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Green Synthesis of Silver Nanoparticles and its Antimicrobial and Antioxidant Activity of *Bacopa monnieri* L.

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ABSTRACT

Bacopa monnieri, also referred to as *Herpestis monnieri,* water hyssop, and "Brahmi" has been used in the Ayurvedic system of medicine for centuries. The silver nanoparticles are most commonly used for sterilizing in consumer and medical products include fabrics, food storage bags, refrigerator surfaces and personal care products. This study explores the green synthesis of silver nanoparticles using *B. monnieri*. The biosynthesized Ag-NPs were characterized using UV-Vis-spectrophotometer and the antioxidant ability of AgNPs mediated *B. monnieri* extract was analyzed using DPPH and Hydrogen peroxide assay. The percentage of DPPH and H_2O_2 activity increased with increasing concentration of AgNPs, The AgNPs mediated leaves extract of *B. monnieri* was performed for the determination of anti-inflammatory activity and antimicrobial activity. *Aeromonas* sp., *Bacillus cereus, Brevibacillus parabrevis, Enterococcus pneumoniae, Escherichia coli, Pseudomonas aeruginosa, Salmonella* sp., *Staphylococcus aureus, Aspergillus flavus, A. niger, A. nidulans, Penicillum funiculosum, A. fumigatus, Trichoderma harzianum, A. terreus* and *A. candidus* were selected for the antimicrobial activity of silver nanoparticles. The maximum zone of inhibition was found against *E. coli* and *A. candidus* at 80 µl concentration. This study concluded that silver nanoparticles have a significant potential as an antimicrobial compound against the pathogenic microorganisms studied and can be used to treat infectious diseases caused by bacteria. Silver nanoparticles have a major role on nanotechnology and nanomedicine.

Key words*: Bacopa monnieri,* silver nanoparticles, UV-Vis characterization, antioxidant activity, antimicrobial activity.

INTRODUCTION

Bacopa monnieri (L.) commonly known as Neer-Brahmi, belonging to the family Scrophulariaceae is a creeping small prostrate annual herb found throughout the Indian subcontinent in wet, damp places near water logs and marshy areas (Prabhu and Poulose 2012). It is mostly used in Ayurveda medicine for treating various diseases like ulcers, tumors, ascites, indigestion, enlarged spleen, leprosy, inflammations, anemia and biliousness. This plant is used as a memory vitalizer and treated with cardiac, respiratory and neuropharmacological disorders like insomnia, insanity, depression, psychosis, epilepsy and stress (Ghosh et al. 2007). *B. monnieri* leaves can be executed as a supportive therapy during cancer chemotherapy, to minimize the toxic side effects on noncancerous cells and to maximize the anticancer drug action (Howes and Houghton 2009). As far as we know, green synthesis of silver nanoparticles (AgNPs) from *B. monnieri* leaf extract evaluated the cytotoxic and anticancer activities are not yet to be reported for lung cancer cell line. Therefore, the present study was investigated to produce AgNPs from *B. monnieri* and to evaluate their antibacterial and antiproliferative activity with toxicity studies.

The widespread use of silver nanoparticles (AgNPs) in the consumer products could be attributed to their potent antimicrobial activity against a wide range of pathogenic microorganisms

