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ORIGINAL ARTICLE

Yellow colored blooms of *Argemone mexicana* and *Turnera ulmifolia* mediated synthesis of silver nanoparticles and study of their antibacterial and antioxidant activity

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Abstract In the present work, AgNPs were prepared using a simple bio-reduction method. This is ecologically welcoming and cost-effective method. Yellow colored blooms concentrate of *Argemone mexicana* and *Turnera ulmifolia* are used as bio reducing agents in the study. The formation of silver nanoparticles was confirmed by UV–Vis spectrophotometer and characterization of the nanoparticles was done by FTIR, SEM, XRD and EDX. The Antibacterial action of silver nanoparticles was tested against *Staphylococus aureus, Pseudomonas aeruginosa, Escherichia coli* and *Klebsiella aerogenes.* The phytochemical analysis of the blooms concentrate has shown the existence of saponins, alkaloids, amino acids, phenols, tannins, terpenoids, flavonoids and cardiac glycosides. In vitro anti-oxidant action of both *A. mexicana* and *T. ulmifolia* AgNPs were studied by DPPH assay and reducing power assay.

Keywords Phytochemical assay · *Argemone mexicana* · *Turnera ulmifolia* · Blooms concentrate · DPPH assay · Reducing power assay

Introduction

Nanoparticles are generally considered as the particles of 1–100 nm in at least one dimension (Chen et al. 2013; Mohamed and Xing 2012; Tian et al. 2013; Xing et al. 2010). As the size of the particles decreases, the surface area to volume ratio of nanoparticles increases considerably, this leads to trivial changes in their physicochemical and biological properties. AgNPs have been among the fewest commonly used in our health care system for hundreds of years. In recent times, the nanoparticles have become a passionate awareness in biomedical applications as they possess antifungal, anti-inflammatory, antiviral, and antibacterial actions (El-Badawy et al. 2010; Zhong et al. 2010). AgNPs have been extensively used for diagnosis treatment (Uchihara 2007; Sibbald et al. 2007), coating on medical devices (Galiano et al. 2008), drug delivery (Skirtach et al. 2006), in wound dressing of (Moore 2006), contraceptive devices (Chen and Schluesener 2008) and medical textiles (Vigneshwaran et al. 2007). Nanoparticles can be easily produced by various approaches which include chemical (Sun et al. 2002), electrochemical (Yin et al. 2003), radiation (Dimitrijevic et al. 2001), photochemical and biological techniques (Naik et al. 2002). The majority of chemical reduction procedures applied for the production of NPs involve the use of lethal, dangerous chemicals that causes biological risks and these methods are not ecologically friendly. This leads to emergent requirement for developing eco-friendly methods by bio-reduction approaches using plants and microorganisms. The production of nanoparticles using plants materials and their concentrate are more advantageous than the microorganisms as they involve complex procedures of maintaining microbial cultures (Sastry et al. 2003a; 2003b).

Among the different biological methods of silver nanoparticles production, the production of nanoparticles using microorganisms is not much appropriate for industrial practicability because of high sterile conditions & their care. Hence utilization of plants concentrate is advantageous over microbes (Kalishwaralal et al. 2010). Plant-mediated synthesis of nanoparticles provides bio available

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capping agents for the stabilization of AgNPs and also contains important bioreduction agents like citric acid, flavonoids, reductases, ascorbic acids, extracellular electron shuttles, dehydrogenases which show a crucial role in bio-reduction of metal ions into nanoparticles (Pandey et al. 2012).

In the present work, we investigated the simple, effective, low-cost biosynthesis of stable AgNPs by the bioreduction method using aqueous blooms concentrate of *A. mexicana* and *T. ulmifolia.*

Argemone mexicana, which is usually known as Mexican prickly poppy (List 2007) & Flowering thistle is found in many parts of India. It is a medicinal plant used in Siddha medicine. The plant has medicinal properties such as purgative, diuretic, and destroys worms. It is used to cure lepsory, skin-diseases, inflammations and bilious fevers. Roots are anthelmintic. Juice is used to cure ophthalmia and opacity of cornea. Seeds are purgative and sedative. The seeds are also taken as a laxative (Moore 1990). The whole plant is used for the treatment of uncomplicated malaria (Willco et al. 2011; Borrell 2014).

Turnera ulmifolia is native to the West Indies and Mexico. It occurs on all island groups in the Bahamian Archipelago as well as Florida, the entire Caribbean region, India, Srilanka, and almost all tropical and subtropical regions throughout the entire world. The plant has medicinal uses such as to treat constipation, diarrhea, cold, flu, and circulatory problems. The laboratory evidence proposes that *T. ulmifolia* concentrate may increase action of antibiotics in aid of methicillin resistant *S. aureus* (Coutinho et al. 2009).

Experimental

Materials

Argemone mexicana plant blooms (Fig. 1) were collected from Devarayanadurga forest, in Tumakuru district, Karnataka, India during the month of May 2017 and *T. ulmifolia* plant blooms (Fig. 2) were collected from Namachilume near Devarayanadurga forest, in Tumakuru district, Karnataka, India during the month of May 2017. Lyophilised bacterial cultures of *S. aureus, K. aerogenes, P. aeruginosa and E. coli* were collected from department of microbiology, Shridevi Institute of Medical Sciences and Research Hospital, Tumakuru, Karnataka, India. The N.B media was procured by Hi-Media Laboratories. $AgNO_3$, KCl and TLC Silica gel 60 F_{254} plates were procured from Merck Pvt. Ltd. Mumbai, India.

