Eco-friendly Biofabrication of Silver Nanoparticles Using *Solanum tuberosum* Peel Extract and their Multifunctional Biomedical Applications

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Green synthesis of silver nanoparticles (AgNPs) has gained increasing attention due to its eco-friendly nature and biomedical potential. In this study, AgNPs were synthesized using *Solanum tuberosum* (potato) peel extract as a reducing and stabilizing agent. Formation of AgNPs was confirmed by ultraviolet–visible (UV–Vis) spectroscopy. Structural characterization using X-ray diffraction (XRD), transmission electron microscopy (TEM), scanning electron microscopy (SEM), and energy-dispersive X-ray (EDX) analysis revealed crystalline, spherical nanoparticles with sizes ranging from 10 to 55 nm. The AgNPs exhibited antimicrobial activity against *Bacillus subtilis*, *Klebsiella pneumoniae*, *Penicillium glabrum*, and *Candida albicans*, with the highest inhibition zone against *B. subtilis* (24.50 ± 4.97 mm). In cytotoxicity assays, AgNPs showed dose-dependent activity against PANC-1 and PC-3 cell lines with IC_{50} values of 128 and 137 µg/mL, respectively, and lower toxicity toward Vero cells (IC_{50} = 439.1 µg/mL). Antioxidant activity was observed in 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2′-azinobis(3-ethylbenzothiazo-line-6-sulfonic acid) (ABTS) assays with IC_{50} values of ~240 and 412 µg/mL, respectively. Additionally, AgNPs showed inhibitory activity against α-amylase (IC_{50} = 461 µg/mL) and α-glucosidase (IC_{50} = 153 µg/mL). These results underscore the potential of potato peel-mediated AgNPs as eco-friendly, multifunctional nanomaterials with promising biological applications.

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INTRODUCTION

Natural products have historically served as important sources in pharmaceutical research because of their wide range of biological properties and therapeutic value (Jin *et al*. 2024). Recently, nanotechnology has developed rapidly as a scientific discipline related to the design and manipulation of materials at the nanoscale, typically below 100 nm (Selim

et al. 2025). Owing to their unique physicochemical properties, nanomaterials play crucial roles in the development of various fields, such as materials science, medicine, engineering, and biotechnology (Tali *et al*. 2026). In the biomedicine field, nanotechnology has provided new strategies for the development of therapeutic approaches (Alfattah *et al*. 2025; Khormi *et al*. 2025; Soliman *et al*. 2026). Nanoparticles are characterized by nanoscale size (typically below 100 nm), significant surface area relative to volume, and special optical and catalytic activity. These characteristics indicate their potential as promising agents as antimicrobial agents, anticancer agents, antioxidant, and drug delivery platforms (Saied *et al*. 2025; Soliman and Salem 2025a, 2025b). In comparison with other types of nanomaterials, silver nanoparticles (AgNPs) have attracted much attention because of their biological efficacy and significant role in medical applications (Soliman *et al*. 2023, 2024a).

Green synthesis has emerged as a sustainable approach to produce nanoparticles (Almuhayawi *et al*. 2024; Soliman *et al*. 2024b). The plant-based production method is the most effective because of the presence of diverse bioactive constituents in plant extracts (Waghchaure and Adole 2023; Dheyab *et al*. 2024). These phytochemicals, such as flavonoids, terpenoids, phenolic acids, tannins, proteins, and polysaccharides, play crucial roles in transforming metal ions into stable nanostructures and preventing particle aggregation (Adeyemi *et al*. 2022). One interesting example is the peel of *Solanum tuberosum* (potato), an abundant agricultural waste that contains various biologically active compounds, including phenolics and antioxidants, which can effectively reduce the amount of metal nanoparticles (Girigoswami *et al*. 2024). Potato peel extract contains various phytochemicals, including phenolics, flavonoids, glycoalkaloids, proteins, and reducing sugars, which facilitate the reduction of Ag^{+} ions and act as stabilizing agents for nanoparticle formation (Makori *et al.* 2022).

Although silver nitrate ($AgNO_3$) may be toxic at high concentrations, controlled synthesis of AgNPs at lower concentrations can improve silver's biocompatibility and therapeutic potential (Ahn *et al.* 2019; Fahimirad *et al.* 2019). Furthermore, biosynthesized silver nanoparticles have been shown to take part in reducing oxidative stress by interacting with reactive oxygen species (ROS), thus contributing to cellular protection from oxidative damage (Villalobos Gutiérrez *et al*. 2023). Their well-documented broad-spectrum antimicrobial activity against numerous pathogenic microorganisms also emphasizes their potential importance in combating infectious diseases and reducing the growing problem of antibiotic resistance (Summer *et al*. 2024).

