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GREEN SYNTHESIS OF SILVER NANOPARTICLES USING *Moringa oleifera* LEAF EXTRACT AND ASSESSMENT OF ANTIMICROBIAL AND ANTIOXIDANT ACTIVITIES

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ABSTRACT

The present study aimed to explore the biosynthesis and characterization of silver nanoparticles (AgNPs) from *Moringa oleifera* leaf extract and its antimicrobial and antioxidant properties. The prepared AgNPs were characterized by UV–visible spectral analysis (UV–vis), and functional groups identification respectively. Antimicrobial and antioxidant properties of the prepared nanoparticles were also determined. UV–vis of the prepared AgNPs authenticated the surface plasmon resonance (SPR) at 420 nm. Functional group identification proved the presence of alcohol and phenolic components in leaf responsible for reduction. AgNPs have produced zone of inhibition (ZOI) of against *Escherichia coli* (*E. coli*) and *Candida albicans* (*C. albicans*) respectively. In addition, the AgNPs have effective antioxidant activity. Thus the obtained antimicrobial and antioxidant properties, suggested the use of obtained AgNPs in medicinal application.

Keywords: *Moringa oleifera* leaf, Silver nanoparticles, Antimicrobial, Antioxidant.

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INTRODUCTION

In recognition of their unique structural characteristics and wide range of applications in several scientific domains, including agriculture, electronic and sensor technologies, medicine, environmental remediation, etc., metal nanoparticles have received a lot of attention recently. According to Eker et al. (2025), the most produced metal nanoparticles are those made of silver, iron, zinc, gold, platinum, and cobalt. Metal salt reduction is often the primary method for the production of metal nanoparticles. Because of their high surface area, tiny particle size, and electrochemical characteristics, silver nanoparticles (AgNPs) are at the forefront of metal nanoparticles (Kirubakaran et al., 2025). However, the production of AgNPs has long been done via chemical and physical approaches. However, both approaches are costly, time-consuming, and detrimental to the environment and human health. However, the green method of synthesizing AgNPs is known to be low-cost, straightforward, and environmentally beneficial. The green synthesis of AgNPs uses a variety of biomasses, including plant extracts (Moradi et al., 2025), bacteria, fungus, algae, and other microorganisms (James et al., 2025). Secondary metabolites such as polyphenols, flavonoids, and triterpenes in plant extracts serve as reducing and capping agents during the plant-mediated production of AgNPs. Because of their low cost and ease of control, plant materials have recently attracted more interest than microorganisms. Stable AgNPs have previously been made from a variety of plant parts, and these

green produced nanoparticles varied in size and shape (Kavin et al., 2025). Furthermore, AgNPs made from plant extracts have drawn particular attention for biological properties as antibacterial, antioxidant, and anticancer (Moges et al., 2025). Green synthesis has been created to get over these restrictions. Plant extract was used in green synthesis as a natural stabilizing and reducing agent. The leaf of the medicinal plant Moringa oleifera is full in bioactive compounds. It has terpenoids, polyphenols, and flavonoids that help with the synthesis of nanoparticles. Plant-mediated synthesis is biocompatible, economical, and environmentally benign. The current work focuses on the green production of silver nanoparticles using leaf extract from *Moringa oleifera* and assesses their antioxidant and antibacterial properties.

MATERIALS AND METHODS

Collection of plant materials

The plant materials were purchased from Thanjavur on October 2025. The collected plant parts were cut into small pieces and shade dried at room temperature and makes a fine powder using grinder mixture.

Preparation of plant extract

1grams of *Moringa oleifera* leaf powder were used for extraction. Extraction was performed with cold extraction using the maceration method into aqueousfor 24 hours using the "intermittent shaking" method to obtain extracts. The extracts were further filtered using Whatman filter No 1 paper and filtrate was used for phytochemical analysis.

Qualitative Preliminary phytochemical analysis

Preliminary phytochemical screening was carried out by using standard procedure followed by Sofowara (1993), Trease and Evans (1989) and Harborne (1973, 1984).

Synthesis and characterization of silver nanoparticles from leaf extract

Preparation of extract

Twenty grams of powder sample (Bark) was mixed into one hundred mille liter of deionized water and the mixture was boiled for 10 min. After cooling the extract was filtered with Whatman No. 1 filter paper. The filtrate was stored at 4◦C for further use.

