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## Biosynthesis of Silver Nanoparticles from *Platostoma palustre* for Agricultural Applications

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### ABSTRACT

Nanoparticle synthesis using natural resources offers a cost-effective and eco-friendly strategy. In this study, silver nanoparticles (AgNPs) were synthesized using *Platostoma palustre* extract (PPE), rich in polysaccharides and bioactive compounds. Characterization by XRD, SEM, and TEM confirmed successful synthesis. TEM revealed oval-shaped nanoparticles (7-80 nm) with PPE forming a stabilizing layer to prevent agglomeration, while XRD indicated a crystallite size of approximately 7 nm with peaks at  $2\theta$  values of  $38.18^\circ$ ,  $44.33^\circ$ ,  $54.89^\circ$ ,  $64.51^\circ$ , and  $77.40^\circ$ . The aqueous extract (90 °C, 120 min) with AgNO<sub>3</sub> produced AgNPs@PPE exhibiting excellent bioactivity. Antioxidant capacity was high, with IC<sub>50</sub> values of  $31.69 \pm 2.78$  µg/mL (DPPH) and  $5.75 \pm 0.08$  µg/mL (ABTS), and FRAP reaching  $90.09 \pm 1.81$  µg vitamin C equivalent. Antibacterial assays (disk diffusion) showed strong activity against *Staphylococcus aureus* and *Escherichia coli* at 0.5 - 1 mg/mL. AgNPs@PPE demonstrate strong antioxidant and antibacterial properties, highlighting their potential for biomedical, environmental, and agricultural applications, including extending post-harvest shelf life.

**Keywords:** Antioxidant, Anti-bacterial, AgNPs, *Platostoma palustre*.

### INTRODUCTION

*Platostoma palustre* (Hsian-tsao) is a traditional herb widely cultivated in East Asia, particularly Taiwan, China, and Japan. Rich in polysaccharides, triterpenoids, and phenolics, it has been reported to possess strong antioxidant, anti-inflammatory, and anti-aging properties (Huang, Ding et al. 2021). These bioactive components not only contribute to its health benefits but also provide reducing and stabilizing agents for the biosynthesis of nanoparticles. Compared with conventional chemical synthesis, biosynthetic approaches using plant extracts, fungi, or bacteria are more environmentally friendly, cost-effective, and biocompatible (Srinivasan and Rana 2024). Green synthesis, in particular, reduces the need for toxic reagents while allowing control over particle size, shape, and stability. Recent studies have highlighted the importance of optimizing parameters such as pH and temperature to enhance nanoparticle functionality, underscoring the growing potential of green nanotechnology in agricultural applications.

## MATERIALS AND METHODS

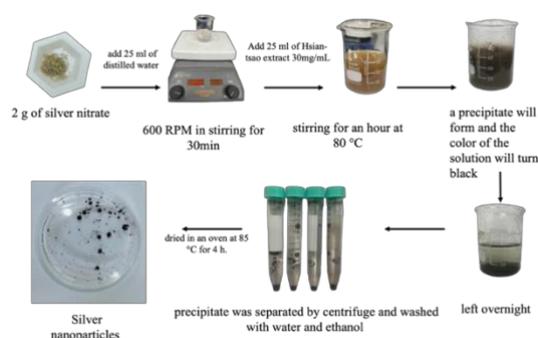
### MATERIALS

*Platostoma palustre* (Hsian-tsao) was collected from Taiwan and washed to remove soil. HsiantSao were washed in reverse osmosis (RO) water for many times. Then HsiantSao will be dried under 50°C and stored in the box with silica gel.

### METHODS

#### Preparation of plant extracts

Using 30 grams of Hsian-tsao were soaked in 200 milliliters of RO water. After 1.5 hours of stirring in a water bath at 60°C, the mixture was then filtered using filter paper and either used immediately for the production of nanoparticles or kept at 4°C for further study.



Biosynthesis Silver nano particles shown in Figure 1 (Ali, Ahmed et al. 2023).

Fig. 1 Process biosynthesis silver nanoparticles

#### Characterization

Nanoparticle morphology was examined using SEM. Samples were prepared by sonicating the nanoparticle solution and depositing 5–10  $\mu\text{L}$  onto carbon-copper grids, followed by drying at 105°C overnight. Structural analysis was conducted using XRD (D2 PHASER, 2nd gen) across a  $2\theta$  range of 10–80°, and particle size was estimated using the Debye-Scherrer equation:

$$D = \frac{K\lambda}{\beta \cos\theta} \quad (1)$$

Where:

$$K = 0.94$$

$$\lambda = \text{X-ray wavelength (1.54 \AA)}$$

$\theta$  = the Brag angle

D = the average crystallite domain size

#### Radical scavenging assay by DPPH, FRAP and ABTS Methods.

The antioxidant activity of AgNPs was assessed using DPPH and ABTS assays. For DPPH, 0.2 mM DPPH solution was mixed with samples at varying concentrations, incubated in the dark for 30 min, and absorbance was measured at 517 nm. For ABTS, ABTS $\cdot^+$  was generated with potassium persulfate, adjusted to an absorbance of  $0.70 \pm 0.05$  at 734 nm, then mixed with samples, incubated for 30 min, and measured at 734 nm. The reducing power of the samples was assessed using a modified FRAP assay, with absorbance measured at 700 nm and ascorbic acid as the positive control (Benkhaira 2021).