Therefore, the present study aimed to establish an environment-friendly approach for AgNPs biofabrication using *Solanum tuberosum* (potato) peel extract. The resulting NPs were evaluated using several techniques, including Ultraviolet-visible spectroscopy (UV–Vis), X-ray diffraction (XRD), transmission electron microscopy (TEM), scanning electron microscopy (SEM), and energy dispersive X-ray (EDX) spectroscopy. Furthermore, the biological activities of the obtained AgNPs were examined by assessing their anticancer, antioxidant, and antidiabetic properties.

EXPERIMENTAL

Materials and Plant Extract

Silver nitrate was obtained from Merck (Germany) and used as the precursor for nanoparticle synthesis. Fresh *Solanum tuberosum* (potato) tubers were purchased from a local market, and their peels were collected for extract preparation. The collected peels

were repeatedly rinsed with distilled water to eliminate surface impurities and dust particles. The peels were then dried at room temperature (25 ± 2 °C) until completely dry. The dried peels were subsequently pulverized to obtain a fine powder. Aqueous extract was prepared by weighing approximately 200 g of dried and powdered potato peel was used for extract preparation was combined with 750 mL of deionized water and heated at approximately 75 °C under constant stirring. The mixture was left to cool gradually to room temperature. To remove solid residues and obtain a clear extract, the solution was filtered using a 0.45 µm membrane filter. Finally, the filtrate was stored at 4 °C for further use.

Production of Silver Nanoparticles *via* Green Method

A silver nitrate solution (40 mM) was prepared by dissolving $AgNO_3$ crystals in distilled water. Subsequently, 50 mL of the prepared solution was added to 750 mL of potato peel extract, and the mixture was allowed to react and synthesize nanoparticles at room temperature under constant stirring. A gradual transition of the reaction mixture color from light yellow to dark brown confirmed the reduction of Ag^+ ions and the formation of silver nanoparticles. The resulting suspension was centrifuged at 4500 rpm for 15 min to recover the nanoparticles, the supernatant was discarded, and the pellet was collected and washed twice. To obtain dry AgNP powder, the NPs were dried in a hot air oven at 200 °C for 3 hours (Pirathiba and Dayananda 2021).

Characterization of Silver Nanoparticles

To identify the characteristic surface plasmon resonance of the silver nanoparticles, the AgNPs were analyzed by a UV–Visible spectrophotometer (JASCO 730 double beam) at wavelengths ranging from 200 to 800 nm. Transmission electron microscopy (TEM) using a JEOL-2100 microscope was performed to determine the morphology and particle size distribution. A small aliquot of the nanoparticle suspension was placed onto copper grids and left to dry under vacuum overnight before scanning electron microscopy (SEM) imaging. In addition, the surface morphology and elemental constituents of the nanoparticles were determined by SEM coupled with energy-dispersive X-ray spectroscopy (EDS) (JEOL JSM-6510 LV). The crystalline nature of the biosynthesized AgNPs was analyzed by X-ray diffraction (XRD) using an X'PERT PRO-PAN analytical diffractometer.

In vitro Antimicrobial Assay

The AgNPs were tested against *Bacillus subtilis* ATCC 6633, *Klebsiella pneumoniae* ATCC 13883, *Penicillium glabrum* OP694171, and *Candida albicans* ATCC 10221 using the agar well diffusion method. Briefly, 100 µL of microbial suspension was spread on TSA plates for bacteria and on PDA plates for fungi. Wells (0.6 cm) were prepared using sterile cork borers and filled with 100 µL of AgNP extract. The plates were incubated at 37 °C for bacteria (48 h) and 30 °C for fungi (72 h), after which the inhibition zones were measured. Chloramphenicol and gentamycin/nystatin were used as positive controls, while DMSO served as the negative control. The minimum inhibitory concentration (MIC) was determined by the broth microdilution method using AgNPs concentrations ranging from 50 to 500 µg/mL in a 96-well microtiter plate. Microbial suspensions (2×10^6 CFU/mL) were added to each well and incubated at 35 °C for 48 h. The MIC was defined as the lowest concentration that completely inhibited microbial growth. To determine the minimum bactericidal concentration (MBC), samples from wells showing no growth were subcultured onto fresh agar plates (Al-Rajhi *et al*. 2025).