(Klaine et al. 2008). Eventuality of AgNPs released into the environment and its interaction with the biotic components of the ecosystem continues to be documented (Impellitteri et al. 2009). Increasing concentration of nanosilver with varied physical and surface properties, could pose a threat to human and environmental health (Panyala et al. 2008). Better knowledge of the engineered nanomaterials, its mode of interaction, uptake, accumulation and impact on the biosystems at various levels is inevitable to device and implement proper mitigation or control measures to avoid nanopollution turning out to be a serious ecological concern (Navarro et al. 2008). Evidence to date indicated that most of the toxicological studies of AgNPs have been conducted on microbial and animal cells; however only a limited study was focused on plant cells (Monica and Cremonini 2009). Generally, the nanoparticles biological properites was based on its size and shapes (Ma et al. 2010). As the concentration of AgNPs increase, there was a decrease in the root biomass and root length, indicating an increase in toxicity. Silver nanoparticles of 6 nm completely vacuolated and collapsed the cortical cells at 40 ppm concentration than the 25 nm size particles (Yin et al. 2011). The unique properties of nanoparticles (NPs) have attracted the attention of researchers in various fields (Hashem and Salem 2021). It was found that silver nanoparticles are applicable because they show antimicrobial activity (Wasilewska and Klekotka 2023). Cancer is a complex, multifactorial heterogeneous disease which has the characteristic feature of the uncontrolled growth and spread of abnormal cells caused by several factors, including a combination of genetic, external, internal and environmental factors and it is treated with various treatments including chemotherapy, hormone therapy, surgery, radiation, immune therapy and targeted therapy (Anonymous 2015). Lung cancer is considered one of the main causes of death all over the world. It is believed to be the major account for about 1.6 million deaths, 20% of the total cancer deaths (Hussein et al. 2015). Lung cancer is a highly metastatic disease, and it ranks as the second most frequently occurring cancer in both males and females (Siegel et al. 2012). Surgical resection, chemotherapy and radiation therapy are standard practices, but the ability of cancerous cells to develop multi drug resistance and a high degree of toxicity to the tissues surrounding the adjacent neoplastic ones are the major obstacles (Moitra et al. 2012).

Silver nanoparticles have been shown in bio-nano-medicine because of their therapeutic applications in cancer as anticancer agents, in diagnostics and in probing. The mechanisms for AgNPs induced toxicity may be related to mitochondrial damage, oxidative stress, DNA damage, and induction of apoptosis (Sukirtha et al. 2012). Different cell types have been investigated for cytotoxicity of AgNPs, including NIH 3T3 fibroblast cells, HeLa cells and human glioblastoma cells (Asha Rani et al. 2009). The therapeutic and diagnostic application of nanoparticles should not be toxic and biocompatible. Synthesis of metal nano-particles is achieved by several techniques which include physical, chemical or biological methods. But physical and chemical methods are not so suitable for the synthesis of silver nano-particles when we consider low toxicity (Bijoy Maitra et al. 2023). Furthermore, biogenic synthesis is low-cost, allowing for the rapid production of effective NPs (Hammad et al. 2022).

The plant-mediated biosynthesis (i.e.'green synthesis') of metal nanoparticles is advantageous over chemical and physical, radiation, electrochemical (Chen et al. 2008) and photochemical methods (Dimtrijevic et al. 2001). Since it is less expensive, single step does not require highly toxic chemicals (Callegari et al. 2003). Human beings are frequently infected by microorganisms such as bacteria, yeast, mould, virus, etc., silver and silver ion-based materials are treated with their bactericidal and fungicidal activities (Prakash et al. 2013) and their antimicrobial effect is appropriate to the blockage of respiratory enzyme pathways, interacting with the sulphur containing protein and modification of microbial DNA. The present investigation was aimed to found about the impact on antimicrobial activity and anti-inflammatory activity by *Bacopa monnieri* synthesized silver nanoparticles.

MATERIALS AND METHODS

Sample preparation

The *B. monnieri* plant leaves were washed thoroughly under running tap water, then with

distilled water and shade dried at room temperature for remove the moisture completely. The dried leaves are then homogenized into fine powder using a mixer grinder and stored in airtight containers for further study.

Synthesis of silver nanoparticles

The synthesis of silver nanoparticles, 10 ml of *B. monnieri* leaf extract was added to 150 ml in a conical flask that containing 90 ml of a solution of 1mM silver nitrate. The mixture was again incubated at 60°C in the dark while being stirred at intervals of a different time interval. Over the period of 24 hrs, the resulting reduction in silver ions (Ag^+) was periodically monitored. After the 24 hrs incubation of reaction mixtures were turning into the colour changes was indicated the synthesis of silver nanoparticles (Gurunathan et al. 2013).