Fig. 1 *Argemone mexicana*

Fig. 2 *Turnera Ulmifolia*

Methods

Preparation of blooms concentrate

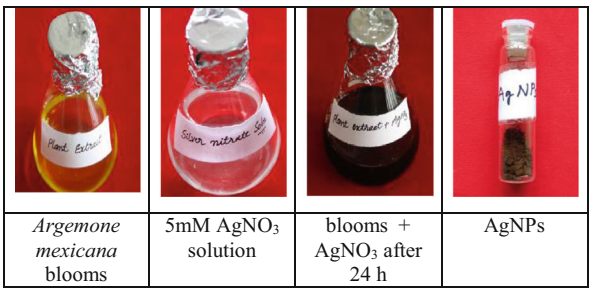
For the biosynthesis of AgNPs, the collected blooms of *Argemone mexicana* and *Turnera ulmifolia* were washed thoroughly with tap water to remove the dust and dirt particles and then washed with double distilled water. 20 g of each chopped blooms were added to two separate conical flasks containing 100 ml of double distilled water and stirred at 60 °C for 20 min on heating mantle. Then, the mixture was cooled for 15 min and the filtrate is separated using Whatman filter paper No. 1. The collected blooms concentrate (golden yellow color) was used for the biosynthesis of AgNPs.

Synthesis of silver nanoparticles using blooms extracts

10 ml of blooms *A. mexicana* and 10 ml of blooms *T. ulmifolia* were added separately to the 90 ml of 5 mM $AgNO_3$ solution at ambient temperature and stirred continuously for 20 min using magnetic stirrer. The mixture is allowed for 24 h for bioreduction process. After 24 h golden yellow color of the mixture turned to dark brown color due to the formation of AgNPs (Fig. 3a and b). The scheme for the synthesis of AgNPs is given in Fig. 4. The AgNPs obtained from the solution was refined by continual centrifugation at 10,000 rotations per minute for 15 min using Remi cooling centrifuge C-24 (Karuppiah and Rajmohan 2013). The obtained residual portion (AgNPs) was cleaned using distilled water then dried and stored for further analysis.

Characterization of Ag nanoparticles

Phytochemical assay Blooms extracts of *Argemone mexicana* and *Turnera ulmifolia* were assessed using standard procedures (Sofowora 1993; Trease and Evans 1989; Siddiqui and Ali 1997; Chandrappa et al. 2013;



Argemone mexicana blooms	5mM $AgNO_3$ solution	blooms + $AgNO_3$ after 24 h	AgNPs

(a)

Turnera ulmifolia blooms	5mM $AgNO_3$ solution	blooms + $AgNO_3$ after 24 h	AgNPs

(b)

Fig. 3 **a** AgNPs produced from *Argemone mexicana*. **b** AgNPs produced from *Turnera ulmifolia*

Ugochukwu et al. 2013) for the presence of phytochemical constituents such as alkaloids, flavonoids, tannins, saponins, terpenoid, phenols, cardiac glycosides, anthraquinones, amino acids and oxalates.

Thin layer chromatography Chromatography is a well-known method for separation, analysis and identification of extracted compounds to their easy forms. The phytochemical constituents of plants blooms concentrate was carried out using thin layer chromatographic method. TLC was carried out on readily available silica gel plates. Thin layer chromatography plate was kept in hot air oven at 115 °C for 25 min for activation. Plants blooms concentrate was applied as spots of 5 mm. The TLC glass chamber was kept for pre-saturation with the mobile phase Ethyl acetate:Toluene:Methanol (0.5:4:0.5) for 30 min. The developed chromatogram was visualized under Ultra Violet light (Wagner and Blodt 1996).

UV–visible assay The formation of AgNPs was noted by UV–visible spectrum (model Shimadzu UV) for its maximum absorbance v/s wavelength to confirm the formation of AgNPs.

Fourier transform infra-red spectroscopy (FT-IR) analysis AgNPs were mixed with potassium chloride and a thin AgNPs particles disc was prepared and placed in FTIR for the assay of the AgNPs. The FTIR measurement of sample was recorded in the range of 400–4000 cm^{-1} using Nicolet Avatar model. It gives information about the rotation and vibration modes which are used to determine the distinct functional groups present in the sample.

X-Ray diffraction analysis The reduced AgNPs powder was coated on a glass substrate and the X-ray diffraction measurement were carried out using a powder X-ray instrument (model PAN analytical BV) operating at 40 kV and 30 mA current. The output was recorded in the form of a graph with 2θ on x-axis and intensity on y-axis. The average particle size was calculated using the Debye–Scherrer formula

$$D = k\lambda/\beta\cos\theta,$$

where λ is wavelength, D is particle diameter size, β is the full width half maximum, k is a constant (value 0.9) and θ is Braggs diffraction angle.

Scanning electron microscopy (SEM) assay The particle size and their morphological distribution of the AgNPs were assessed with scanning electron microscopy (SEM). A drop of aqueous solution containing purified silver nanoparticles obtained after repetitive centrifugation was placed on the carbon-coated copper grids and dried under infrared lamp for characterization using TESCAN, VEGA3 LMU model scanning electron microscope at accelerating voltage of 30 kV.