Anticancer Activity

The AgNPs were assessed using the MTT assay against Vero normal cells and two human cancer cell lines, PC-3 (prostate cancer) and PANC-1 (pancreatic cancer). Briefly, 100 µL of cell suspension (1×10^5 cells/well) was seeded into 96-well plates and incubated for 24 h at 37 °C in a humidified atmosphere with 5% CO_2 to allow cell attachment. After washing with phosphate buffer, the cells were treated with different concentrations of AgNPs (15.63 to 1000 µg mL^{-1}) and incubated for 48 h. Untreated cells served as the control. Afterwards, 50 µL of MTT solution (5 mg mL^{-1}) was added and incubated for 4 h to allow formazan formation. The crystals were dissolved using 200 µL of 10% DMSO, and the absorbance was measured at 570 nm using an ELISA (BioTek ELx800, BioTek Instruments Inc., USA) microplate reader to determine cell viability and cytotoxicity (Pandey *et al*. 2025).

Antioxidant Assays

DPPH radical scavenging activity

A 1 mM DPPH solution was prepared in 50% methanol and kept in the dark for 30 min before use. Various concentrations of AgNPs (15.62 to 1000 µg mL^{-1}) were mixed with the 2,2-diphenyl-1-picrylhydrazyl (DPPH) solution and incubated in darkness at room temperature for 30 min. Ascorbic acid was used as the positive control, while DPPH solution without nanoparticles served as the negative control. The absorbance was measured at 517 nm.

ABTS radical scavenging activity

The $ABTS^{\bullet+}$ solution was prepared by mixing 7 mM ABTS with 2.4 mM potassium persulfate and allowing the reaction to proceed in the dark at 25 °C for 12 to 16 h. The solution was then diluted with ethanol to obtain the desired absorbance. Equal volumes of the diluted ABTS solution and AgNPs at different concentrations (15.62 to 1000 µg mL^{-1}) were mixed and incubated for 10 min at room temperature. Ascorbic acid served as the standard antioxidant, while ABTS solution without nanoparticles was used as the control (Khormi *et al*. 2025).

Antidiabetic Activity

α-Amylase inhibition assay

The AgNPs and acarbose (1.95 to 1000 µg mL^{-1}) were mixed with 0.02 M phosphate buffer (pH 6.9) and α-amylase enzyme solution, followed by incubation at 37 °C for 10 min. Afterwards, 1% starch solution was added as the substrate and the mixture was incubated for another 10 min. The reaction was terminated by adding 3,5-dinitrosalicylic acid (DNS) reagent and heating at 60 °C for 15 min. After dilution with distilled water, the absorbance was measured at 540 nm.

α-Glucosidase inhibition assay

AgNPs or acarbose at different concentrations were mixed with sodium phosphate buffer (0.1 M) and α-glucosidase enzyme, then incubated at 37 °C for 10 min. Subsequently, p-nitrophenyl-D-glucopyranoside (2 mM) was added as the substrate and incubated for 20 min. The reaction was stopped by adding sodium carbonate, and the absorbance was measured at 405 nm (Soliman *et al*. 2025).

RESULTS AND DISCUSSION

Characterization

The green approach is considered environmentally friendly, economically feasible, and capable of producing stable nanoparticles in ignorance of any chemicals. Plant extracts are rich in various phytochemical constituents, including phenolic compounds, flavonoids, proteins, sugars, and other secondary metabolites. These materials act as natural reducers that convert Ag^{+} ions into metallic silver as well as stabilizing agents that prevent particle aggregation and enhance nanoparticle stability and biocompatibility (Eker *et al*. 2025). In the present work, peel extract of *Solanum tuberosum* was utilized as a biological reducing medium for the biosynthesis of AgNPs.

The optical properties of the synthesized nanoparticles were further examined using UV–Visible spectroscopy within a range 200 to 800 nm. The spectrum displayed a distinct absorption band around 455 nm (Fig. 1a), which is widely recognized as the characteristic SPR peak of AgNPs. Previous reports indicate that SPR bands for plant-mediated silver nanoparticles generally appear within the range of 410 to 450 nm (Kandwal *et al*. 2024).