Antioxidant activity

1-Diphenyl-2-picryl-hydrazyl (DPPH) free radical scavenging activity

The free radical scavenging activity of *B. monnieri* was measured by DPPH assay, following the methodology described (Rubab et al. 2022). Where in the bleaching rate of the stable free radical, DPPH is monitored at a characteristic wavelength in the presence of the sample. In its radical from, DPPH absorbs at 517 nm, but upon reduction by an antioxidant or a radical species its absorbance decreases. Briefly, 0.1 mM solution of DPPH in ethanol was prepared and 1ml of this solution was added to 3 ml of TG solution in water at different concentration (25-250 µg/ml). Thirty minutes later, the absorbance was measured at 517 nm. Lower absorbance of the reaction mixture indicates higher free radical scavenging activity (Blois 1958, Jayaprakasha et al. 2001). IC_{50} value in the tested compound is concentration required to scavenge 50% DPPH free radicals. The DPPH radical scavenging activity was calculated according to the following equation

$$\text{DPPH radical scavenging activity (\%)} = [\{A_o - A1/A_o\}] \times 100.$$

Where, A_o is the absorbance of DPPH, A_1 is the absorbance of DPPH solution in presence of the extract.

Hydrogen peroxide (H_2O_2) scavenging capacity assay

The hydrogen peroxide scavenging ability of *B. monnieri* was determined according to the standard method (Chelliah et al. 2022). A solution of H_2O_2 (40 mM) was prepared in phosphate buffer (pH 7.4). The different concentration of *B. monnieri* (10-50 µg/ml) leaves extract was added to a H_2O_2 solution (0.6 ml, 40mM). The absorbance value of the reaction mixture was recorded at 230 nm. Blank solution was containing phosphate buffer without H_2O_2 (Ruch et al. 1989). The percentage of H_2O_2 scavenging of *B. monnieri* and standard compound was calculated as H_2O_2 radical.

$$\text{Scavenging activity (\%)} = [\{A_o - A_1/A_o\}] \times 100.$$

Where, A_o is the absorbance of H_2O_2, A_1 is the absorbance of H_2O_2 solution in presence of the extract.

***In-vitro* anti – inflammatory activity (Mizushima and Kobayashi 1968)**

Inhibition of albumin denaturation

The reaction mixture consists of different concentrations like 100, 200, 300, 400 and 500 µl of *B. monnieri* leaves crude extract and AgNPs were performed. Diclofenac sodium (10 mg) was used as a standard drug. The sample extracts and standard were incubated at 37°C for 20 min and then heated to 51°C for 20 min. After cooling the sample, the turbidity was measured spectrophotometrically at 660 nm. Percentage inhibition of protein denaturation was calculated as follows.

$$\text{\% of inhibition} = \text{control}_{OD} - \text{test}_{OD} / \text{Control}_{OD} \text{ X } 100$$

Where, control OD is the absorbance without sample, test OD is the absorbance without sample, test OD is the absorbance of sample extract / standard.

Characterization techniques (Devika et al. 2012)

UV-Vis spectroscopy analysis

The nanoparticles obtained were characterized by UV-vis spectroscopy, to calculate the maximum wavelength for the quantitative determination and optical properties. The UV-vis spectrum of synthesized silver nanoparticles quantity was determined by using Elico UV-vis-spectrophotometer. The instrument was operated at a room temperature with 300-540 nm scales.

Determination of antimicrobial activity (Perez et al. 1990)

Preparation of stock microbial cultures

15ml of nutrient broth (bacteria) and potato dextrose broth (fungi) were prepared in a sterile test tube separately. Inoculated loop full of 48 hours old ocular pathogen was inoculated and incubated in 30-37°C for 24-48 hrs. The freshly prepared cultures were used as antimicrobial activity study.

Test microorganisms

Anti-microbial activity assessment of the formed Ag-NPs over five bacterial pathogens such as Gram-negative bacteria, viz., *Pseudomonas aeruginosa*, *Escherichia coli, Aeromonas* sp., *Salmonella* sp. and the Gram-positive bacteria viz. *Bacillus cereus*, *Brevibacillus parabrevis*, *Enterococcus pneumoniae*, *Staphylococcus aureus* and fungi viz., *A. niger, A. flavus, A. terreus, A. nidulans, A. fumigatus, Trichoderma harzianum, A. candidus* and *Penicillium funiculosum* and were selected for this study was performed utilizing Nutrient agar (NA) medium and Potato dextrose agar (PDA) medium by well diffusion test .

