.46. 2.0mm	1.1.47. 2.5mm	1.1.48. -
1.1.49. *Streptococcus pyogenes*	1.1.50. 2.2mm	1.1.51. 2.6mm	1.1.52. 2.7mm	1.1.53. 2.9mm	1.1.54. -

A certain level of Ag NPs prevents spore germination and mycelial growth of the fungus. Different concentrations of Ag NPs exhibit varying inhibitory effects on fungal growth **(Li *et al*., 2022).** An identical approach was employed to test the antifungal activity against *Candida albicans* (1.2 mm) at 40 µg/mL (Figure 8 and Table 4). A zone of inhibition was visible around the well, indicating the sample extract activity.

Figure 8 MIC of Ag NPs against *Candida albicans*

Table 4 Antifungal activity of Ag NPs of varied concentrations on *C. albicans*

1.1.55. **Pathogenic Fungi**	1.1.56. **20 µg/mL**	1.1.57. **40 µg/mL**	1.1.58. **Control**	1.1.59. **DMSO**
1.1.60. *Candida albicans*	1.1.61. 0.8mm	1.1.62. 1.2mm	1.1.63. 1.5mm	1.1.64. -

Anti-inflammatory activity

It refers to the degradation of pro-inflammatory molecules and proteins that cause cell inflammation **(Carvalho-Silva *et al*., 2024)**. Ag NPs have been utilized as carriers in drug delivery systems due to their therapeutic effects on human health **(Singh *et al*., 2022)**. *M. crenata* aqueous leaf extracts at different concentrations (50, 100, 150, 200 µg/mL) showed significant stabilization towards protein denaturation as the concentration increased (Fig. 9 and Table 5). The IC_{50} value of 268.81 µg/mL demonstrates the anti-inflammatory activity of Ag NPs. Subsequently, the chemical profile of *Miconia albicans* revealed the presence of triterpenes and a few other phenolic compounds that regulate pro-inflammatory mediators and alleviate inflammation, as well as the pain associated with inflammatory conditions **(Vasconcelos *et al*., 2006)**. Therefore, the dual action of phytochemicals in *Miconia* species and the Ag NPs derived from them exhibits anti-inflammatory abilities in biomedicine and regenerative therapeutic studies.

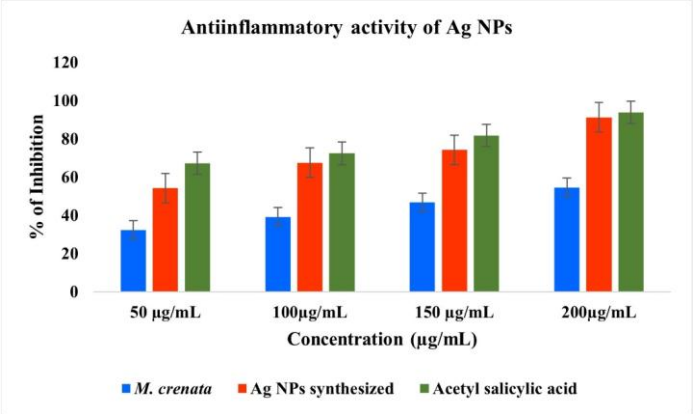


Figure 9 Percentage of inhibition at different concentration levels of *M. crenata*-mediated Ag NPs

Table 5 Analysis of anti-inflammatory properties using the *M. crenata*–mediated Ag NPs

1.1.65. **Compounds**	1.1.66. **50 µg/mL**	1.1.67. **100µg/mL**	1.1.68. **150 µg/mL**	1.1.69. **200µg/mL**
1.1.70. *M. crenata*	1.1.71. 32.4	1.1.72. 39.2	1.1.73. 46.7	1.1.74. 54.6
1.1.75. Ag NPs synthesized	1.1.76. 54.2	1.1.77. 67.5	1.1.78. 74.2	1.1.79. 91.2
1.1.80. Acetyl salicylic acid	1.1.81. 67.2	1.1.82. 72.4	1.1.83. 81.7	1.1.84. 93.8

Antioxidant activity

25 µg/mL of *M. crenata*-mediated Ag NPs shows 62.30% scavenging activity, while 200 µg/mL shows 95.90% scavenging activity (Figure 10) with an IC_{50} value of 104 µg/mL. Aqueous extract from *Cestrum nocturnum* leaf possesses strong antioxidant properties **(Keshari *et al*., 2020)**. MgO NPs made with extracts from *C. ternatea* showed 65% maximum inhibitory activity **(John Sushma *et al*., 2016)**. Our findings are similar to those of **Narendhran *et al* (2019)**, who reported that MgO NPs synthesized with *Solanum trilobatum* exhibited an IC_{50} value of 72.24 µg/mL for radical scavenging activity. Upon analyzing the scavenging rate of biosynthesized Ag NPs using the DPPH assay, an effective result of approximately 10.06 ± 0.15 µg/mL was obtained.