The crystal structure of the biosynthesized AgNPs was characterized using X-ray diffraction (XRD), and the diffraction pattern shown in Fig. 1b revealed many prominent peaks located at 2θ values of 38.2°, 44.37°, 64.5°, and 77.48°. These reflections corresponded to the (111), (200), (220), and (311) lattice planes of metallic silver, confirming the formation of a face-centered cubic (fcc) crystalline structure. Here, the observed diffraction pattern of crystalline silver is consistent with the standard reference data reported in previous studies, suggesting the high purity and crystalline nature of the synthesized nanoparticles (Revathi *et al*. 2024).

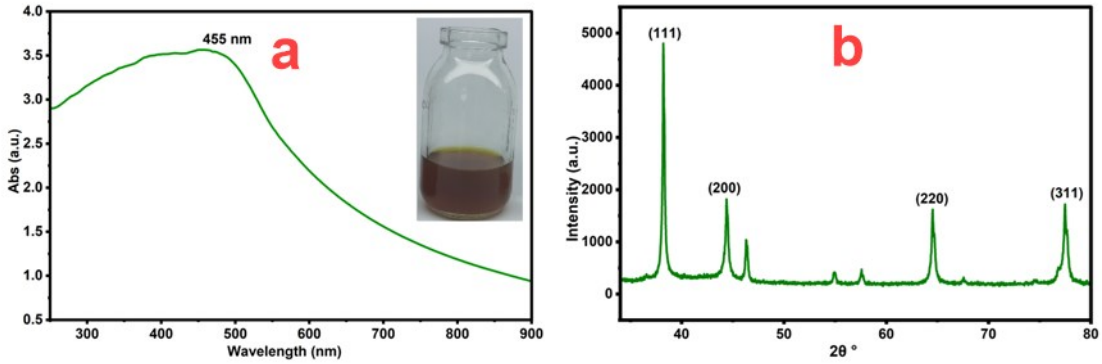

Fig. 1. (a) UV–Vis of AgNPs; (b) XRD study showing characteristic diffraction peaks

TEM revealed that the nanoparticles were spherical and well dispersed (Fig. 2a), indicating the effective stabilization provided by the biomolecules of the tested extract. The particle sizes were determined to be between 10 and 55 nm. PSA-TEM analysis revealed a relatively narrow and uniform distribution (Fig. 2b), which is in agreement with the findings of other studies, including those of plant-mediated silver nanoparticle synthesis (Fahim *et al*. 2024). In addition, SEM analysis confirmed the nanoscale size and shape (Fig. 2c). Notably, aggregation of few nanoparticles was observed, which could be attributed to interactions among the particles or the drying process during sample preparation. Similar aggregation behavior has been reported in several studies on biosynthesized AgNPs (Sivalingam *et al.* 2024). The EDX results, as shown in (Fig. 2d),

revealed a strong and characteristic signal corresponding to silver. A prominent peak appeared at approximately 3 keV, which is considered a typical signature peak for metallic silver nanoparticles. In addition to the dominant silver signal, minor peaks for carbon and oxygen were detected, which may be attributed to phytochemical residues from the plant extract attached to the nanoparticle surface and acting as natural capping agents during nanoparticle formation (Revathi *et al*. 2024).