Synthesis of Ag nanoparticles using leaf extract

Silver nanoparticle synthesized by the method of Arunachalam *et al.,* (2012). In this method, 5 ml of leaf extract was added to 45 ml of 1 mM aqueous AgNO3 solution in a 250 ml Erlenmeyer flask. The flask was then incubated in the dark at five hours (to minimize the photo activation of silver nitrate), at room temperature. A control setup was also maintained without extract. The AgNPs solution thus attained was purified by repeated centrifugation at 10,000 rpm for 15 min followed by re-dispersion of the pellet in de-ionized water. Then the silver nanoparticles were freeze dried for using characterization analysis.

Characterization of Nanoparticles

UV Spectroscopic analysis

The silver nanoparticles were examined under UV and visible spectrophotometer analysis. The silver nanoparticles were scanned within the wavelength starting from 200-1000 nm using Perkin Elmer photometer and also the characteristic peaks were identified. Functional group also identified.

Antimicrobial study

The effects of synthesized AgNPs and plant extract were tested for antimicrobial activity against one bacteria (*Escherichia coli*) and fungi (*Candida albicans*) using disk diffusion assay. The test organisms were cultured overnight using nutrient broth media (OD600 = 0.05) and the cultures were plated on agar plates. Then nanoparticles suspension was added in the disks and incubated for 6 hrs at 4°C. Finally, the plates were incubated at 37°C for 24 hrs and the zone of inhibition was measured (NCCLS, 1993; Awoyinka *et al.*, 2007).

Antioxidant study

The antioxidant capabilities of green synthesized AgNPs and ascorbic acid (standard) were analyzed by DPPH free radical scavenging assay (Shimada et al., 1992). Briefly, 2.0 mL of 0.1 mM DPPH solution in methanol was added to 1.0 mL of samples (AgNPs and ascorbic acid) solution in water at different concentrations. After shaking, these reaction mixtures were kept in the dark place for 30 minutes at room temperature and then the absorbance of each resulting mixture was measured at 517 nm.

RESULTS AND DISCUSSION

Qualitative Phytochemicals Analysis of Moringa oleifera leaf extract showed the presence of tannins, saponins, flavonoids, terpenoids, alkaloids and polyphenols (Table 1). Presence of the phytochemicals further confirmed in the histochemical analysis (Table 2). These phytochemicals are responsible for the Reduction and stabilization of Silver Nanoparticles (Velavan et al., 2015). Histochemical analysis of leaf powder confirmed the presence of flavonoids, polyphenols and terpenoids. The presence of the compound Support the suitability of the plant for Green synthesis. The formation of silver Nanoparticle was initially confirmed by a visible colour change of the reaction mixture (Figure 1). This colour change Indicate the reduction of silver ions to silver Nanoparticles. UV-Visible spectroscopic analysis showed characteristic absorption at 420nm peak confirming Nanoparticle formation (Figure 2). The observed peak is due to surface plasmon resonance of silver nanoparticle. Analysis revealed the Functional groups such as alcohols, phenols, aldehydes and carboxylic acids (Table 3). These

functional groups indicate the involvement of plant biomolecules in capping and stabilizing. The positive Tyndall effect confirmed the colloidal nature of synthesized Nanoparticle (Figure 4). Antimicrobial activity studies showed that silver nanoparticle exhibited higher inhibition compared to plant extract and silver nitrate. This enhanced activity may be due to the small size and high surface area of nanoparticle. Antimicrobial activity against also E. Coli and C. albicans showed better inhibition by silver nanoparticles (Table 4). The DPPH assay Demonstrated a concentration-dependent increase in Antioxidant activity, indicating strong free-radical scavenging potential (Table 5). Present study agreement with earlier report by Nadeem et al., (2025) and Keskin et al., (2025). Another investigation (Simon et al., 2022) into the biomedical applications of plant extract mediated silver nanoparticles revealed that green synthesized silver nanoparticles possess antimicrobial and antioxidant activities that are comparable to, and in some cases superior to, conventional antimicrobial and antioxidant agents. Furthermore, when combined with traditional drugs, these green-synthesized silver nanoparticles display synergistic effects, enhancing their overall antimicrobial and antioxidant activities.

