ANALYSIS OF *Senecio rowleyanus* (STRING-OF-PEARLS) BIOLOGICAL CHARACTERISTICS BY MEANS OF GOLD NANOPARTICLES (AUNPS)

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ABSTRACT

There has been a deluge of research on the biosynthesis of AuNPs in recent years. In this day and age, when germs are increasingly resistant to treatment, there has to be a strong effort to discover new antibacterial agents and an improved antibiotic. Studies studying the antibacterial activities of AuNPs functionalized with organic molecules have increased dramatically as a result of this. The pharmaceutical industry could find several applications for biosynthesised gold nanoparticles functionalized with bioactive chemicals derived from *Senecio rowleyanus*. Envelopes including carbohydrates, vitamins, phenolic compounds, proteins, lipids, or flavonoids are created to stabilize the biosynthesised AuNPs. The chemical makeup of the natural coating influences the size, shape, stability, and interactions of AuNPs with the bacterial cell wall. Because of the diversity of *Senecio rowleyanus* and biosynthesised AuNPs, their exact composition is a mystery. In order to develop the most effective drug combinations, it is essential to understand the antibacterial mechanisms. There has been little research on the potential use of antibacterial treatments that have been functionalized using chemicals from *Senecio rowleyanus* in conjunction with AuNPs. But their unique physicochemical and biological properties show how versatile AuNPs may be in the future.

Keywords: Gold nanoparticles; Anti-fungal activity; Anti-microbial; Anti-bacterial activity; *Senecio rowleyanus*

INTRODUCTION

Investigating the potential of alternative antimicrobial agents, including nanoparticles, is highly motivated by the increasing issue of antibiotic resistance. Out of all the nanoparticles being tested, AuNPs stand out due to their many desired qualities, such as their easily functionalizable nature, well-known outstanding biocompatibility, and stability. Making antimicrobial gold nanoparticles from extract of the string-of-pearl plant, Senecio rowleyanus, is the primary goal of this study. Actually, this hardy succulent plant may have unique phytochemical components that boost the antibacterial effects of AuNPs. The main goal of this study was to create an additional approach that uses bioactive components generated from *Senecio rowleyanus's* organic extracts in combination with antibacterial AuNPs. Potentially useful as agents against several bacterial species, the resulting nanoparticle-extract composites show tremendous promise. In order to address the increasing problem of microbial resistance, this introductory section aims to study the biosynthesis, characterization, and antibacterial efficacy of gold nanoparticles produced from *Senecio rowleyanus*. Future research in nanomedicine could build on this work (Alodaini & Ranganathan, 2022).

Among its many names, the succulent vine *Senecio rowleyanus* (a member of the aster family) is known as string-of-pearls. This plant often grows in dry, southwestern African locations. It spreads its thick mat of stems, which may be two to three feet long, and roots at the nodes of those stems. The pearly, spherical leaves of this plant have adapted to their arid environment in southwestern Africa by developing a "window"—a narrow, transparent strip of tissue that allows light to enter and irradiate the inside of the leaf, increasing the area of leaf tissue used for photosynthesis. In photosynthetic organisms, this helps in carbon absorption. This little plant has an incredible adaption that lets it survive in harsh conditions by maximizing its usage of light and water. Here researcher see how plants adapt to harsh conditions using a streamlined version of the scientific process (Alsareii et al., 2025).