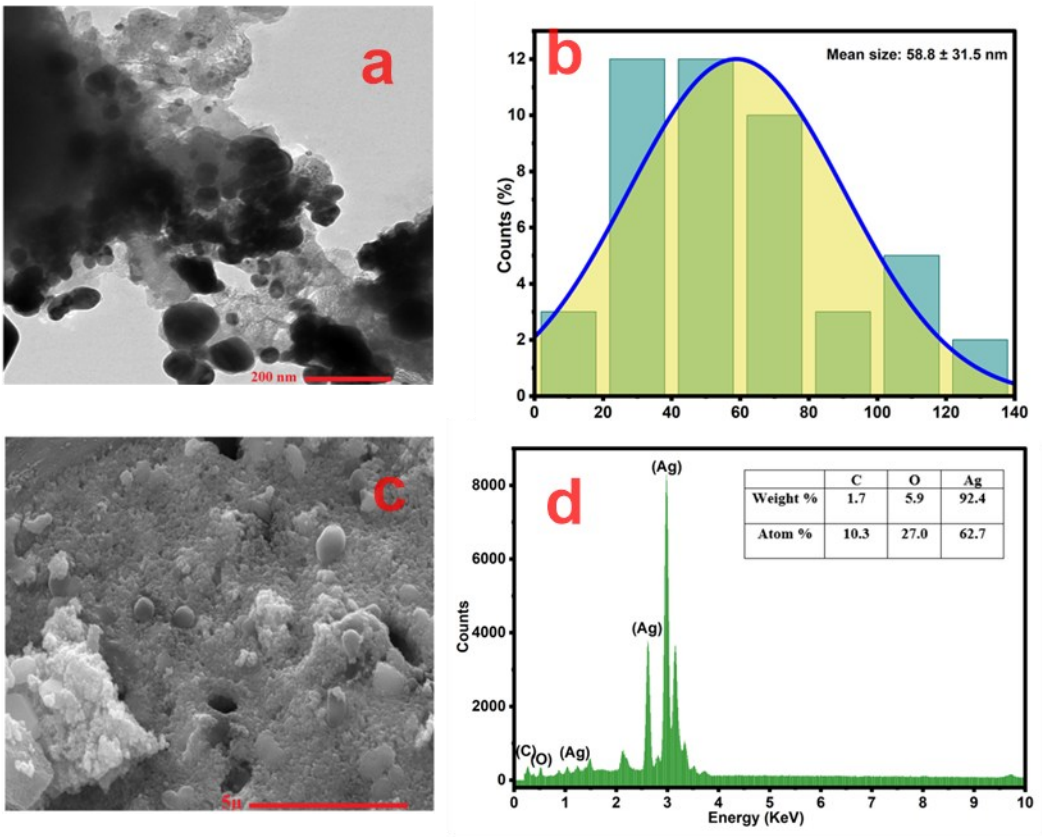

Fig. 2. (a) TEM image of the AgNPs. (b) Particle size distribution of the AgNPs (PSA-TEM). (c) SEM image of AgNP morphology. (d) EDX spectrum confirming the elemental composition of the AgNPs

Table 1. Antimicrobial Activity, MIC, and MBC of AgNPs

Tested Microorganisms	AgNPs Inhibition Zone (mm)	Positive Control (Gentamycin/Chloramphenicol) (mm)	MIC (µg/mL)	MBC (µg/mL)
Klebsiella pneumoniae	15.63 ± 1.53	16.07 ± 0.51	300	400
Bacillus subtilis	24.50 ± 4.97	15.83 ± 0.38	100	50
Penicillium glabrum	22.47 ± 0.50	19.90 ± 0.85	200	200
Candida albicans	19.63 ± 0.40	22.23 ± 2.22	200	100

Antimicrobial Activity

The effectiveness of the synthesized AgNPs as antimicrobial agents was examined against *K. pneumoniae*, *B. subtilis*, *P. glabrum*, and *C. albicans*, as shown in Table 1. The results showed that the nanoparticles inhibited all the examined pathogens. Interestingly, *B. subtilis* was strongly inhibited by the AgNPs, as the inhibition zone was 24.50 ± 4.97 mm, which may suggest that gram-positive bacteria may be more susceptible to silver nanoparticles. In contrast, *K. pneumoniae* was resistant to nanoparticles, as the inhibition zone was 15.63 ± 1.53 mm. In contrast, *P. glabrum* and *C. albicans* were inhibited by 22.47 ± 0.50 mm and 19.63 ± 0.40 mm, respectively, suggesting that the nanoparticles have antifungal activity. The minimum inhibitory dose (MIC) values ranged between 100 and 300 µg/mL, whereas the minimum bactericidal dose (MBC) values ranged from 50 to 400 µg/mL. *B. subtilis* had the lowest MIC (100 µg/mL) and MBC (50 µg/mL). However, *K. pneumoniae* has high MICs of nanoparticles (MIC = 300 µg/mL; MBC = 400 µg/mL). AgNPs demonstrate potential activity against *P. glabrum* and *C. albicans*. Previous studies have reported that AgNPs have significant antimicrobial effects against different pathogenic microorganisms (Liknaw *et al*. 2025; Mushtaq and Rohit 2025). The antimicrobial activity of AgNPs is mediated by several mechanisms, including microbial cell membrane disruption, oxidative stress induction through the generation of ROS, and interactions with intracellular biomolecules such as proteins and DNA, which therefore attenuate essential cellular processes and lead to microbial cell death (Khalifa *et al*. 2025).