Agar well – diffusion method

Agar well-diffusion method was followed for determination of antimicrobial activity. Nutrient agar (NA) and Potato Dextrose Agar (PDA) plates were swabbed (sterile cotton swabs) with 24 hours culture and 48 hours old-broth culture of respective bacteria and fungi. Agar wells (5 mm diameter) were made in each of these plates using sterile cork borer. About 20, 40, 60 and 80 µL of aqueous and ethanol extracts were added using sterilized dropping pipettes into the wells and plates were left for 1 hour to allow a period of pre-incubation diffusion in order to minimize the effects of variation in time between the applications of different solutions the plates were incubated in an upright position at 37±2 °C for 24 hrs for bacterial and 28±2 °C for fungi. Results were recorded as the presence or absence of inhibition zone. Triplicates were maintained and the average values were recorded for antimicrobial activity.

RESULTS

In current study, the bio synthesis of silver nanoparticles is the colour of the solution changes from yellow to ruby-brown and finally to dark brown for the leaf extract of *Bacopa monnieri* respectively (Fig. 1). It was observed that the color of the solution turned from dark brown after 48 hrs of the reaction, which indicated the formation and stability of the reduced silver nanoparticles in the colloidal solution were monitored for the synthesize quantity of nanoparticles. The UV-vis-spectra showed absorbance at 300-540 nm, it shows gradually increased absorbance in various concentration (0.5, 1.0, 1.5, 2.0 and 2.5 mM) and the silver nanoparticles surface plasmon resonance is where the peaks were detected. The different nanometers were demonstrated that the stability of synthesized silver nanoparticles quantity. The maximum quantity of synthesized silver nanoparticles was observed at 420nm in all the concentration of 0.5, 1.0, 1.5, 2.0

