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Green Synthesis of Silver Nanoparticles from *Weissella cibaria* UPMC 1451 and Evaluation of their Antibacterial Activity *in vitro*

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Biosynthesis, Weissella cibaria; Silver nanoparticles; Antibacterial;and K. pneumoniae

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ABSTRACT

This research aimed to generate silver nanoparticles (Ag NPs) using the *Weissella cibaria* (*W. cibaria*) UPMC 1451 supernatant and evaluate their effectiveness in inhibiting *Klebsiella pneumoniae* M1-RP-23–01. *W. cibaria* is a well-known starter culture that plays a very important role in the initial fermentation process of products such as kimchi and sourdough. It has been found that *Weissella* is beneficial as a novel probiotic due to its biotechnological capabilities. In the present study, Ag NPs were synthesised extracellularly using the *W. cibaria* UPMC 1451supernatant. The appearance of a dark brown colour in the solution indicates the presence of Ag NPs. Ag NPs were characterised using dynamic light scattering and Transmission Electron Microscopy. The hydrodynamic radius of Ag NPs was found to be 28.52 nm along with zeta potential (-30.0 mV) and polydispersity index (0.466). The TEM micrograph shows that the produced Ag NPs are spherical with an average diameter of 4.63 nm at a 10 nm scale. The antibacterial effectiveness of Ag NPs was tested against the bacterial strain *K. pneumoniae* by the agar well diffusion method. The diameters of the inhibition zone clearly showed that the Ag NPs have potent antibacterial properties against *K. pneumoniae*. In this study, the *W. cibaria* UPMC 1451 was used for the first time to generate Ag NPs. Henceforth, we conclude that Ag NPs biosynthesised are eco-friendly and exhibit antibacterial properties against *K. pneumoniae*, highlighting their potential as alternative antimicrobial agents and warranting further investigation for possible applications in agricultural and food-related environments.

التخليق الأخضرلجسيمات الفضة النانوية من *Weissella cibaria* UPMC 1451 وتقييم نشاطها المضاد للبكتيريا في المختبر

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الخلاصة

هدفت هذه الدراسة إلى إنتاج جسيمات الفضة النانوية باستخدام الراشح الخلوي لبكتيريا *Weissella cibaria* UPMC 1451، وتقييم فعاليتها في تثبيط نمو بكتيريا *Klebsiella pneumoniae* M1-RP-23–01. تُعدّ بكتيريا *W. cibaria* من البادئات المعروفة التي تلعب دورًا بالغ الأهمية في عملية التخمير الأولية لمنتجات مثل الكيمتشي والخبز المخمر. كما تبيّن أن *Weissella* مفيدة كبروبيوتيك جديد بفضل قدراتها التقنية الحيوية. في هذه الدراسة، تمّ توليف جسيمات الفضة النانوية صديقة للبيئة خارج الخلية باستخدام الراشح الخلوي لبكتيريا *W. cibaria* UPMC 1451. يشير ظهور اللون البني الداكن في المحلول إلى وجود جسيمات الفضة النانوية. تمّ توصيف الجسيمات النانوية باستخدام تقنية تشتت الضوء الديناميكي والمجهر الإلكتروني النافذ. وُجد أن نصف القطر الهيدروديناميكي للجسيمات الفضة النانوية يبلغ 28.52 نانومتر، بالإضافة إلى جهد زيتا (-30.0 ملي فولت) ومعامل تشتت (0.466). تُظهر صورة المجهر الإلكتروني النافذ أن جسيمات الفضة النانوية المُنتجة كروية الشكل بقطر متوسط يبلغ 4.63 نانومتر على مقياس 10 نانومتر. تم اختبار فعالية جسيمات الفضة النانوية كمضاد للبكتيريا ضد السلالة البكتيرية *K. pneumoniae* باستخدام طريقة الانتشار في الآبار على وسط الآجار. أظهرت أقطار منطقة التثبيط بوضوح أن الجسيمات الفضة النانوية تتمتع بخصائص قوية مضادة للبكتيريا ضد *K. pneumoniae*. في هذه الدراسة، استُخدمت سلالة *W. cibaria* UPMC 1451 لأول مرة لإنتاج جسيمات الفضة النانوية مضادة للبكتيريا. وبناءً على ذلك، نستنتج أن الجسيمات الفضة النانوية المضادة للبكتيريا المُصنّعة بواسطة الراشح الخلوي لسلالة *W. cibaria* UPMC 1451 صديقة للبيئة وتُظهر خصائص مضادة للبكتيريا ضد بكتيريا *K. pneumoniae*، مما يسلط الضوء على إمكاناتها كعوامل مضادة للميكروبات بديلة ويستدعي إجراء المزيد من البحث لتطبيقاتها المحتملة في البيئات الزراعية والغذائية.