Anticancer Activity

The anticancer activity of the AgNPs was assessed using the MTT assay against two human cancer cell lines, pancreatic carcinoma (PANC-1) and prostate cancer (PC-3), whereas Vero cells were used as a normal cell model (control). Serial concentrations of AgNPs ranging from 15.63 to 1000 µg mL-1 were used (Fig. 3).

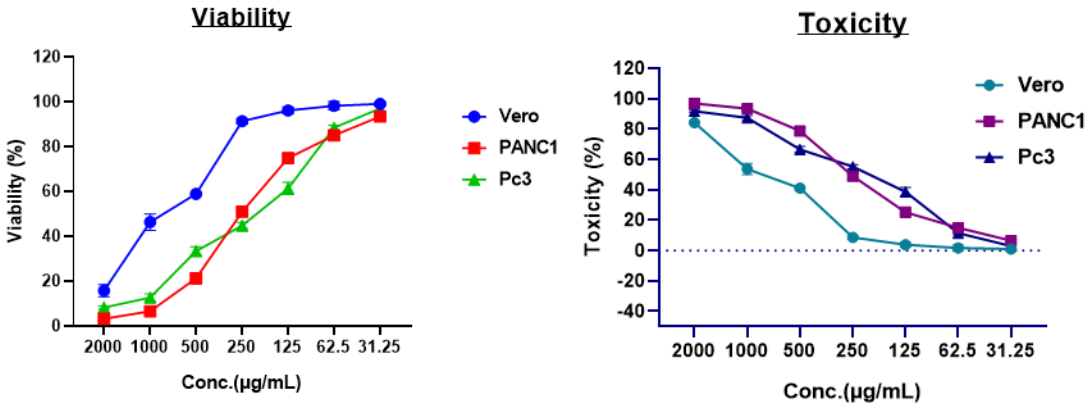

Fig. 3. Effects of different concentrations of AgNPs (15.63–1000 µg mL-1) on the viability and cytotoxicity of Vero, PANC-1, and PC-3 cells

The results clearly revealed that the concentration-dependent cytotoxic effect of the AgNPs on both cancer cell lines was concentration dependent. As the concentration of nanoparticles increased, a significant reduction in cell viability was observed, suggesting that higher concentrations of AgNPs lead to stronger cytotoxic effects against tumor cells (Soliman *et al*. 2023; Okur *et al*. 2026). With respect to PANC-1 cells, the cell viability decreased from 93.48% at 15.6 µg/mL to 3.2% at 1000 µg/mL, corresponding to an

increase in cytotoxicity from 6.51% to 96.78%, respectively. Similarly, the cell viability of the PC-3 cells decreased from 97.1% at 15.6 μg mL^{-1} to 8.2% at 1000 μg mL^{-1}, indicating that the synthesized AgNPs strongly inhibited prostate cancer cells. In contrast, compared with cancer cells, Vero normal cells showed relatively higher viability at lower concentrations of AgNPs, indicating lower toxicity toward normal cells. The calculated IC_{50} values were approximately 127.6 μg mL^{-1} for PANC-1 cells, 137.3 μg mL^{-1} for PC-3 cells, and 439.1 μg mL^{-1} for Vero cells, suggesting that the biosynthesized AgNPs possess selective cytotoxic activity toward cancer cells (Soliman *et al*. 2024).

Antioxidant Activity

The antioxidant activity of the synthesized AgNPs was evaluated using DPPH and ABTS assays, and the results are shown in Fig. 4. As shown in the graph, both assays clearly demonstrated concentration-dependent antioxidant activity, where the inhibition percentage increased progressively with increasing nanoparticle concentration. In the DPPH assay, the scavenging activity of the AgNPs ranged from 8.8% at 15.62 μg mL^{-1} to 71.7% at 1000 μg mL^{-1}, whereas the inhibition activity of the standard antioxidant ascorbic acid was greater, reaching 93.8% at the highest concentration. Similarly, in the ABTS assay, the inhibition activity of the AgNPs increased from 6.3% to 60.9% across the tested concentrations, whereas ascorbic acid displayed higher antioxidant efficiency, with inhibition values reaching 95.7%. As shown in Fig. 4, the synthesized AgNPs exhibited moderate antioxidant activity, although the activity remained lower than that of the reference antioxidant. This difference may be due to the higher radical scavenging capacity of pure antioxidants such as ascorbic acid in comparison with that of nanoparticle-based systems. The antioxidant activity of synthesized AgNPs is affected mainly by the phytochemical composition on the surface of the nanoparticles formed by the green synthesis process. These biomolecules act as natural reducing and stabilizing agents and play essential roles in electron transfer systems that contribute to the neutralization of free radicals. The obtained IC_{50} values, which were approximately 240 μg mL^{-1} for the DPPH assay and 412 μg mL^{-1} for the ABTS assay, further confirm the moderate antioxidant potential of the synthesized nanoparticles.