BACKGROUND OF THE STUDY

Gold nanoparticles have risen to the top of the noble metal research food chain due to their exceptional characteristics. Bio transformed nanoparticles provide minimal threat to ecosystems and people alike due to their low toxicity. The anti-inflammatory, laxative, and diuretic effects of *Senecio rowleyanus* have been recognized in traditional medicine for quite some time. Since more and more viruses and bacteria are developing resistance to antibiotics, there is an urgent need to discover new ways to combat these infections (Keskin et al., 2021). In particular, AuNPs were eagerly pursued for this endeavor because to their unique physicochemical properties, such as their large surface area, ease of functionalization, and potent antibacterial activity. Because of their diminutive size, they are able to penetrate through microbial cells with relative ease, making them very effective against a broad variety of pathogens. There has been increasing talk of using plant extracts as a greener alternative for nanoparticle stabilization and production. As a result, the *Senecio rowleyanus*, or string-of-pearls, attracted a lot of attention due to its decorative and medicinal uses. Some of the terpenoid bioactive chemicals found in this plant have antibacterial properties; they include flavonoids and phenolics (Aly Khalil et al., 2024).

So, the antibacterial activity of both substances is enhanced when gold nanoparticles as well as *Senecio rowleyanus* extracts are combined. The purpose of this research is to examine the effectiveness of various AuNPs produced from *Senecio rowleyanus* extracts in combating three prevalent bacterial illnesses. The creation of new antimicrobial agents and a more environmentally friendly nanotechnology method might both be aided by this study. In the ongoing battle against the alarming rise of antibiotic resistance, these agents will play a crucial role. To understand the potential medicinal uses of these nanoparticles in the future, it is necessary to understand how they interact with microbial cells (Asker & Al Haidar, 2024).

PROBLEM STATEMENT

"Due to fact that antibiotic resistance is on the rise, the number of viable medicines for treating bacterial diseases is being severely reduced, which is a major issue for public health. Because of the difficulties caused by resistance, traditional antibiotics are becoming more ineffective, making the development of new antimicrobial treatments an extremely pressing matter. Consequently, this study seeks to satisfy the increasing need for novel antimicrobials by exploring the potential of gold nanoparticles synthesized from *Senecio rowleyanus* extracts. Starting from this assumption, the study's objective is to determine if gold nanoparticles made from *Senecio rowleyanus* extracts are effective against different types of bacteria and might be used as a substitute for antibiotics in the fight against antibiotic resistance."

Researchers face a number of challenges in fight against bacterial infections, not the least of which is the growing issue of antibiotic resistance. This illness is considered one of the most critical issues in public health today. As infections progress, traditional antibiotics become less effective, leading to an increase in morbidity, death, or healthcare costs. Because of this, there is an immediate need to investigate potential new methods of combating germs that may overcome the shortcomings of current treatments. In this light, nanotechnology has become one of the most exciting new fields, and AuNPs have shown remarkable antibacterial capabilities (Chappalathottil Sethumadhavan & Pottail, 2019).

Studying the generation and antibacterial activity of GNPs derived from *Senecio rowleyanus*, more commonly known as string-of-pearls, is consequently being conducted to address this significant gap in the current antibiotic landscape. When combined with the bioactive phyto-constituents found in *Senecio rowleyanus* preparations, nano-participation may enhance the antibacterial effects even more (Sekar et al., 2022). This study aims to provide insight on potential novel treatment options for antibiotic-resistant bacteria by exploring the potential of these AuNPs as antimicrobial agents. Finally, this strategy is to pave the path for the development of new antimicrobial treatments that are more effective for patients and reduce the healthcare system's vulnerability to antibiotic resistance (Chowdhury et al., 2021).

LITERATURE REVIEW

There is a great deal of curiosity in the potential uses of AuNPs as an antimicrobial due to their unique properties, such as their large surface area, biocompatibility, and simplicity of functionalization. Based on studies, AuNPs have shown promise in combating antibiotic-resistant bacteria, thanks to their inherent antibacterial properties (Pawar et al., 2022). Reactive Oxygen Species (ROS) production, bacterial membrane rupture, and cellular process interference are some of the ways they work. When synthesized with nanoparticles, extracts from *Senecio rowleyanus* improve the antibacterial efficacy and durability of gold nanoparticles. An attractive and perhaps medicinal succulent is *Senecio rowleyanus*. Based on what is known presently, plants may contain phytochemicals like flavonoids and phenolic acids that have antimicrobial effects. The bioactive components in *Senecio rowleyanus* extract may provide gold nanoparticles an additional boost when it comes to killing germs (Dash et al., 2022).