Figure 1 Synthesis of silver nanoparticle using *Moringa oleifera* leaf extract

Table 1 Qualitative analysis of *Moringa oleifera* leaf extract

S. No	Phytochemical	Result
1	Tannin	+
2	Saponin	++
3	Flavonoids	+
4	Terpenoids	+
5	Alkaloids	+
6	Polyphenol	++

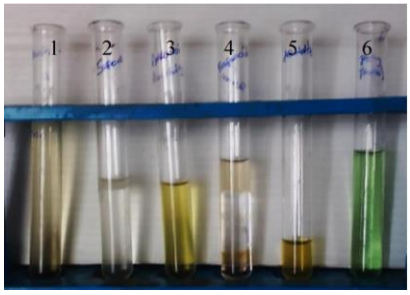
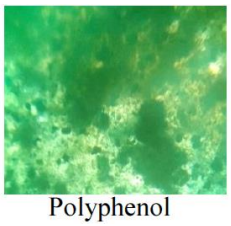
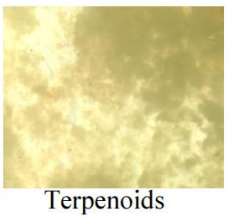


Table 2 Histochemical analysis of *Moringa oleifera* leaf powder

S.NO	Phytochemical	Result
1	Flavonoids	+
2	Polyphenol	++
3	Terpenoids	+


Flavonoids


Polyphenol


Terpenoids

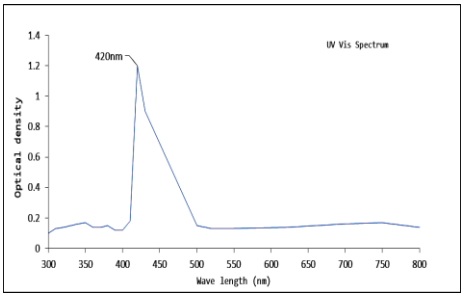
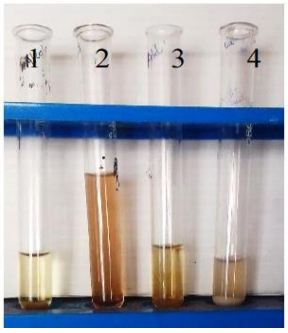


Figure 2 UV visible spectroscopic analysis of silver nanoparticles

Table 3 Identification functional groups in silver nanoparticles

SNO	Detection of Group	Result
1	Alcohols	+
2	Phenol	+
3	Aldehyde	+
4	Carboxylic acid	+



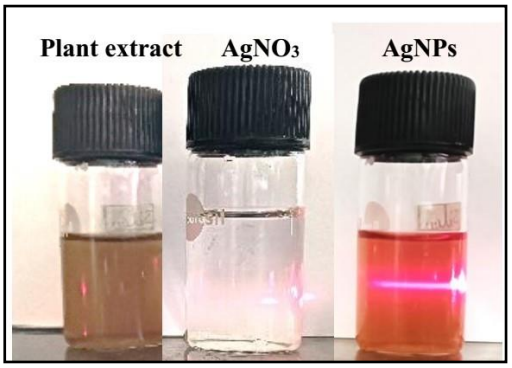


Figure 4 Tyndal effect observed in AgNPs

Table 4 Antimicrobial activity (Plating techniques for Microbes) of *Moringa oleifera* leaf extract against *E.Coli* and *C. albicans*

Samples	*E.Coli* (mm)	*C. albicans* (mm)
Silver Nitrate	4.25mm	5mm
Standard solution	10mm	18.25mm
Nanoparticle	8.5mm	10.75mm
Plant extract	3.5mm	8mm

E.Coli *C. albicans*

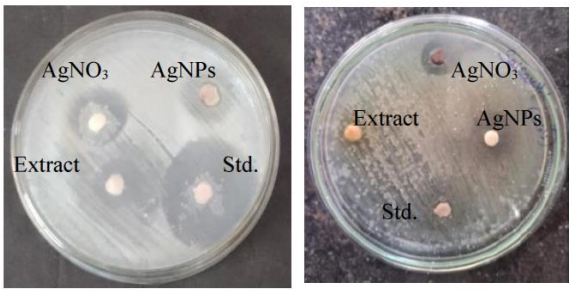


Table 5 *In vitro* antioxidant activity of silver nanoparticles using DPPH assay

S.NO	Concentrations	Result
1	20µl	13.41%
2	40 µl	32.11%
3	60 µl	67.07%
4	80 µl	78.45%
5	100 µl	88.21%

CONCLUSION

The green synthesis technique was considered to reduction of $AgNO_3$ using *M. oleifera* leaves. It has been concluded that the aqueous extract of *M. oleifera* leaves is capable of producing AgNPs. The green synthesis of silver nanoparticles showed excellent antimicrobial against some pathogenic bacteria and fungi (yeast) and possesses significant antioxidant activity using DPPH assay. This simple procedure for obtaining silver nanoparticles has such an advantage such as compatibility for pharmaceutical and medical applications.

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