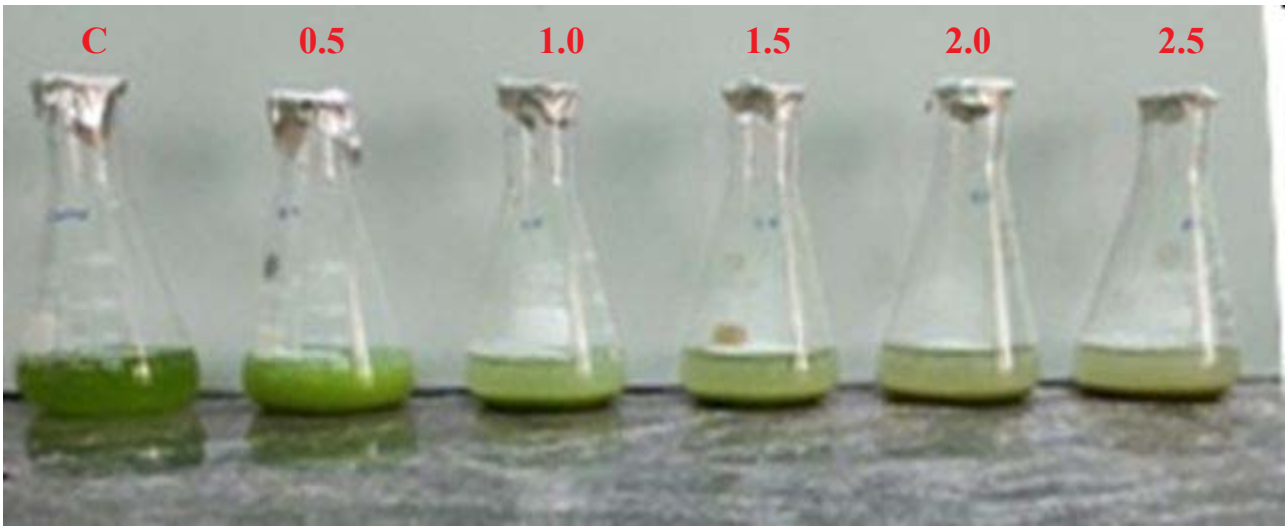

Figure 1. Silver nanoparticles from *B. monnieri* leaves extract

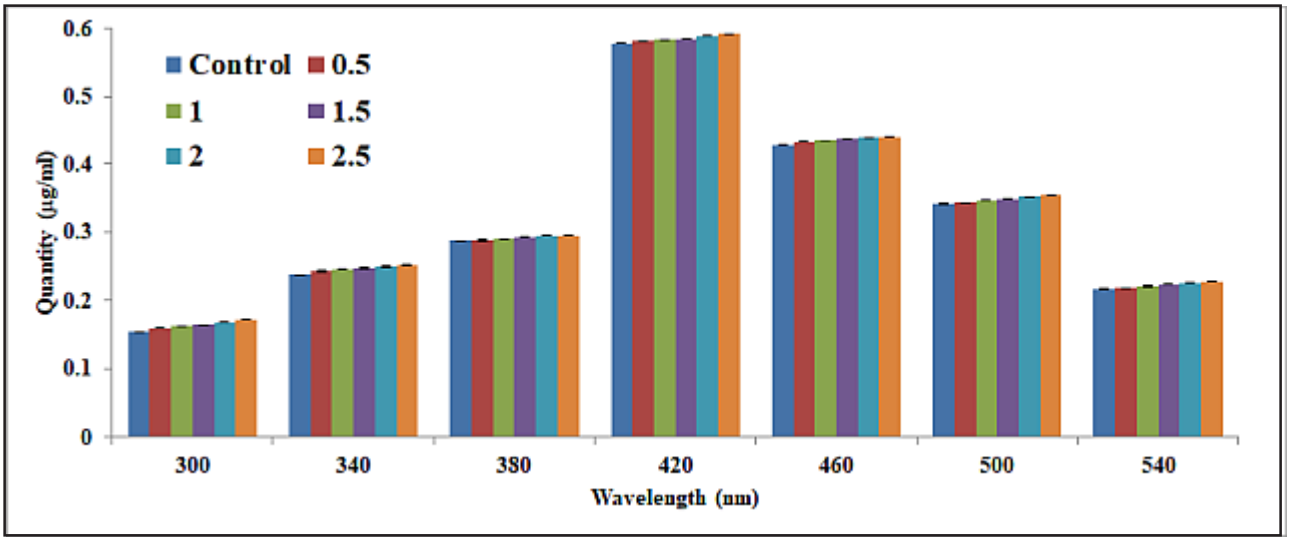

Figure 2. Estimation of *B. monnieri* mediated AgNPs by UV-Vis-spectral analysis

and 2.5 mM of silver nitrate treated *B. monnieri* extract. The 0.578, 0.581, 0.583, 0.585, 0.589 and 0.592 µg/ml quantity were observed at 420 nm of 0.5, 1.0, 1.5, 2.0 and 2.5 mM of silver nitrate treated *B. monnieri* extract. According to the UV-Vis-spectra analysis showed the maximum quantity of silver nanoparticles synthesized from 2.5 mM of silver nitrate treated *B. monnieri* extract (Fig. 2).

The present study of antioxidant activity of silver nanoparticles mediated *B. monnieri* leaves extracts performed with hydrogen peroxide scavenging assay and DPPH assay. In the hydrogen peroxide scavenging assay showed moderate antioxidant activity such as 12.8±0.26, 14.8±0.13, 16.5±0.16, 17.2±0.10 and 19.9±0.12% for 100, 200, 300, 400 and 500 µl, respectively, of silver nanoparticles mediated *B. monnieri* extract. This activity was showed maximum antioxidant property than the standard ascorbic acid. Similarly, founded from DPPH assay showed moderate antioxidant properties than the standard drug. Antioxidant activity of 15.6±0.65, 15.9±0.15, 16.8±0.13, 17.4±0.18 and 18.0±0.11% was observed from 100, 200, 300, 400 and 500 µl concentrations, respectively, of silver nanoparticles mediated *B. monnieri* extract (Table 1).

In the present investigation of anti-inflammatory activity were performed with *B. monnieri* crude aqueous extract and mediated silver nanoparticles of this plant leaves. The aqueous extract of *B. monnieri* showed 191.4±0.17, 22.53±0.00, 55.31±0.06, 19.99±0.24 and 6.961±0.36% of anti-inflammatory activity for 100, 200, 300, 400 and 500 µl, respectively, of crude aqueous extract. Similarly, conducted the anti-inflammatory activity of *B. monnieri* mediated AgNPs. They showed significant

Table 1. Antioxidant activity (%) of *B. monnieri* mediated AgNPs by *in-vitro* method