When tested against "Gram-positive as well as Gram-negative bacteria," studies examining the antibacterial properties of AuNPs synthesized from different plant extracts have shown promising results. What this means is that plant-mediated AuNPs may be able to successfully halt the spread of antibiotic-resistant strains of Staphylococcus aureus and Escherichia coli. Surprisingly, in spite of all the advancements in the field of gold nanoparticles, very little research has focused on the antibacterial effects of gold nanoparticles generated from *Senecio rowleyanus* extract (Hatipoğlu, 2021).

The antibacterial activity of AuNPs produced from *Senecio rowleyanus* needs additional exploration, according to this review. The results of the investigations on the effectiveness against different kinds of bacteria should lead to the development of new tactics to fight antibiotic resistance and a treatment method that makes use of nanotechnology combined with natural components (Hlapisi et al., 2024).

RESEARCH QUESTIONS

What are the anti-bacterial activities of *Senecio rowleyanus* (String-of-pearls) extract?

RESEARCH METHODOLOGY

When gold ions in water react with a water-based *Senecio rowleyanus* extract, gold nanoparticles (AuNPs) are created.

Plant Collection: An agricultural area was the site of the *Senecio rowleyanus* collection. The researcher carefully selected this plant for further investigation in the field of botany. This experiment only made use of analytical grade substances.

AuNP bio-reduction: To prepare the water extract, the *Senecio rowleyanus* was meticulously harvested, washed, and finely sliced. A water-based extract was prepared by simmering 20 grams of the whole plant in 100 millilitres of distilled water. The steam extract was collected after 20 minutes using filter paper. In order to make gold nanoparticles, a solution of 0.1 mM gold chloride was mixed with three different proportions of water-based *Senecio rowleyanus* lysates for one hour: 1:10, 1:5, and 1:3. The mixture was then subjected to bio reduction while kept in darkness. The resultant purple solution was retained for further characterization experiments by the researchers.

Research on antimicrobials: "Staphylococcus aureus (ATCC25923), Pseudomonas aeruginosa (ATCC10231), Streptococcus pneumoniae (ATCC49619), and E. coli (ATCC11229)" were the microorganisms used in this investigation. The bacterial cultures were stored as a glycerol stock at a temperature of -80 °C in the lab. One colony was revived using the glycerol culture stock and maintained as a subculture in the nutritional broth at 4 °C. By means of agar well diffusion, the antibacterial activity was assessed. The suspended culture was equally spread across plates of nutrient agar. Then, carefully poking holes in the solid medium using a cork borer was the next step. To every well, 100 µl of AuNPs that had been synthesized was added. The plates were allowed to incubate for 24 hours at 37 °C. A control group was given the antibiotic amoxicillin. Researchers assessed the inhibitory zone width around the well to evaluate the antibacterial activity.

RESULT

Characterizations of AuNPs: For this purpose, researcher used a UV Lambda 650, a UV/VIS spectrophotometer manufactured by PerkinElmer, which can measure wavelengths between 200 and 800 nm, to determine the initial composition of the gold nanoparticles. The size and surface morphology of the produced gold nanoparticles were examined using a scanning electron microscope (ZEISS Gemini SEM 360). The results show that the nanoparticles are shaped like tubes and have an arrangement reminiscent to floral arrangements. Analysed were the biosynthesised AuNPs' shape and structure using Bruker X-flash into energy-dispersive X-ray spectroscopy (eZAF). Thermos iS50 Fourier transform infrared technology was used to study the mechanisms involved in the creation of gold nanoparticles. Gold nanoparticle stabilization was accomplished using a Windows version of "HORIBA SZ-100," the Z Type, Ver2.20. To determine the synthetic gold nanoparticles' durability, scientists used "HORIBA SZ-100" for Windows [Z Type] Ver2.20. For the next step, the size and form of the gold nanoparticles were confirmed using a transmission electron microscope ("FEI Tecnai G220 S-TWIN"). Analysis of the generated gold nanoparticles for crystallinity, phase purity, and overall crystal systems was done using a powder X-ray scattering instrument (D8 Advance Bruker).