الكلمات المفتاحية: التخليق الحيوي، ويسيلا سيباريا، جسيمات الفضة النانوية، مضاد للبكتيريا، كليبسيلا الرئوية

INTRODUCTION

Klebsiella pneumoniae (*K. pneumoniae*) is a highly evolving and rapidly emerging MDR pathogen that is prevalent on a global scale, especially within the livestock sector and other agricultural environments (Matheou *et al*., 2025). Surveillance programmes have identified contingent populations of resistant *K. pneumoniae* with carbapenem resistance and carriage of resistance genes such as bla_{NDM}, $bla_{OXA\text{-}48}$, or ESBL genes on cattle and poultry farms (Wareth & Neubauer, 2021). The overuse of antibiotics in livestock farming has promoted the emergence of MDR bacteria due to selective pressure and environmental dissemination (Matheou *et al*., 2025). As an example, when manure is used as a fertiliser, the presence of penicillin and other antibiotics (present in the animal's faeces at the time of deposition) acts as selective pressure to promote the emergence of MDR bacteria by promoting the spread of resistant genes into soils and water systems to establish reservoirs of MDR bacteria that could infect humans and other animals (Manyi-Loh *et al*., 2018). Increasingly more studies are identifying these pathogens in various livestock species and agricultural equipment, with evidence of their ability to be transmitted from one host to another through zoonotic pathways (Lau *et al*., 2024; Zhu *et al*., 2024). These bacterial strains can survive therapeutic doses of β-lactam antibiotics (including carbapenems), complicating treatment. A key factor in the aetiology of Carbapenem-resistant *Klebsiella pneumoniae* (CRKP) is the remarkable capacity of this organism to form biofilms (Shamkhali *et al*., 2025). Rising antibiotic resistance among biofilm-related isolates emphasises the importance of new approaches to prevent biofilm formation (Gebreyohannes *et al*., 2019). Recent breakthroughs in nanotechnology have highlighted