Concentration (µl)	Standard ascorbic acid	H_2O_2 assay activity	Standard value	DPPHassay
100	10.3±0.01	12.8±0.26	14.0±0.04	15.6±0.65
200	12.2±0.03	14.8±0.13	13.7±0.00	15.9±0.15
300	12.5±0.00	16.5±0.16	0.39±0.02	16.8±0.13
400	13.8±0.02	17.2±0.10	13.8±0.04	17.4±0.18
500	15.5±0.00	19.9±0.12	14.0±0.01	18.0±0.11

The values are expressed as Mean ± Standard deviation

Table 2. Anti-inflammatory activity (%) of *B.monnieri* aqueous extract and its mediated AgNPs by *in-vitro* method

Concentration (µl)	Aqueous	AgNPs
100	19.14±0.17	45.41±0.76
200	22.53±0.00	49.58±0.34
300	55.31±0.06	52.49±0.15
400	19.99±0.24	13.14±0.16
500	6.961±0.36	5.612±0.03

The values are expressed as Mean ± Standard deviation

results such as 45.41±0.76, 49.58±0.34, 52.49±0.15, 13.14±0.16 and 5.612±0.03% anti-inflammation activity for 100, 200, 300, 400 and 500 µl, respectively, of *B. monnieri* mediated AgNPs (Table 2).

In the present study, the four different concentrations *B. monnieri* mediated AgNPs were used for the antibacterial activity such as 20, 40, 60 and 80 µl. The concentration 80 µl is showed maximum zone of inhibition in all bacteria. The Ag-NPs performed antibacterial activity against eight bacteria *Aeromonas* sp., *Bacillus cereus, Brevibacillus parabrevis, Enterococcus pneumoniae, Escherichia coli, Pseudomonas aeruginosa, Salmonella* sp. and *Staphylococcus aureus* by agar well diffusion method. *Aeromonas* sp., *B. cereus, B. parabrevis, E. coli, P. aeruginosa* and *Salmonella* sp. were inhibited by 20 µl concentration of AgNPs, they produced 0.55±0.01, 0.58±0.04, 0.59±0.01, 1.03±0.03, 0.58±0.03 and 0.55±0.08 mm zone of inhibitions, respectively. The 40 µl of AgNPs produced 0.61±0.04, 0.61±0.04, 1.30±0.01, 0.83±0.02 and 0.63±0.02 mm zone of inhibition

Table 3. Antibacterial activity (expressed as zone of inhibition (mm)) of *B. monnieri* mediated AgNPs against clinical bacteria

Name of the bacteria	Concentration			
	20µl	**40µl**	**60µl**	**80µl**
Aeromonas sp.	0.55±0.01	0.61±0.04	0.70±0.03	0.73±0.02
Bacillus cereus	0.58±0.04	_	0.55±0.01	0.81±0.05
Brevibacillus parabrevis	0.59±0.01	0.61±0.04	0.64±0.04	0.72±0.02
Enterococcus pneumoniae	_	_	0.61±0.03	0.92±0.03
Escherichia coli	1.03±0.03	1.30±0.01	1.62±0.03	1.69±0.06
Pseudomonas aeruginosa	0.58±0.03	0.83±0.02	0.87±0.07	0.99±0.04
Salmonella sp.	0.55±0.08	_	0.56±0.10	0.58±0.11
Staphylococcus aureus	_	0.63±0.02	0.68±0.01	0.69± 0.03

The values are expressed as Mean ± Standard deviation

Table 4. Antimicrobial activity (expressed as zone of inhibition (mm)) *B. monnieri* mediated AgNPs against clinical fungi

Name of the fungi	Concentration			
	20µl	**40µl**	**60µl**	**80µl**
Aspergillus candidus	0.92±0.21	1.00±0.16	1.09±0.17	2.08±0.18
A. flavus	_	_	0.57±0.12	0.59±0.10
A. fumigatus	_	_	_	0.56±0.02
A. nidulans	_	0.58±0.04	0.59±0.09	1.05±0.06
A. niger	_	_	0.53±0.11	1.00±0.03
A. terreus	0.58±0.16	1.06±0.12	2.01±0.13	2.05±0.19
Penicillum funiculosum	_	_	0.56±0.15	1.20±0.14
Trichoderma harzianum	0.56±0.05	0.61±0.03	0.62±0.04	0.67±0.04