Energy dispersive X-ray assay Energy dispersive X-ray is used for the elemental assay or chemical characterization of a sample. It relies on interaction of X-ray excitation and the sample. EDX assay was employed to affirm the

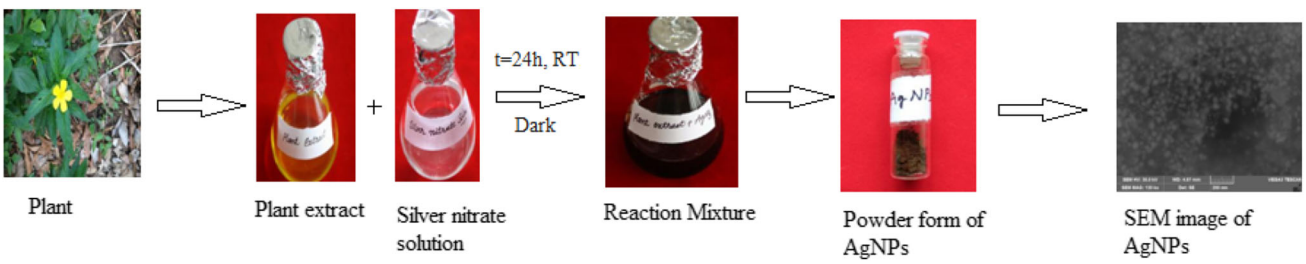


Fig. 4 Reaction mechanism

presence of Ag in sample and also to find the other elementary compositions in sample.

Antibacterial activity of silver nanoparticles The antibacterial activity of AgNPs produced by *A. mexicana* and *T. ulmifolia* blooms concentrate was evaluated by the disc diffusion method for their potential bio-medical applications (Murali Krishna et al. 2016). *Staphylococus aureus, K. aerogenes, P. aeruginosa and E. coli* bacterial strains were developed in nutrient broth (NB) media for 24 h at 37°c and 1 ml of each broth culture was spread on nutrient agar media plates. 5-mm sterilized filter paper discs were dipped in synthesized silver nanoparticles suspension (10 µl) and placed over the discs, double distilled water as negative control, Taxim (1 µg ml^{-1}) as standard also used as a positive control and blooms concentrate was placed over the agar plates and incubated for 24 h at ambient temperature. Zone of inhibition was observed around the disc and was measured (Murali Krishna et al. 2016).

Antioxidant assays The antioxidant activities of synthesized silver nanoparticles were carried out by utilizing DPPH and reducing power assay.

DPPH-free radical scavenging assay

DPPH (0.3 mM) reagent was prepared in methanol, the synthesized AgNPs sample with various concentration were taken and 300 µl of DPPH reagent was added and made it to 3 ml. Resulted solution was kept in dark place for 30 min and measured the absorbance at 517 nm including negative control. Ascorbic acid was used as standard. Scavenging activity was calculated by the following equation (Patel and Patel 2010).

$$\text{DPPH searched } (\%) = [(\text{A control} - \text{A test}) \div \text{A control}] \times 100$$

Reducing power assay

Various concentrations of test samples were prepared with 0.75 ml of Potassium ferricyanide and 0.75 ml of Phosphate buffer, this mixture was incubated at 50 °C for 20 min, to this 0.75 ml of Tri-chloro acetic acid was added and centrifuged at 3000 rotation/min for 10 min. Finally, the supernatant was mixed with equal volume of double distilled water and 0.1 ml $FeCl_3$. The absorbance was recorded at 700 nm.

Results and discussion

Phytochemical analysis

The results of phytochemical screening of *A. mexicana* and *T. ulmifolia* blooms showed the presence of flavonoids, saponins, alkaloids, amino acids, phenols, tannins, terpenoids and cardiac glycosides (Table 1).

TLC

The thin layer chromatographic study of *A. mexicana* and *T. ulmifolia* blooms concentrate have shown distinguishable different bands of phytochemicals (Figure 5).

UV–Vis-spectroscopy analysis

Bio-reduction of Ag^+ ions present in the solution of $AgNO_3$ into silver nanoparticles by the phytocompounds present in the *A. mexicana* and *T. ulmifolia* plants blooms concentrate was studied using UV–visible spectroscopy.

Table 1 Phytochemical analysis (blooms extracts)

S. No.	Phytochemicals	*Argemone mexicana*	*Turnera ulmifolia*
1	Flavonoids	++	++
2	Alkaloids	+++	+++
3	Phenols	++	+
4	Tannins	+	+
5	Cardiac glycosides	++	+
6	Saponins	+	+++
7	Anthraquinones	−	−
8	Amino acids	+	+
9	Oxalate	−	−
10	Terpenoids	++	++

+, confirms; −, absent

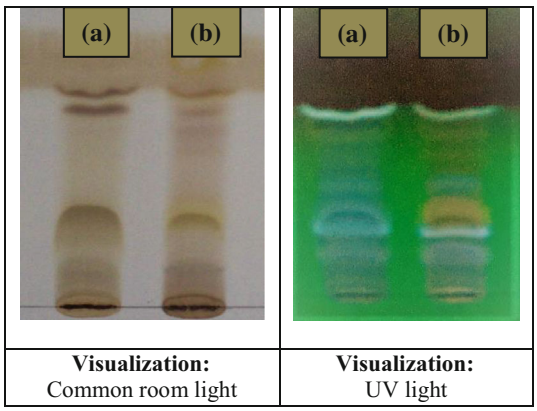


Fig. 5 TLC of blooms extracts. **a** *Argemone mexicana* blooms extract, **b** *Turnera ulmifolia* blooms extract