NPs as an attractive class of antibacterial agents for controlling these challenging infections (Mishra *et al*., 2023). Algburi *et al*. (2025) demonstrated that Ag NPs have shown great promise because of their small size and exceptional efficiency against multidrug-resistant bacteria. The preparation of Ag NPs is also very important. Several methods have been used for the synthesis, including biological, chemical, and physical methods (Vanlalveni *et al*., 2024). The traditional synthesis process tends to consume a lot of energy and involves toxic chemicals, causing some environmental issues. Conversely, biological synthesis methods offer cost-efficient alternatives and are eco-friendly, utilizing microorganisms such as fungi, yeast, and bacteria (Vanlalveni *et al*., 2024). NPs synthesis depends on selecting suitable microorganism candidates, as different organisms exhibit varying metabolic and enzyme activities (Al-Tameemi *et al*., 2025). Multiple probiotic bacterial species have been examined for their ability to generate NPs, including species from the *Bacillus* and *Lactobacillus* genera. *Bacillus sonorensis* MAHUQ-74 supernatant isolated from fermented vegetables produced Ag NPs rapidly with a size range of 13 to 50 nm after reducing silver ion (Ag^{+}) to Ag NPs (Wang *et al*., 2022). *Limosilactobacillus fermentum* (*L. fermentum*) isolated from fermented dairy products (El-Hawary *et al*., 2025), *Lactobacillus acidophilus* (*L. acidophilus*) isolated from canine feces (Algburi *et al*., 2025), *Ligilactobacillus salivarius* KC27L (*L. salivarius*) isolated from chicken feces (Yuksekdag *et al*., 2025), and *B. safensis* isolated from potable water (Jadoon *et al*., 2025) reported were successfully synthesised Ag NPs. There is widespread evidence that biosynthesised NPs, specifically Ag NPs, are effective against bacteria at nanoscale sizes of fewer than 100 nm (Sati *et al*., 2025). Generally, Ag NPs have been observed to have activity against a wide range of Gram-negative and Gram-positive pathogens due to their excellent properties, such as damage to cell structures and reactive oxygen species (ROS) (Vanlalveni *et al*., 2024). Hussein *et al*. (2025) documented that biosynthesised Ag NPs have antibacterial activity against *K. pneumonia* and *Staphylococcus aureus*. Extracellular Ag NPs synthesised by *Lysinibacillus* sp were proven to have antibacterial activity on *K. pneumoniae* ATCC 29665, *E. coli* ATCC 25922, *P. aeruginosa* CECT 108, and *S. aureus* CECT 794 (Pernas-Pleite *et al*., 2025). Ag NPs also showed antibacterial activity against multidrug-resistant *K. pneumoniae* isolated from food sources (AlKhafaji *et al*., 2024; Mousavi *et al*., 2023). Extracellular Ag NPs synthesised by plant extract were proven to have antibacterial activity on *Klebsiella* spp (Dunah *et al*., 2025). Therefore, the study on the antibacterial efficacy of Ag NPs synthesised by different biological sources is of substantial importance. NPs with smaller sizes, as well as secretory proteins, can possess greater antibacterial properties. *Weissella* is a Gram-positive bacterium belonging to the Lactobacillaceae family (Ahmed *et al*., 2022), which has a coccoid morphology or short bacillus shape. *Weissella cibaria* is a well-known starter culture that plays a very important role in the initial fermentation process of products such as kimchi and sourdough (Fessard & Remize, 2017). It is considered to be a food-grade microorganism, which is often used as a starter culture to improve the nutritional value and sensory characteristics of food products through the production of exopolysaccharides and bacteriocins (Jang *et al*., 2021). As a result, the use of *W. cibaria* strains that produce dextran has been found to greatly improve the overall quality of sourdough made from buckwheat, chickpea, and quinoa flours (Russo *et al*., 2023). It has been found that *Weissella* is beneficial as a novel probiotic due to its biotechnological capabilities (Liu *et al*., 2025). In the present work, Ag NPs were prepared with supernatant of *W. cibaria* UPMC 1451 strain previously isolated from a wastewater sample (Al-Tameemi *et al*., 2023). The size and morphology of the Ag NPs were confirmed using DLS and TEM. Additionally, the anti-bacterial activity of biosynthesised Ag NPs toward *K. pneumoniae* M1-RP-23–01strain was examined by agar well diffusion assay. The bacterium has been used to varying degrees for different purposes except for synthesis of Ag NPs using it as a whole cell; the use of *W. cibaria* in this work provides better insight into biogenic, green NP synthesis without toxic chemicals utilising microbial resources.

MATERIALS AND METHODS

Materials and Bacterial Strains

A 1 mM stock solution of silver nitrate ($AgNO_3$) (Sigma-Aldrich, USA) was prepared in deionized water. *Weissella cibaria* UPMC 1451, previously isolated from a sewage sample, was obtained from the Microbial Culture Collection Unit (UNiCC) at the Institute of Bioscience, Universiti Putra Malaysia. *K. pneumoniae* M1-RP-23–01strain was collected from the Laboratory of Microbiology/ UPM.