The values are expressed as Mean ± Standard deviation

against *Aeromonas* sp., *B. parabrevis, E. coli, P. aeruginosa* and *S. aureus,* respectively. The 60 µl of AgNPs produced 0.70±0.03, 0.55±0.01, 0.64±0.04, 0.61±0.03, 1.62±0.03, 0.87±0.07, 0.56±0.10 and 0.68±0.01 mm zone of inhibitions against *Aeromonas* sp., *B. cereus, B. parabrevis, E. pneumoniae, E. coli, P. aeruginosa, Salmonella* sp. and *S. aureus,* respectively. The 60 µl of AgNPs produced 0.73±0.02, 0.81±0.05, 0.72±0.02, 0.92±0.03, 1.69±0.06, 0.99±0.04, 0.58±0.11 and 0.69±0.03 mm zone of inhibitions against *Aeromonas* sp., *B. cereus, B. parabrevis, E. pneumoniae, E. coli, P. aeruginosa, Salmonella* sp. and *S. aureus,* respectively (Table 3). According to the antifungal activity was carried out with *Aspergillus candidus, A. flavus, A. fumigatus, A. nidulans, A. niger, A. terreus, Penicillum funiculosum* and *Trichoderma harzianum.* The 20 µl of *B.monnieri* mediated AgNPs produced 0.92±0.21, 0.58±0.16 and 0.56±0.05 mm zone of inhibitions against *Aspergillus candidus, A. terreus* and *Trichoderma harzianum,* respectively. The 40 µl of *B. monnieri* mediated AgNPs produced 1.00±0.16, 0.58±0.04, 1.06±0.12 and 0.61±0.03 mm zone of inhibitions against *Aspergillus candidus, A. nidulans, A. terreus* and *Trichoderma harzianum,* respectively. The 60 µl of *B. monnieri* mediated AgNPs produced 1.09±0.17, 0.57±0.12, 0.59±0.09, 0.53±0.11, 2.01±0.13, 0.56±0.15 and 0.62±0.04 mm zone of inhibitions against *Aspergillus candidus, A. flavus, A. nidulans, A. niger, A. terreus, Penicillum funiculosum* and *Trichoderma harzianum,* respectively. The *Aspergillus candidus, A. flavus, A. fumigatus, A. nidulans, A. niger, A. terreus, Penicillum funiculosum* and *Trichoderma harzianum* growth was 2.08±0.18, 0.59±0.10, 0.56±0.02, 1.05±0.06, 1.00±0.03, 2.05±0.19, 1.20±0.14 and 0.67±0.04 mm, respectively, inhibited by 60 µl of *B. monnieri* mediated AgNPs (Table 4).

DISCUSSION

The synthesis of silver nanoparticles using a *Bacopa monnieri* leaf extract can be visualized by the change in the colour from colorless to stable yellow. Most of the studies confirmed silver nanoparticle synthesis by ultraviolet visible spectrum analysis (Suganya et al. 2018). The usage of plant extract for reducing silver metal ions has been detected using UV-visible spectra as also noted by the *B. monnieri* leaves extract which had a high peak at 428 nm. This band called surface Plasmon resonance (Mulvaney 1996). Interestingly, the shift of absorption peak of silver surface Plasmon resonance suggesting the formation of smaller silver nanoparticles. These findings point to a protein release into the filtrate as a possible explanation for the existence of silver ions in the solution (Maliszewska and Puzio 2009). Due to the strong reactivity of plant extract and the wide availability of plant materials, the generation of plant-mediated nanoparticles has grown more and more popular.

Inflammation is a common phenomenon and it is a reaction of living tissues towards injury. Prostaglandin-E2, an effective vasodilator in combination with histamine which are potent inflammatory vasodilators lead to the increased blood flow and redness in the region of acute inflammation (Mohamed et al. 2011). The astringent property affords them the therapeutic value in arresting hemorrhage by constructing blood vessels and in protecting wounds, inflammation and ulcer from external irritation by the participating surface protein which form impervious coating on them. Thus, it is evident that the constituents are sufficient to cure infection and tannins are also responsible to cure inflammatory diseases. The results obtained support the use of *B. monnieri* extract locally against inflammation, ROS related diseases, fever, ulcer, infection etc.