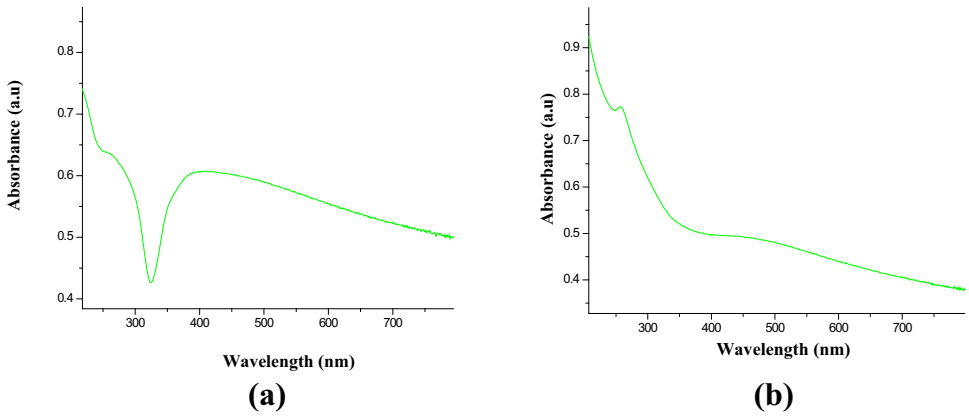


Fig. 6 UV–vis spectrum of AgNPs synthesized by blooms concentrate. **a** *Argemone mexicana* AgNPs. **b** *Turnera ulmifolia* AgNPs

UV–visible spectrograph of AgNPs solution was noted as a function of time by a quartz cuvette and water as reference. Highest absorbance peak was observed at 398 nm for *A. mexicana* Fig. 6a (Karthika et al. 2014) and 423 nm for *T. ulmifolia* Fig. 6b (Arora and Grewal 2015), which indicates the formation of AgNPs.

Fourier transform infra-red spectroscopy (FT-IR) analysis

FT-IR (Fourier transform infra-red spectroscopy) spectrum was performed to identify and assigned to determine the different functional groups present in the synthesized AgNPs by *A. mexicana* and *T. ulmifolia* blooms extracts (Fig. 7a, b). The IR bands were observed at 3790, 3436, 2920, 2350, 1593, 1385, 1264, 675 and 527 cm^{-1} was determined in the AgNPs formed by *A. mexicana* blooms extracts (Fig. 7a). The strong bands which appeared at 3790 cm^{-1} Alcohol O–H stretching and 3436 cm^{-1} Primary amine N–H, the bands at 2920 cm^{-1} Alkane C–H, 2350 cm^{-1} Carbon dioxide O=C=O, 1593 cm^{-1} Cyclic alkene C=C, 1385 cm^{-1} Sulfate S=O, 1264 cm^{-1} Aromatic ester C–O, 675 cm^{-1} Halo compound C–Br and the low band at 527 cm^{-1} corresponds to Halo compound C–I, while IR bands were observed at 3783, 3439, 2924, 2849, 1593, 1381, 1258, 681 and 536 cm^{-1} was noticed in AgNPs formed by *Turnera ulmifolia* blooms extracts (Fig. 7b). The strong bands which appeared at 3783 cm^{-1} Alcohol O–H stretching and 3439 cm^{-1} Primary amine N–H, the bands at 2924 cm^{-1} Alkane C–H, 2849 cm^{-1} weak band at Alcohol O–H, 1593 cm^{-1} strong band at Cyclic alkene C=C, 1381 cm^{-1} Sulfate S=O, 1258 cm^{-1} Aromatic ester C–O, 681 cm^{-1} Halo compound C–Br and the low band at 536 cm^{-1} corresponds to Halo compound C-I. The FT-IR spectra of the AgNPs and also by the phytochemical analysis of the blooms concentrate, indicates the existence of phytochemicals such as presence of flavonoids, saponins, alkaloids, amino acids, phenols, tannins, terpenoids and cardiac glycosides, which might have played an active in the process of bio synthesis of silver nanoparticles (Karuppiah and Rajmohan 2013; Sathyavathi et al. 2010; Daizy 2011).

X-ray diffraction analysis

X-ray diffraction pattern was recorded for the synthesized AgNPs are shown in Fig. 8a, b, which shows a number of

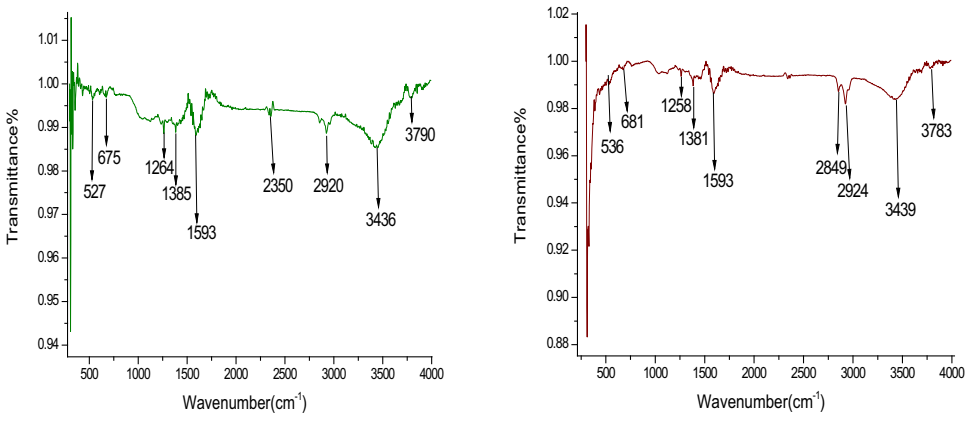


Fig. 7 IR spectra of AgNPs synthesized using blooms concentrate. **a** *Argemone mexicana* AgNPs, **b** *Turnera ulmifolia* AgNPs