Biosynthesis of Ag NPs

W. cibaria UPMC 1451 was inoculated and grown overnight in a flask containing 75 mL of MRS broth (Merck, Germany) at 37 °C with shaking at 120 rpm. Then, the broth culture was neutralised with 0.4 M sodium hydroxide (NaOH; pH 10), to standardise Ag NPs synthesis (Solís-Sandí *et al*., 2023). The broth culture then was centrifuged at 1000 rpm during ten minutes, and the supernatant was employed for the next assays. Thereafter, 30 mL (1 mM) $AgNO_3$ was gradually supplemented in droplets to the supernatant of *W. cibaria* UPMC 1451 in a 7.5 mL flask with magnetic stirrer. The mixture was therefore incubated for 27 h in the dark at 60 °C. The supernatant of *W. cibaria* UPMC 1451 without $AgNO_3$ was tested under the same experimental conditions as a control solution. Formation of Ag NPs was observed by modification of the colour (from light yellow to dark brown) of the bacterial supernatant after 27 h incubation with a 1 mM $AgNO_3$ aqueous solution (Solís-Sandí *et al*., 2023). At the end of the process, As-prepared Ag NPs were collected by high-speed centrifugation (10,000 rpm, 30 min, 4 °C), dried out in an oven (37 °C), and stored as powder samples to the further characterisation and antibacterial activity studies (Mondal *et al*., 2020).

Characterisation of biosynthesised Ag NPs

DLS and zeta potential analysis

The DLS (Nano-ZS, United Kingdom) was used for the determination of particle size, Zeta potential, and polydispersity index of the biosynthesised Ag NPs. For sample preparation, a 1:3 dilution of biosynthesised Ag NPs suspension in Milli-Q water was used for analysis.

HR-TEM analysis

Transmission Electron Microscopy (TEM) (JEOL, model JEM 2011, Japan) was utilised to characterise the morphology and size of the biosynthesised Ag NPs. The image was shown using an HR-TEM. 200 kV of the electron voltage was used to image the particles. The particle size was identified by ImageJ software (National Institutes of Health (NIH), US). TEM samples were prepared by drop-casting 5 µl of Ag NPs suspensions onto carbon-coated copper grids and air-drying.

Antibacterial activity of biosynthesised Ag NPs

The antibacterial effectiveness of biosynthesised Ag NPs from *W. cibaria* UPMC 1451 was tested against *K. pneumoniae* M1-RP-23–01by the agar well diffusion method (Baygar & Ugur, 2017; Jafar *et al*., 2022). Briefly, the *K. pneumoniae* M1-RP-23–01 inoculum was grown overnight in nutrient broth at 37 °C. Bacterial inoculum was prepared by adjusting the medium turbidity to match the 0.5 McFarland standard. A sterilised swab was used to streak CRKP onto the Mueller–Hinton agar plate. A cork borer was used to make the wells of 6-mm diameter on Mueller–Hinton agar plate. Then 100 µL (100 µg/mL) biosynthesised Ag NPs was added into the wells. Under the same conditions, 1 mM $AgNO_3$ was used as a control. After incubation for 24 hours at 37 °C, antibacterial activity was estimated by measuring the zone of inhibition around the wells.

RESULT AND DISCUSSION

In the present study, an aqueous solution of $AgNO_3$ was reduced to Ag NPs upon addition to the *W. cibaria* UPMC 1451supernatant. Synthesis of Ag NPs was suggested by changing the colour of *W. cibaria* UPMC 1451supernatant from light yellow to dark brown after 27 h of incubation with a 1 mM $AgNO_3$ aqueous solution (Figure 1-b). In similar conditions, the supernatant of *W. cibaria* UPMC 1451 without $AgNO_3$ was used as a negative control. The negative control did not show any colour change after 27 h incubation, and did not appear dark brown in the flask, confirming the privacy of the biosynthesis process for Ag NPs (Figure 1-a).

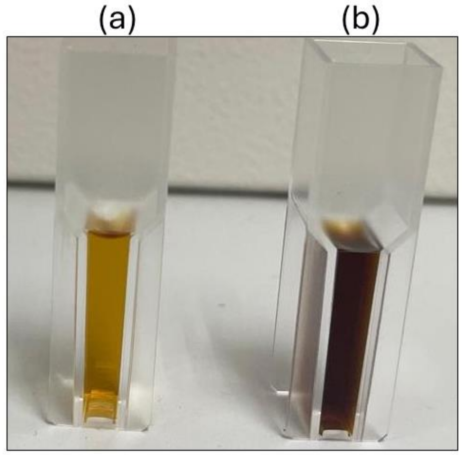

Figure 1. Extracellular biosynthesis of Ag NPs using *W. cibaria* UPMC 1451supernatant at 27 hours: **(a)** The supernatant of *W. cibaria* UPMC 1451 without $AgNO_3$ treatment; **(b).** The supernatant of *W. cibaria* UPMC 1451 with $AgNO_3$ treatment.