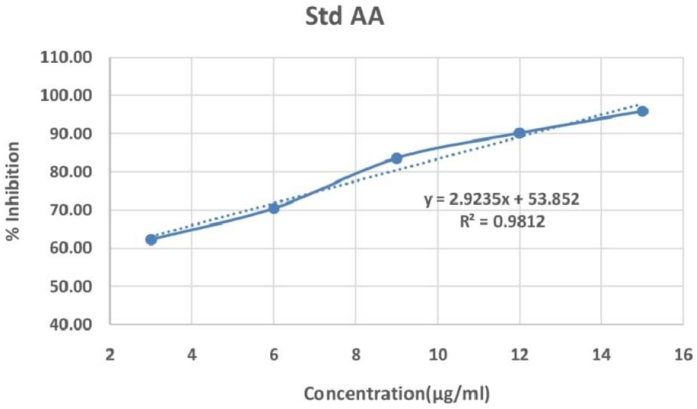


Figure 10 Antioxidant activity of synthesized Ag NPs

Antiarthritis activity

The Ag NPs demonstrated strong antiarthritic action, with an IC_{50} value exceeding 57.94 µg/mL. 53.8% of *Physalis angulata* leaves exhibited antiarthritic properties **(Shravan Kumar *et al*., 2011)**. Increasing Ag NPs concentrations can prevent BSA and albumin from denaturing and reduce protein denaturation (Figure 11 and Table 6). 85% inhibition of protein denaturation demonstrated that artificially generated Ag NPs prevent autoantigens, the primary cause of inflammation, which leads to arthritis.

Table 6 Efficacy of *M. crenata–mediated* Ag NPs in anti-arthritic activity

1.1.85. **Compounds**	1.1.86. 20 µL	1.1.87. 40 µL	1.1.88. 60 µL	1.1.89. 80 µL
1.1.90. *M. crenata*	1.1.91. 0.27	1.1.92. 0.41	1.1.93. 0.43	1.1.94. 0.68
1.1.95. Ag NPs synthesized	1.1.96. 0.43	1.1.97. 0.56	1.1.98. 0.67	1.1.99. 1.05
1.1.100. Diclofenac sodium drug	1.1.101. 0.57	1.1.102. 0.92	1.1.103. 1.27	1.1.104. 1.87

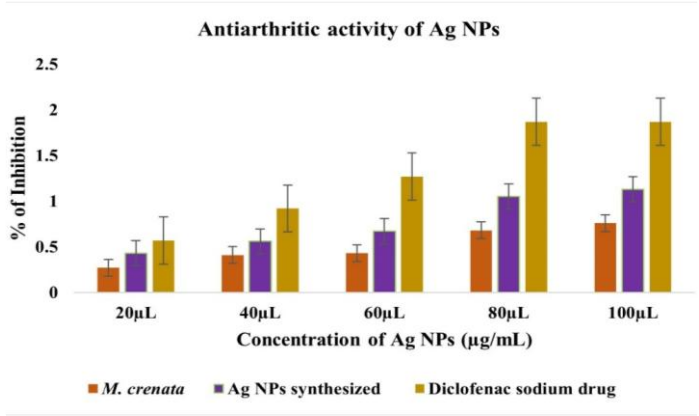


Figure 11 Antiarthritic activity of *M. crenata-mediated* Ag NPs

CONCLUSION

Recent advancements in nanobiotechnology and nanoscience have significantly improved the standards for diagnosing and treating human health and environmental issues while maintaining sustainability. The nanostructures are resourceful, and the methods employed appear cost-effective and straightforward to perform. The nanomaterials are multifunctional and are appropriately characterized and utilized based on their unique properties. This research study led to the biogenic synthesis of Ag NPs from the aqueous extract of *M. crenata,* and the characterization procedures were followed to assess their benefits for our community's well-being. This study concludes that Ag NPs are promising materials with antimicrobial, anti-inflammatory, and antioxidant properties and can be used as drug delivery systems. Various other applications of Ag NPs include wastewater treatment, biosensing, and textiles, due to their unique properties that determine their efficiency across these applications.

Conflict of interest: The authors declare that they have no conflict of interest.

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