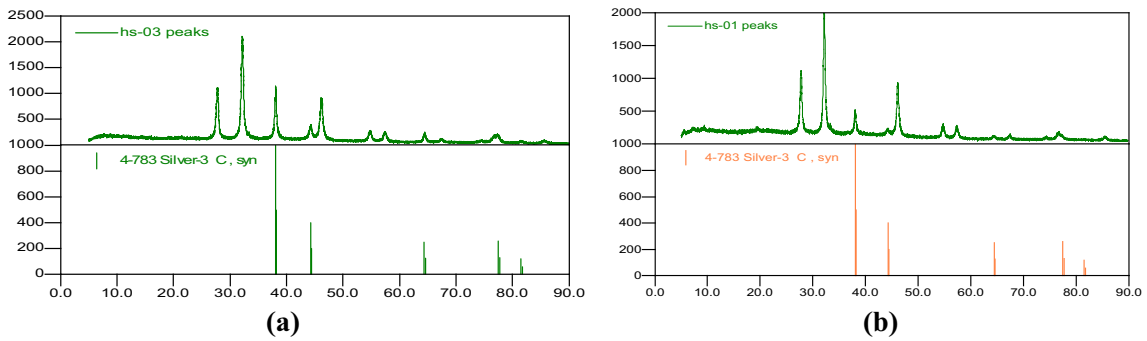


Fig. 8 XRD patterns recorded for the AgNPs synthesized using blooms concentrate. **a** *Argemone mexicana* AgNPs. **b** *Turnera ulmifolia* AgNPs

Bragg reflections corresponding to (111), (200), (220) and (311) sets of lattice planes are observed. Which may be indexed based on the structure of Ag. The diffraction peaks at $2\theta = 38°$, 44°, 64° and 77° were indexed with the planes (111), (200), (220) and (311) for the fcc lattice of obtained silver (Ag) as per the Joint Committee on Powder Diffraction Standards (JCPDS) Card No. 04-783 was matched with database. XRD has revealed the average size (D) of synthesized AgNPs was found to be 29.13 nm for *A. mexicana* AgNPs and 31.47 nm for *T. ulmifolia* as calculated using Debye–Scherer formula. The XRD pattern thus clearly shows that the synthesized AgNPs are crystalline in nature (Agrawal and Kulkarni 2017).

Scanning electron microscopy analysis

The SEM has shown the uniform distribution of AgNPs. The SEM images (Fig. 9a, b) has shown separate AgNPs as well as particle agglomeration. This indicates that the particle size is spherical shape with an average size of 29.34 nm for *A. mexicana* AgNPs and 32.42 nm for *T. ulmifolia* AgNPs. Both the particles have the particle size ranging from 23 to 38 nm, respectively (Abdelghany et al. 2017).

EDX analysis

The EDX spectrum describes elemental analysis of the AgNPs. The spectra shows characteristics of Ag signals was obtained at the energy of 3 keV, for silver (Ag), and also some of the weak peaks for C, Cl, O, N and Cl were found in (Fig. 10a, b). The emission energy at 3 keV indicates the reduction of silver ions to elemental of silver.

Antibacterial assay

The synthesized AgNPs by the blooms concentrate of *A. mexicana* and *T. ulmifolia* have a significant antibacterial activity against *K. aerogenes* followed by *P. aeruginosa, E. coli,* and *S. aureus* were tested by disc diffusion method. The zone of inhibition was found to be in the range of 20–24 mm for *A. Mexicana* (Fig. 11; Table 2) and 21 mm–27 mm for *T. ulmifolia* (Fig. 12; Table 3). Maximum antibacterial activity was shown by *T. ulmifolia* AgNPs with inhibition zone maximum of 27 mm than *A. mexicana* (Murali Krishna et al. 2016). Based on the zone of inhibition results, it is evident that the AgNPs have potential antibacterial activity.

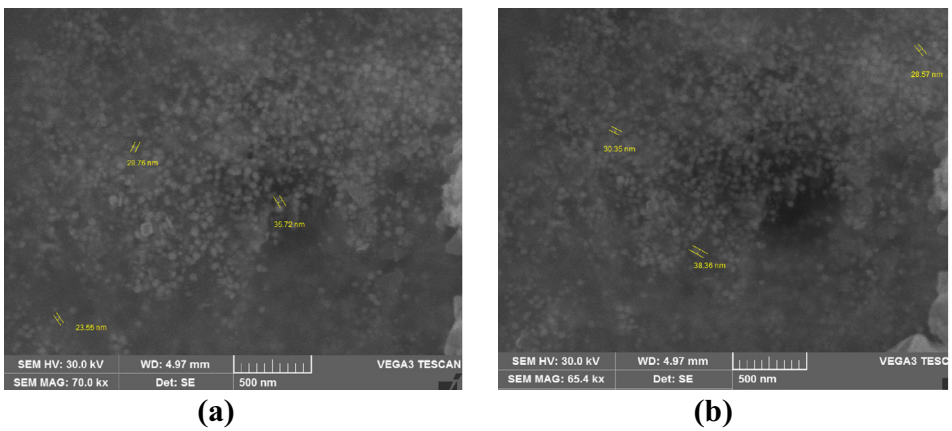


Fig. 9 SEM images for the AgNPs synthesized using blooms concentrate. **a** *Argemone mexicana* AgNPs, **b** *Turnera ulmifolia* AgNPs