Cekuolyte *et al*. (2023) reported that the initial method for determining the extracellular Ag NPs production is the change in medium colour after bacterial supernatant incubation with $AgNO_3$. It is known that the brown colour is due to the reduction of Ag^+ to Ag NPs by bacterial biomolecules like proteins, phenolics, and polysaccharide which act as reducing as well capping agents (Mohd Yusof *et al*., 2020). For example, biosynthesis of Ag NPs by *Kocuria rhizophila* BR-1 was dependent on released nitrate reductase present in the supernatant (Kumar *et al*., 2022), which catalyzed the reduction reaction from nitrate to metal group via electron transfer (Samuel *et al*., 2020). Likewise, Gholami-Shabani *et al*. (2015) described that the reduction of NPs was carried out by α-NADPH-dependent sulfite reductase *Escherichia coli*. Banerjee *et al*. (2021) reportedly examined the capability of *B. anthracis* PFAB2 toward extracellular production of exopolysaccharides, and their involvement in Ag NO_3 reduction to Ag NPs. On the other hand, Dey *et al*. (2023) reported that the biosynthesised Ag NPs are mainly related to the hydroxyl, carboxyl, and phosphate groups of bacterial metabolites which can efficiently trigger Ag^+ reduction. *Weissella* has been known to have a thick peptidoglycan layer, teichoic acids, and proteins rich extraction of anionic surface groups in the cell membrane with exopolysaccharides full of carbonyl, hydroxyl, and carboxyl over the cell membrane or neighbouring environment (Zammouri *et al*., 2024)**.** These bacterial biomolecules would have played an important role in transferring electrons to Ag^+, thereby reducing them to (Ag^o) and producing Ag NPs (Mikhailova, 2020). Biomolecules function as key reducing, stabilising, and capping agents, which are necessary for the controlled synthesis of Ag NPs (Ranjani & Hemalatha, 2025). In addition, biomolecules of probiotic bacteria provide an eco-friendly environment and are safe not only for the synthesis of Ag NPs (Ranjani & Hemalatha, 2025). Wherefore, it can be postulated that biomolecules secreted by the *W. cibaria* UPMC 1451 serve as reducing and capping agents, promoting the production of Ag NPs.

Figure 2 shows the particle size distribution of Ag NPs synthesised by *W. cibaria* UPMC 1451 supernatant, where an average hydrodynamic radius of 28.52 nm is indicated with a polydispersity index of 0.466.

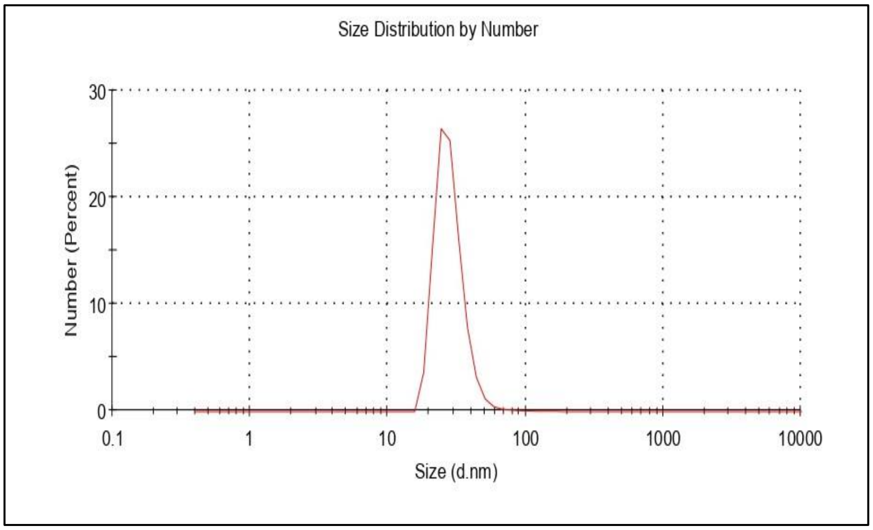

Figure 2. Particle size distribution analysis of Ag NPs synthesised using *W. cibaria* UPMC 1451supernatant