Ultraviolet-visible spectroscopy: In this case, "UV-visible spectroscopy was used to investigate the synthesised gold nanoparticles." Gold ions were shown to undergo a biological transformation into clusters of atoms, or AuNPs, when water was added to a solution containing the ions. The purple colour is caused by something called "surface plasmon resonance (SPR)". Phyto fabricated AuNPs have their colours altered to exhibit excited electrons, as shown in Figure 1 (a). Researchers captured UV light spectra within the 200–800 nm range. The presence of three distinct plasmon surface peaks at 546 nm, 544 nm, and 555 nm in Figure 1 (b) indicates that three distinct ratios of AuNps were synthesized using an aqueous extract of *Senecio rowleyanus* plants: 1:3, 1:5, and 1:10. The characteristic absorption peak of gold nanoparticles, seen around 500 to 600 nm, makes them easy to spot. Because the surface plasmon excitation mode varies with nanoparticle size, AuNps have a one-of-a-kind UV absorbance band.

"Fourier transform infrared spectroscopy (FTIR)": Photometry using infrared light bio-reducers, caps, and stabilisers of AuNPs synthesized from a water-based *Senecio rowleyanus* extract were identified by means of the Fourier series (Figure 2). For the FT-IR experiment, researcher used either a water-based *Senecio rowleyanus* extract or gold nanoparticles synthesized by phytosynthesis. If the spectra of "AuNPs" are obtained in the 500-4000 cm−1 region, an excellent signal-to-noise ratio may be achieved. Notable intensity peaks may be seen at 3200 cm−1, 2100 cm−1, and 1600 cm|1. Aromatic functional groups such as "C-H stretching, CH3-R, N-H, C-O-C, and C=O stretching" were identified at various cycle numbers. When vibrations are present that stretch the OH or NH groups of proteins and carbohydrates, bio-reduction may occur. It may provide light on the noticeable band at 3297 cm−1.

Figure 1: a) Initial screening of synthesis process of AuNPs; **b)** UV–Visible spectrum of synthesized gold nanoparticles from the aqueous extract of *Senecio rowleyanus*

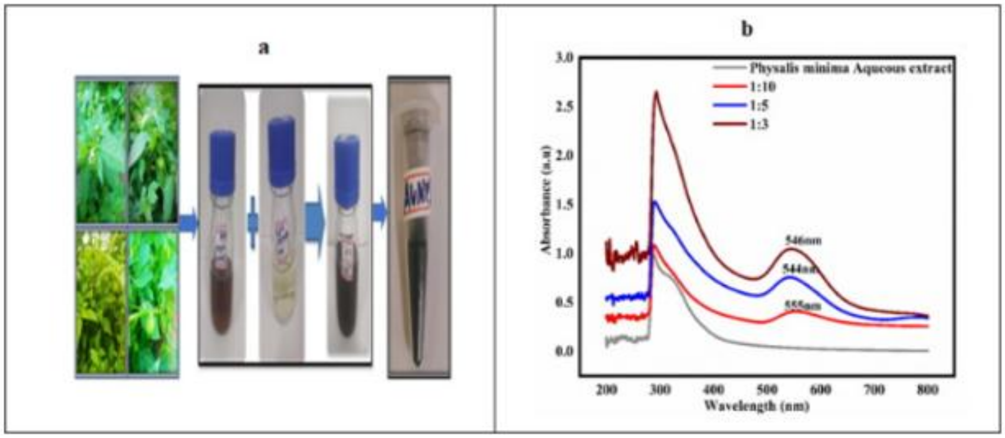
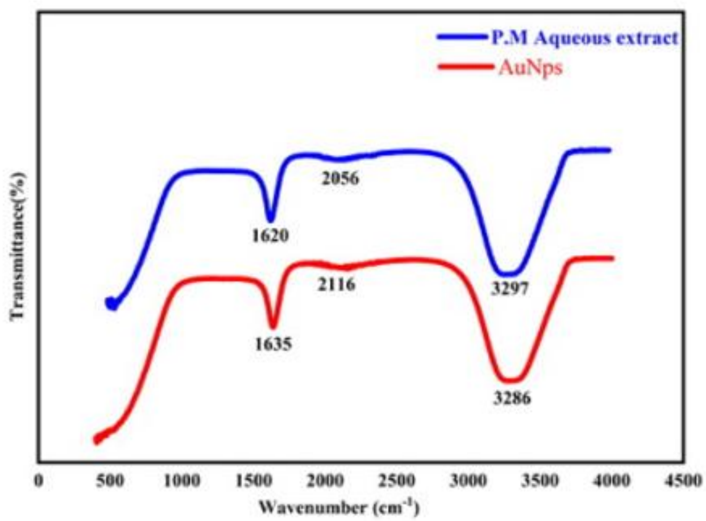