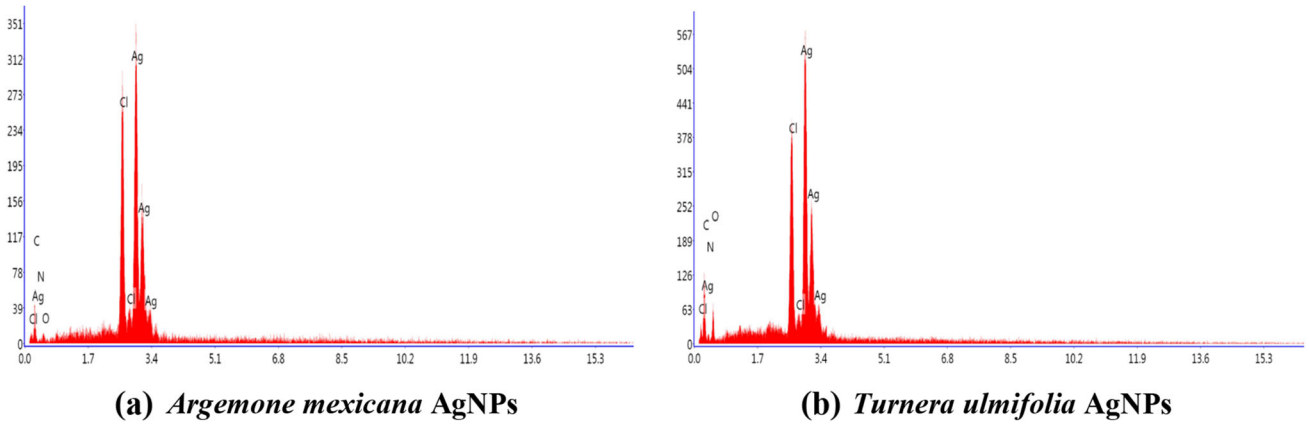


Fig. 10 EDX spectra for the AgNPs synthesized using blooms concentrate. **a** *Argemone mexicana* AgNPs, **b** *Turnera ulmifolia* AgNPs

Fig. 11 Antibacterial activity of AgNPs synthesized by blooms concentrate *of Argemone mexicana*. **a** *Argemone mexicana* AgNPs

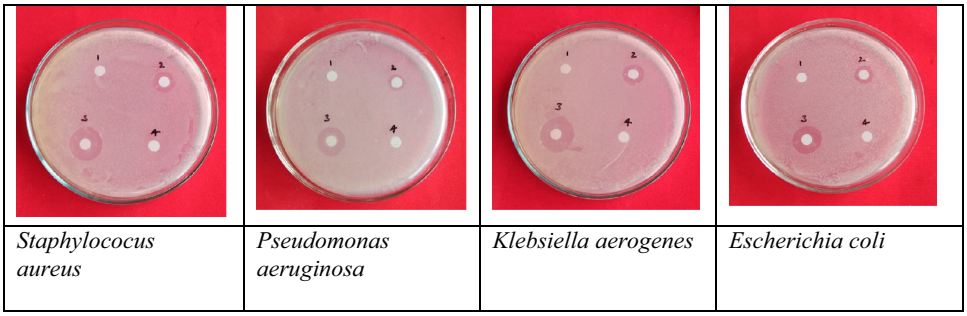


Table 2 Antibacterial zone of inhibition (*Argemone mexicana* AgNPs)

Zone of inhibition (in mm)					
S. No	Strains	(1) Control	(2) Standard	(3) AgNPs	(4) Blooms Extract
1	*Staphylococus aureus*	_	13	23	_
2	*Pseudomonas aeruginosa*	_	8	20	_
3	*Klebsiellaaerogenes*	_	13	24	_
4	*Escherichia coli*	_	12	21	_

Control double distilled water; AgNPs Silver Nanoparticles, Standard Taxim; Blooms Extract *Argemone mexicana* blooms concentrate

Antioxidant activity

DPPH assay The synthesized AgNPs exhibited a maximum DPPH scavenging activity of 87.06% at 500 µg ml^{-1} concentration, whereas for ascorbic acid (standard) was found to be 96.83% (Table 4 and Fig. 13).

The synthesized AgNPs exhibited a maximum DPPH scavenging activity of 84.62% at 500 µg ml^{-1}, whereas for ascorbic acid (standard) was found to be 94.89% (Table 5 and Fig. 14).

Reducing power assay The synthesized AgNPs have good reducing power when compared with the reducing power of standard ascorbic acid. The results obtained for the reducing power assay and the bar diagram representation were presented for AgNPs synthesized from *A. Mexicana* (Table 6 and Fig. 15) and for AgNPs synthesized from *T. ulmifolia* (Table 7 and Fig. 16).