Elamawi *et al*. (2018), Ag NPs homogeneity is defined based on the presence of NPs harboring PDI values in the range of 0 and 1. DLS was employed to analyze Ag NPs produced by *Bacillus sonorensis* MAHUQ-74 and the researcher reported that the NPs were 44.6 nm in size with a DPI of 0.406 (Wang *et al*., 2022). The measurement of particle size for biosynthetic Ag NPs, as reported in study was found to be within the range of 1 to 100 nm (Eker *et al*., 2025). Depending on the pH and bacterial strain, the size and distribution of bacterial-generated silver spheres are different. In another study, it was reported that the average hydrodynamic radius of Ag NPs produced by *Ligilactobacillus salivarius* KC27L was 79.47 nm with a PDI of 0.60 (Yuksekdag *et al*., 2025). In addition, the zeta potential is an important coefficient of surface charge of nanoparticles in colloidal solutions. The stability of the NPs was assessed, and the zeta potential of Ag NPs produced using the upper filtrate of *W. cibaria* UPMC 1451 was -30.0 mV, indicating very good stability.

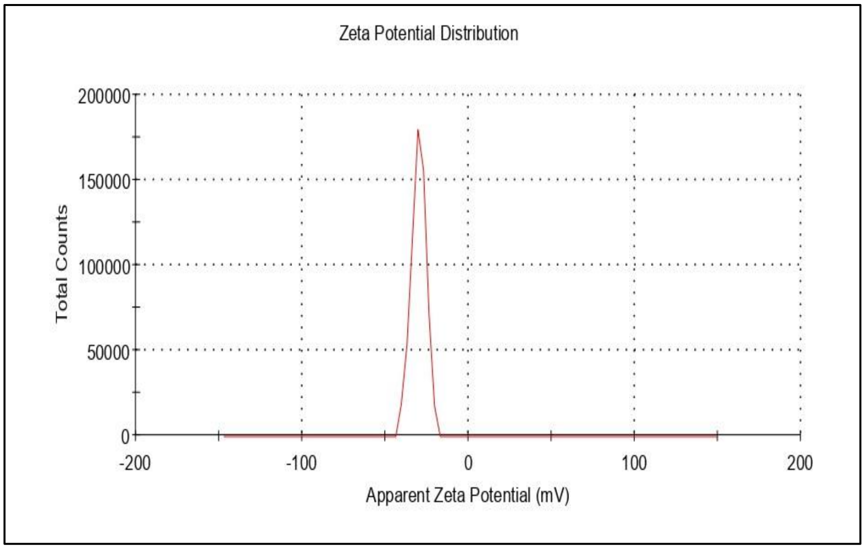

Figure 3. Zeta potential analysis of Ag NPs synthesised using *W. cibaria* UPMC 1451supernatant

Saeb *et al*. (2014) reported that the NPs with zeta potentials below than -30 mV or above +30 mV are normally considered stable. The stability of the Ag NPs synthesised by bacteria varies based on the bacterial strain. Abdelgadir *et al*. (2024) found that during the production of Ag NPs using *Lactobacillus salivarius* the zeta potential was −14.53 mV. Other scientists found that during the formation of Ag NPs synthesised by *Komagataeibacter rhaeticus* N1 MW322708*,* the zeta potential was −32.7 mV. The measurement suggested that the *W. cibaria* UPMC 1451 supernatant was stable during Ag NPs synthesis. Figure 3 depicts the zeta potential graph of the Ag NPs biosynthesised using *W. cibaria* UPMC 1451supernatant*.*