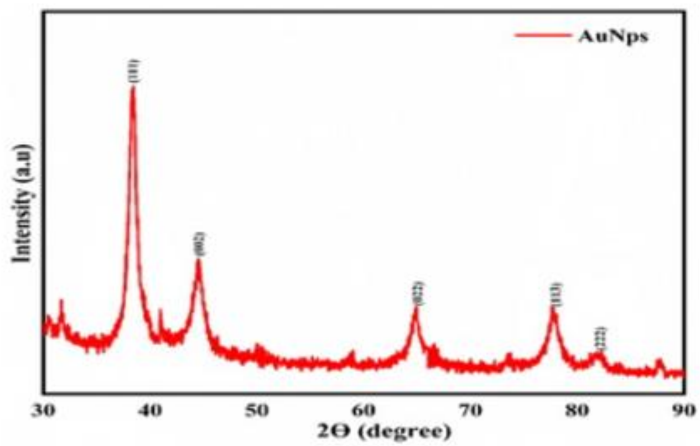
Figure 2. FTIR Spectrum of biosynthesized gold nanoparticles and aqueous extract of *Senecio rowleyanus*



Powder diffraction using X-rays

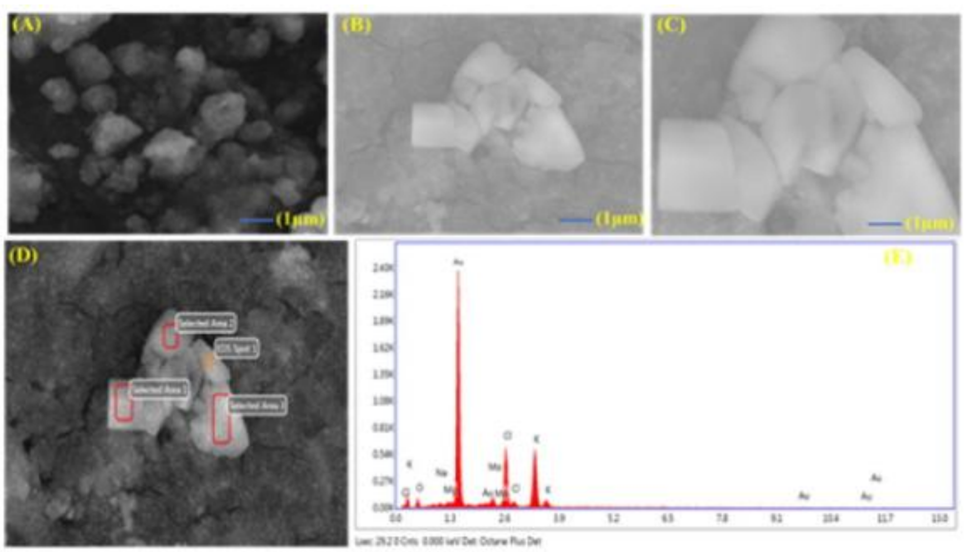
The X-ray diffraction analysis verified the Crystallite size, structure, and phase purity of the synthesized gold nanoparticles. The XRD structure of the gold nanoparticles that were synthesized is shown in Figure 3. In their X-ray diffraction structure, gold nanoparticles synthesized using a water extract of *Senecio rowleyanus* had significant peaks in the "2 θ range at 38.089, 44.256, 64.379, 77.312, and 81.412". The crystalline cubic arrangement of nanogold is associated with certain peaks, including those in the (1 1 1), (0 0 2), (0 2 2), (1 1 3), or (2 2 2) planes, as well as (JCPDS:98-006-2677).