Conclusion

The green synthesis of AgNPs has been successfully carried out using the blooms concentrate of *A. mexicana* and *T. ulmifolia.* From XRD studies, the average size of produced AgNPs is established to be 29.13 nm for *A. mexicana* AgNPs and 31.47 nm for *T. ulmifolia* AgNPs, which is close to the size of particles obtained from SEM analysis, i.e., 29.34 nm for *A. mexicana* AgNPs and 32.42 nm for *T. ulmifolia* AgNPs. In FTIR spectra has shown the presence

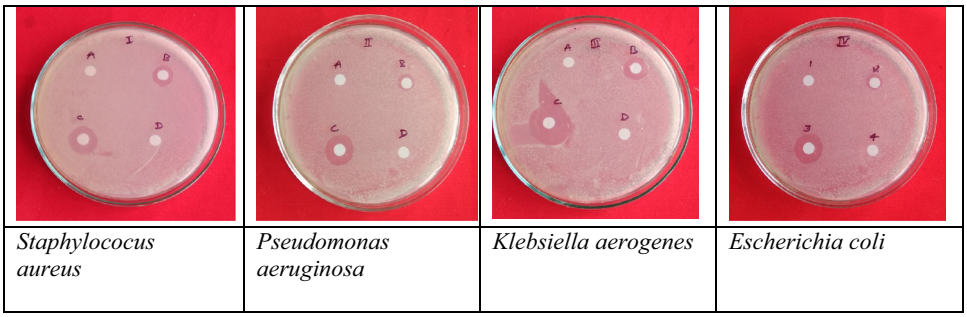


Fig. 12 Antibacterial activity of AgNPs synthesized by blooms concentrate of *Turnera ulmifolia*. **b** *Turnera ulmifolia* AgNPs

Table 3 Antibacterial zone of inhibition (*Turnera ulmifolia* AgNPs)

Zone of inhibition (in mm)					
S. No	Strains	(A) Control	(B) Standard	(C) AgNPs	(D) Blooms extract
1	*Staphylococus aureus*	_	12	21	_
2	*Pseudomonas aeruginosa*	_	7	21	_
3	*Klebsiellaaerogenes*	_	14	27	_
4	*Escherichia coli*	_	7	21	_

Control double distilled water; AgNPs silver nanoparticles; Standard Taxim, Blooms Extract *Turnera ulmifolia* blooms concentrate

Table 4 DPPH scavenging activity of AgNPs synthesized by *Argemone mexicana* blooms concentrate and ascorbic acid

Concentration of synthesized AgNPs and ascorbic acid (µl)	Scavenging (%)	
	Synthesized AgNPs	Ascorbic acid
100	74.683 ± 0.053	93.173 ± 0.052
200	76.021 ± 0.047	93.841 ± 0.059
300	78.234 ± 0.033	95.562 ± 0.065
400	78.157 ± 0.056	96.527 ± 0.073
500	87.063 ± 0.031	96.836 ± 0.045

Values are mean ± standard deviation of triplicate analyses. Results of each concentration of AgNPs were analyzed separately

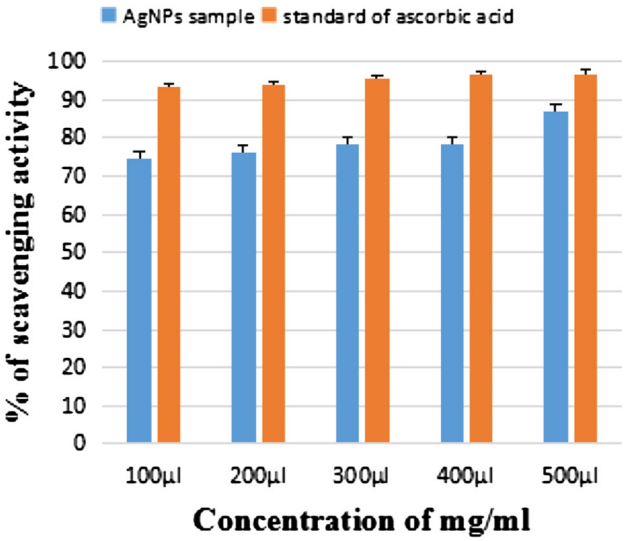


Fig. 13 DPPH scavenging activity of AgNPs synthesized by *Argemone mexicana* blooms concentrate and ascorbic acid

of phytocompounds which are responsible for the bioreduction of silver ions into silver nanoparticles. The phytochemical screening of *A. mexicana* and *T. ulmifolia* blooms concentrate has shown the presence of flavonoids, saponins, alkaloids, amino acids, phenols, tannins, terpenoids and cardiac glycosides. Green synthesis route is of low cost, non-toxic, vitality (energy) productive, surroundings prompting lesser waste and quicker than the conventional method of synthesizing the AgNPs. AgNPs synthesized from the blooms concentrate of *A. mexicana* and *T. ulmifolia* have shown efficient antimicrobial activities against *E. coli*, *K. aerogenes, P. aeruginosa* and *S. aureus*. *In vitro* antioxidant method by DPPH and reducing power assay has shown that AgNPs synthesized by the blooms concentrate of *A. mexicana* have better activity than the AgNPs synthesized by the blooms concentrate of *T. ulmifolia*. In conclusion, biosynthesis of AgNPs using

Table 5 DPPH scavenging activity of AgNPs synthesized by *Turnera ulmifolia* blooms concentrate and ascorbic acid