The morphology of biosynthesised Ag NPs was analysed by using TEM; the micrograph shows that the Ag NPs produced are spherical with an average diameter of 4.63 nm and a size distribution of 3.41 to 7.38 nm at a 10 nm scale (Figure 4).
NPs synthesised by bacteria vary in size and dispersion depending on the bacterial strain, temperature, and PH level. Vijayakumar *et al*. (2023) used TEM to characterise the production of Ag NPs synthesised by the supernatants of *L. plantarum* at pH 8 and 37 °C. They found that the size of the NPs was 14 nm, while Kumar *et al*. (2022) performed a similar experiment using *Kocuria rhizophila BR-1* and obtained spherical Ag NPs with an average particle size of 7.6 nm. It has been documented that various microorganisms secrete a range of biomolecules in varying proportions (Pinu & Villas-Boas, 2017), including proteins, polysaccharides, carbohydrates, and lipids (Sidhu *et al*., 2022; Wanke *et al*., 2021), which have been reported as biomolecules responsible for the eco-friendly synthesis of Ag NPs.

The current investigation demonstrates that the Ag NPs produced using *W. cibaria* UPMC 1451supernatant are small compared to the previous research of Vijayakumar and his group (Kumar *et al*., 2022; Vijayakumar *et al*., 2023). Small-sized NPs are thought to be better for biological activities, and size plays a significant role in regulating the use of NPs (Osonga *et al*., 2020).

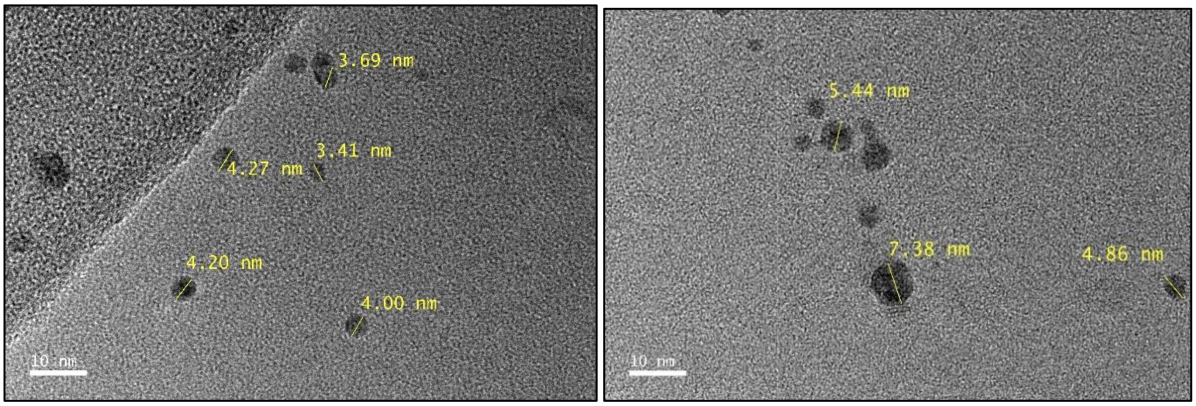

Figure 4. TEM images display the Ag NPs synthesised by *W. cibaria* UPMC 1451supernatant at a 10 nm scale

In the present study, the biosynthesised Ag NPs measured by TEM were smaller than those observed by DLS. This discrepancy is anticipated since the hydrodynamic diameter, which comprises the nanoparticle core, biomolecular, and surrounding solvent layer or capping agents attached to the surface, is measured by DLS (Yeap *et al*., 2018). TEM, on the other hand, gives the proper core size in the dry state without the hydration layer (Eaton *et al*., 2017). Consequently, the impact of the biological coating and dispersion medium is reflected in the larger DLS size.

The antibacterial potential of the biosynthesised Ag NPs was tested against *K. pneumoniae* M1-RP-23–01 using an agar well diffusion procedure. The Ag NPs (100 µg/mL) resulted in the formation of an inhibition zone that was about 17.65 mm higher than that obtained with the silver precursor control (13 mm) (Figure 5), signifying that NP development improved the antibacterial efficacy. Such enhanced activity is believed to originate from both nanoscale factors, such as higher surface area and reactivity, as well as biomolecules in the bacterial supernatant that may alter surface interactions.