The relatively lower IC_{50} obtained for the DPPH assay suggests that the nanoparticles have a higher affinity toward DPPH radicals than toward ABTS radicals, which has also been reported in other nanoparticle-based antioxidant studies. The antioxidant activity observed in the present study is in agreement with previously published reports on green-synthesized AgNPs using *P. guajava*, where no significant differences were observed between concentrations of 100 and 120 μg mL^{-1} compared with the positive control (Wang *et al*. 2018). In that study, ascorbic acid demonstrated scavenging activities of approximately 90% and 89% at these concentrations, whereas the scavenging efficiencies of the AgNPs were approximately 83.6% and 89%, respectively. Similarly, AgNPs synthesized from *Artocarpus altilis* leaf extract showed notable DPPH radical scavenging activity, reaching approximately 79.8% (Ravichandran *et al*. 2016). In another study, the IC_{50} value of AgNPs biosynthesized using *Erythrina suberosa* was reported to be 30 μg mL^{-1} according to a DPPH assay (Mohanta *et al*. 2017). These results provide evidence that plant-generated AgNPs possess significant antioxidant potential and may act as alternative antioxidants for preventing disease-associated free radical damage (Sarwer *et al*. 2022). The antioxidant potential of AgNPs is essentially associated with their ability to scavenge reactive free radicals mediated by either electron donation or electron acceptance mechanisms. This activity is linked to the ability of silver to transition between

different oxidation states, such as Ag^{+} and Ag^{2+}, depending on the surrounding chemical environment (Bedlovičová *et al*. 2020). Consequently, AgNPs produced through green methods may serve as promising antioxidant materials with potential applications in protecting biological systems from oxidative stress and related degenerative disorders.

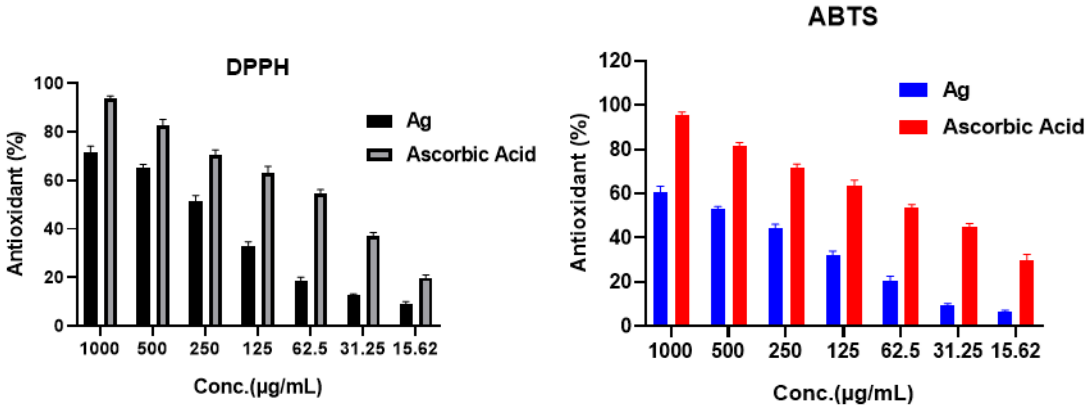

Fig. 4. Antioxidant activity of the biosynthesized AgNPs compared with that of ascorbic acid determined by DPPH and ABTS radical scavenging

Antidiabetic Activity

The effects of the AgNPs on α-amylase and α-glucosidase enzymes are illustrated in Fig. 5. As shown in the graphs, both enzymes exhibited concentration-dependent inhibition, where the inhibitory activity increased with increasing nanoparticle concentration. For the α-amylase assay, AgNPs showed inhibition values ranging from 5.7% at 1.95 µg mL^{-1} to 57.3% at 1000 µg mL^{-1}, while the standard drug acarbose demonstrated stronger inhibition ranging from 21.2% to 95.1% across the tested concentrations. Similarly, in the α-glucosidase assay, the inhibition by AgNPs increased from 11.2% at 1.95 µg mL^{-1} to 63.6% at 1000 µg mL^{-1}, whereas acarbose reached inhibition values up to 95.3%. The calculated IC_{50} values were approximately 461 µg mL^{-1} for α-amylase and 153 µg mL^{-1} for α-glucosidase, indicating that the synthesized nanoparticles exert stronger inhibition toward α-glucosidase than α-amylase.