### Antibacterial

The antibacterial activity of the AgNPs was evaluated using the paper disk diffusion method. Bacterial suspensions ( $7 \times 10^6$  cells/mL) were inoculated on nutrient agar plates (20 mL). Sterile paper disks (0.6 cm) were loaded with 10  $\mu$ L of sample and placed on the agar surface. A disk containing streptomycin–penicillin served as the positive control. Zones of inhibition (mm) were measured after incubate at 37°C for 24h (Bauer, Kirby et al. 1966).

## RESULTS & DISCUSSION

Characterization techniques, including XRD, SEM, and TEM shown in Figure 2 , confirmed the successful synthesis of AgNPs@PPE nanoparticles. TEM results showed the combination of *Platostoma palustre* extract and AgNPs, with *Platostoma palustre* extract forming a layer around the nanoparticles to reduce agglomeration. The synthesized silver nanoparticles exhibited an oval morphology, with sizes ranging from 7 to 80 nm as observed in TEM analysis. The average crystallite size estimated from XRD analysis was approximately 7 nm. The XRD pattern displayed characteristic diffraction peaks at  $2\theta$  values of 38.18°, 44.33°, 54.89°, 64.51°, and 77.40°, corresponding to the (111), (200), (112), (220), and (311) planes. The diffraction data for AgNPs were compared with the silver reference file No. 04-0783 from the International Center for Diffraction Data card (ICDD)(Ali, Ahmed et al. 2023).

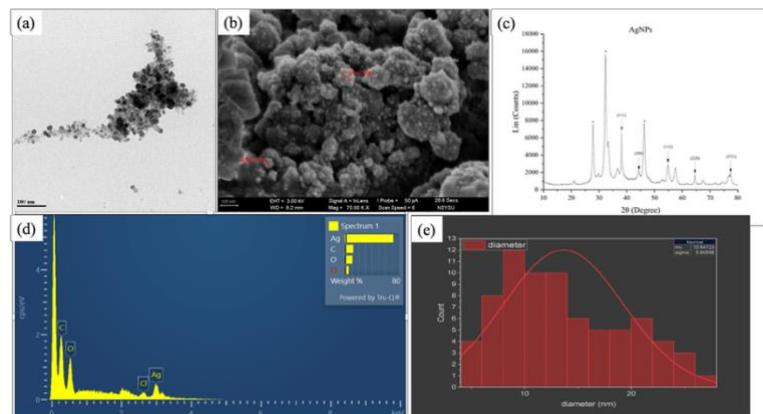


Fig. 2 The characterization of AgNPs was detected using (a) TEM, (b) SEM, (c) XRD , (d) EDX (e) particle size distribution map

Table 1 Anti-oxidant ability of AgNPs@PPE

Assay	Result	Unit
DPPH	$31.69 \pm 2.78$	$\mu$ g/mL
ABTS	$5.75 \pm 0.08$	$\mu$ g/mL
FRAP	$90.09 \pm 1.81$	$\mu$ g vitamin C

The antioxidant capacity of AgNPs@PPE nanoparticles in Table 2 shows that the IC50 values against DPPH and ABTS were  $31.69 \pm 2.78$   $\mu$ g/mL and  $5.75 \pm 0.08$   $\mu$ g/mL, respectively. In addition, the FRAP value reached  $90.09 \pm 1.81$   $\mu$ g vitamin C, indicating a comparable iron-reducing ability.

Table 2 Sterile zone diameter of AgNPs on 2 bacterial strains.

Sample	Concentration (mg/mL)	<i>Staphylococcus aureus</i> (mm)	<i>Escherichia coli</i> (mm)
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	0.3	2.33 ± 0.28	3.83 ± 0.28
AgNPs@PPE	0.5	3.16 ± 0.28	6 ± 0.5
	1	4.5 ± 0.5	6.67 ± 0.28
Penicillin/Streptomycin	0.1	34.16 ± 0.76	18 ± 0.57

The antibacterial ability of silver nano was clearly and strongly shown in both Gram-positive and Gram-negative bacterial lines, the results showed that the antimicrobial halo gradually increased from  $2.33 \pm 0.28$  to  $4.5 \pm 0.5$  for *S. aureus* and from  $3.83 \pm 0.28$  to  $6.67 \pm 0.28$  for *E. coli* when the concentration of silver nano increased from 0.3 - 1mg/mL, indicating the resistance potential Bacteria of nano silver are biosynthesized from *Platostoma palustre*.

## CONCLUSIONS

This study successfully synthesized silver nanoparticles by green synthesis method using *Platostoma palustre* water extract, which has good biological activity such as strong antioxidant at low concentrations, and has antibacterial ability in both Gram-negative and Gram-positive bacteria. These green silver nanoparticles will be a potential material in many fields.

## ACKNOWLEDGEMENTS

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