Concentration of synthesized AgNPs and ascorbic acid (µl)	Scavenging (%)	
	Synthesized AgNPs	Ascorbic acid
100	73.023 ± 0.064	91.037 ± 0.025
200	74.521 ± 0.058	91.148 ± 0.095
300	76.554 ± 0.043	93.256 ± 0.056
400	76.157 ± 0.067	94.572 ± 0.038
500	84.620 ± 0.042	94.896 ± 0.057

Values are mean ± standard deviation of triplicate analyses. Results of each concentration of AgNPs were analyzed separately

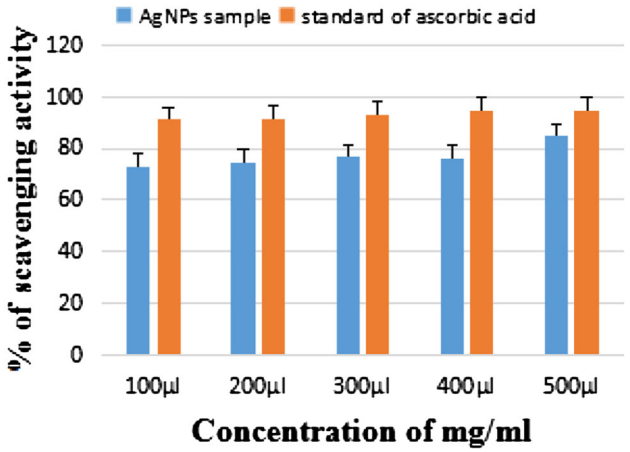


Fig. 14 DPPH scavenging activity of AgNPs synthesized by *Turnera ulmifolia* blooms extracts and ascorbic acid

Table 6 Reducing power assay of AgNPs synthesized by *Argemone mexicana* blooms concentrate and ascorbic acid

Concentration of synthesized AgNPs and ascorbic acid (µl)	Reducing power (%)	
	Synthesized AgNPs	Ascorbic acid (Std)
100	20.46 ± 0.041	28.17 ± 0.055
200	39.59 ± 0.085	56.96 ± 0.065
300	60.23 ± 0.013	72.03 ± 0.016
400	71.86 ± 0.047	83.98 ± 0.058
500	85.9 ± 0.082	96.89 ± 0.067

Values are mean ± standard deviation of triplicate analyses. Results of each concentration of AgNPs were analyzed separately

plant material is an easy, ecologically friendly and conventional method compared to the chemical and physical methods of synthesis. This method is significantly used because the plants are widely distributed in nature, safe to

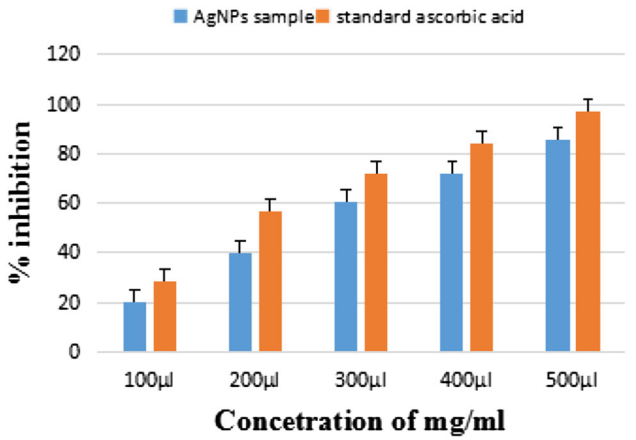


Fig. 15 Antioxidant activity by reducing power assay of Ascorbic acid and AgNPs synthesized from *Argemone mexicana* blooms extracts. *Turnera ulmifolia*

Table 7 Reducing power assay of AgNPs synthesized by blooms concentrate and ascorbic acid

Concentration of synthesized AgNPs and ascorbic acid (µl)	Inhibition (%)	
	Synthesized AgNPs	Ascorbic acid
100	17.66 ± 0.054	25.71 ± 0.055
200	36.95 ± 0.048	53.96 ± 0.045
300	57.23 ± 0.063	69.3 ± 0.016
400	67.86 ± 0.027	80.98 ± 0.088
500	81.19 ± 0.052	93.18 ± 0.067

Values are mean ± standard deviation of triplicate analyses. Results of each concentration of AgNPs were analyzed separately

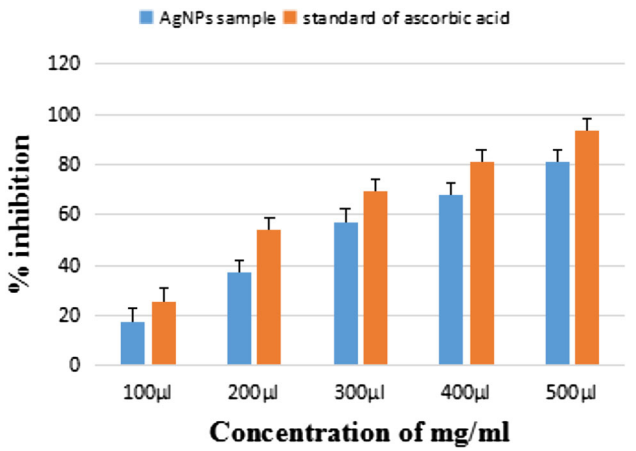


Fig. 16 Antioxidant activity by reducing power assay of Ascorbic acid and AgNPs synthesized from *Turnera ulmifolia* blooms concentrate

handle, nontoxic, easily available and low cost. Further studies are needed to optimize the scaling up of the synthesis of silver nanoparticles.

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Compliance with ethical standards

Conflict of interest None.

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