When compared with previously reported results, the IC_{50} values obtained in the current study fall within the range reported for biosynthesized nanoparticles. For instance, fungal-mediated AgNPs exhibited an α-amylase IC_{50} of approximately 326 µg mL^{-1}, demonstrating a similar order of magnitude to the inhibitory activity observed in the present work (Kaur *et al.* 2024). This observation is helpful for diabetes management because the selective inhibition of α-glucosidase can effectively decrease postprandial hyperglycemia, whereas minimizing gastrointestinal side effects is generally associated with excessive α-amylase inhibition (Li *et al*. 2022).

The results shown in Fig. 5 are in agreement with similar studies in the literature previously reported studies that revealed that green-synthesized AgNPs significantly inhibit carbohydrate-digesting enzymes. The antidiabetic activity of these nanoparticles is due mainly to the phytochemical compounds on their surface that are adsorbed during the process of green synthesis, such as phenolics and flavonoids, which can interact with the enzyme active sites and alter the catalytic activity. Furthermore, the large surface area and nanoscale size of AgNPs increase their interaction with biological molecules, thereby improving their enzyme inhibition efficiency (Abbigeri *et al*. 2025; González-Garibay *et al*. 2025). Although the inhibitory effect of the AgNPs was lower than that of acarbose, the

synthesized AgNPs showed significant enzyme inhibitory activity, emphasizing their potential as natural nanomaterials for the development of alternative antidiabetic therapies.

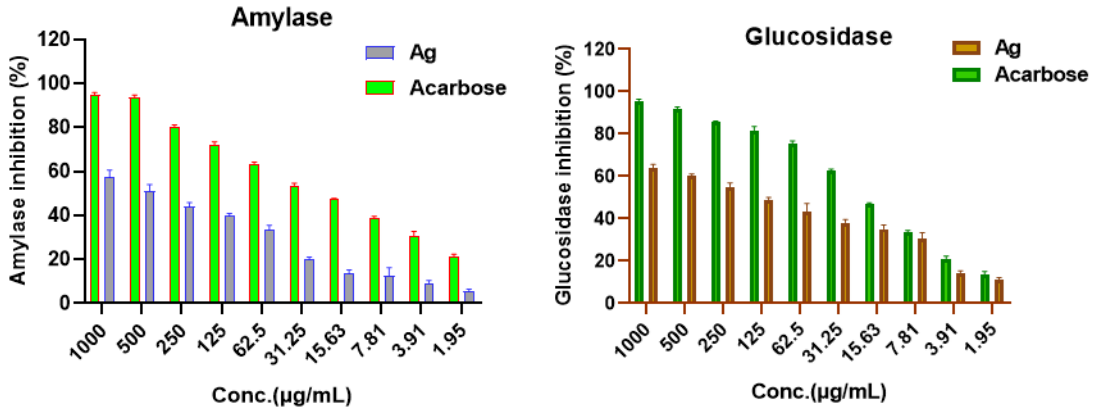

Fig. 5. AgNPs and acarbose against α-amylase and α-glucosidase enzymes

CONCLUSIONS

1. Silver nanoparticles (AgNPs) were successfully produced using *Solanum tuberosum* (potato) peel extract through a green, environmentally friendly, and economical synthesis approach. Characterization techniques including UV–Vis, X-ray diffraction (XRD), transmission electron microscopy (TEM), scanning electron microscopy (SEM), and energy-dispersive X-ray (EDX) analysis.
2. The synthesized AgNPs demonstrated strong antimicrobial activity against both bacterial (*Bacillus subtilis*, *Klebsiella pneumoniae*) and fungal (*Penicillium glabrum*, *Candida albicans*) strains, indicating broad-spectrum antimicrobial potential.
3. AgNPs exhibited dose-dependent cytotoxic effects against PANC-1 and PC-3 cancer cell lines but relatively low toxicity toward Vero normal cells, suggesting that they have selective anticancer activity.
4. The nanoparticles also showed moderate antioxidant activity (DPPH and ABTS assays) and notable antidiabetic potential through concentration-dependent inhibition of α-amylase and α-glucosidase enzymes.

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