Figure 5. Antibacterial activity of biosynthesised Ag NPs by the well diffusion method, showing inhibition zones for Ag NPs (100 µg/mL) compared with the $AgNO_3$ control (1 mM).

Compared to NPs generated by some other microorganisms, which needed higher concentrations of Ag NPs for synthesis in previous works (Yakoup *et al*., 2024), the synthesised particles here showed stronger antibacterial activity. This enhancement is probably attributed to the smaller particle size and the existence of biomolecules present in *W. cibaria* UPMC 1451supernatant, which might act as reducing and stabilising agents for the synthesis. Our findings also emphasise that the size of Ag NPs is a crucial factor affecting their antimicrobial activity. The smaller NPs have higher activity, as they are easily able to reach the cytoplasm and nucleus of microbial cells (Duman *et al*., 2024). However, other characteristics of the NPs, such as concentration, morphology, and surface charge, also play a role in their general antimicrobial effect (Wang *et al*., 2017). The detection of antibacterial activity against *K. pneumoniae* in agriculture and food production is important since this bacterium is commonly found within clinical settings but also in farm soils, irrigation water, animal waste, and fresh produce. Thus, qualifying agricultural ecosystems as possible pathogenic reservoirs of *K. pneumonia*. This has been noted through research conducted by (Junaid *et al*., 2022; Wareth & Neubauer, 2021) who stated that *K. pneumoniae* has been recovered from farm soils and irrigation systems. *K. pneumoniae*'s presence in both agricultural soil and water systems creates the opportunity for both pathogenic strain and antibiotic-resistant microbial strains to be disseminated through both food production systems and the food chain (Ananya *et al*., 2025). Additionally, the use of organic fertilizers (e.g., manure) provides an environment for the incorporation of antibiotic-resistant microorganisms and their resistance genes into agricultural soils, and these genes may be subsequently transferred to crops and adjacent aquatic environments. Therefore, the environmental dissemination of antibiotic-resistance benefits posed through the introduction of *K. pneumoniae* to agricultural soils and water systems is creating additional concerns regarding food safety (Sun *et al*., 2025). Sedlakova-Kadukova *et al*. (2024) reported that biosynthesised AgNPs are a promising environmentally friendly alternative, reducing bacterial resistance and mitigating the risks associated with silver-induced antibiotic resistance in soil ecosystems. They have greater potential for sustainable applications while addressing critical concerns about environmental safety and antimicrobial resistance. According to Tian *et al*. (2022), biosynthesised AgNPs have been reported to be effective against *Xanthomonas oryzae* pv. *oryzae*, one of the most important plant pathogens. Therefore, the strong antibacterial activity of biosynthesised silver nanoparticles suggests their potential application as antimicrobial agents in agricultural settings, including incorporation into biofertilizers or soil amendments to reduce pathogenic bacteria and limit the dissemination of resistance genes in agroecosystems.

CONCLUSION

The Ag NPs synthesised using a “friendly” bacteria *W. cibaria* UPMC 1451 has potent antibacterial properties as they are effective against *K. pneumoniae* M1-RP-23–01. The extracellular biomolecules present in the bacterial supernatant could be responsible for the reduction and stabilisation of silver ions into Ag NPs. The *W. cibaria* bacteria can be found in fermented foods, faeces, and access to culture. Thus, the synthesis protocol of Ag NPs can be easily scaled up. The Ag NPs produced were stable and had antibacterial applications. The synthesised NPs can significantly inhibit multidrug-resistant bacteria, enhancing the application of these Ag NPs in various fields. To ensure both environmental and food safety, it is critical to control *K. pneumoniae*, as there have been reports of the pathogen in agricultural soils, manure, irrigation water, and also in fresh produce. Therefore, the biosynthesised Ag NPs developed in this study may have potential applications in agricultural systems, such as incorporation into biofertilizers or soil treatments, to reduce pathogenic bacteria and limit the spread of antimicrobial resistance in agroecosystems. Warranting further investigation for possible applications in agricultural and food-related environments.

CONFLICT OF INTEREST

It is confirmed with the researchers who are involved that there has been no conflict of interest.

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