Silver nanoparticles have been shown to exhibit antibacterial properties in several studies, however the exact mechanisms underlying their antimicrobial properties against pathogenic bacteria remains unclear. Physical components reportedly have a part in the antibacterial activity. According to research, electrostatic forces between positively charged AgNPs and negatively charged bacterial cells may be responsible for AgNPs' bactericidal effects (Lanje et al. 2010). The concentration of antimicrobial agents increases at the vital spot, increasing the amount of bacteria that are destroyed. So, increasing the concentration of an antimicrobial agent is essentially part of the method to generate an antimicrobial group (Singh et al. 2013). The susceptibility of gram-positive and gram-negative bacteria to silver nanoparticles differed slightly. in

addition to interacting with the membrane's surface In addition to interacting with the membrane's surface, Ag-NPs could also be able to penetrate the thick wall of Gram-positive bacteria (Morones et al. 2005). This ensures that some of the particle's surface is in contact with the surface of the bacterial cell, which is expected to increase the level of bacterial exclusion (Gong et al. 2007). Most of the studies were reported that the strong growth inhibitions were observed against *E. coli, S. aureus, K. pneumoniae, S. typhi* and *P. vulgaris* by the influences of *B. monnieri* synthesized silver nanoparticles (Suganya et al. 2018). But the present study results showed very meager amount of zone of inhibitions against bacteria as well as fungi by AgNPs of *B. monnieri*. The biological efficacy of CuO-NPs was observed against *Helicobacter felis, H. suis, H. salomonis* and *H. bizzozeronii.* The *H. suis* was most susceptible strain with maximum zone of inhibition. This study was compared with the present study, it shows the copper nanoparticles were most effective than the silver nanoparticles biogenesis from *B. monnieri* for the biological activity (Faisal et al. 2022). The present study was founded closely similar efficacy of biological properties from AgNPs of *B. monnieri* leaves against *E. coli, E. faecalis, S. aureus, C. albicans* and *P. aeruginosa* (Prasad 2014).

The culture medium was inoculated with the fungal strains separately suspended in potato dextrose broth. A total of 8 mm diameter wells were punched into the agar and filled with plant extracts and solvent blanks. The procedure was done for determining antifungal activity but in this case standard antibiotic (Fucanazole, concentration 1 mg/ml) was used as positive control and fungal plates were incubated at 37ˆC for 72h also the diameter of zone of inhibition observed was measured. Due to their antimicrobial properties, biologically significant nanoparticles could be extremely useful in the medical field.

CONCLUSIONS

The present study concluded, it is possible to treat infectious diseases caused by pathogenic microorganisms using silver nanoparticles (Ag-NPs), which have a great potential as antimicrobial compounds. The biologically synthesized silver nanoparticles could be of immense use in medical field for their efficient antimicrobial function. The distinct antioxidant (free radical scavenging) activities of extracts when compared to the gold standard antioxidant, vitamin C, indicated that it's possible that the antioxidant activity of this medicinal plant may contribute to play their role against various ROS-mediated disorders such as cellular ageing and cancer, becoming an alternative in the fight against skin ageing and cancer cells. These findings collectively support the therapeutic uses of *B. monnieri* and its usage as a herbal remedy for the control of ROS and the treatment of bacterial and inflammatory illnesses. Ag-NPs have been characterized by UV-Vis spectroscopy. As a result, the biological approach appear to be a more alternative than the conventional physical and chemical methods of synthesizing AgNPs, and it would be suitable to develop a biological process for large-scale production. The Ag-NPs synthesized from *B. monnieri* leaves extract seem to be a promising and effective antimicrobial agent against the multidrug resistant of bacteria and fungi. The variety of AgNPs could find applications in administering drugs and their application has been extended to include cancer diagnosis and treatment. The overall report highlights the cost-effective and sustainable synthesis of AgNPs from this study. Hence, this study concluded that the silver nanoparticles of *B. monnieri* were more effective for the antimicrobial activity. This method of treatment cures microbial infections by natural way and do not cause any side effects for humanbeings.

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