Figure 3. XRD Pattern of synthesized gold nanoparticle from the aqueous extract of *Senecio rowleyanus*



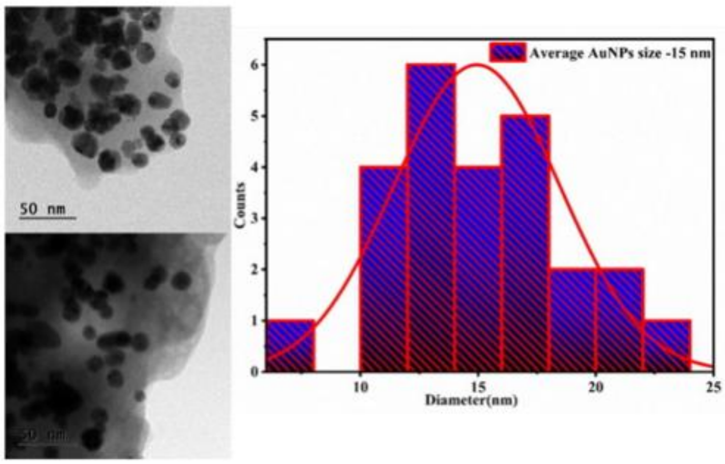
Microscopic image analysis: The structure and form of photosynthesised gold nanoparticles may be observed via scanning electron microscopy (SEM). Triangular and arranged in a cube-like pattern, the resultant gold nanoparticles display obvious aggregation blooms and flaws. Researchers may be able to deduce the elemental distribution of the material from an analysis of the EDAX spectra (Figure 4). Gold nanoparticles are one of the distinguishing characteristics.

Figure 4. SEM micrographs and EDAX Spectrum of biosynthesized gold nanoparticles



"High resolution transmission electron microscope (HR-TEM)": HR-TEM examines the size and structural shape of biosynthesised gold nanoparticles. Figure 5 displays the size and composition of the particles. The median size of the nanoparticles was 15 nm, and the vast majority of them were spherical. Through a process of bio-reduction, the phytochemicals contained in *Senecio rowleyanus* can create gold nanoparticles.

Figure 5. HR-TEM Picture and distribution curve of biosynthesized gold nanoparticles



Antimicrobial activity: Using the agar diffusion well test, researcher could determine if the synthesized gold nanoparticles have antibacterial properties. After twelve hours of development, 100 microliters of each nanoparticle were added to agar. Figure 6 shows that the β-lactam antibiotic was used as a positive control. Following incubation, the region around the well was measured. This led researchers to speculate that plant-regulated nanoparticles could have antimicrobial properties (Table 1).

Figure 6. Antimicrobial activity of biosynthesized gold nanoparticles against *Staphylococcus aureus* (ATCC-25923); *Streptococcus pneumoniae* (ATCC-49619); *Pseudomonas aeruginosa* (ATCC-10231), *Escherichia coli* (ATCC-11229). Zone of A – control, Zone of B – bacteria.

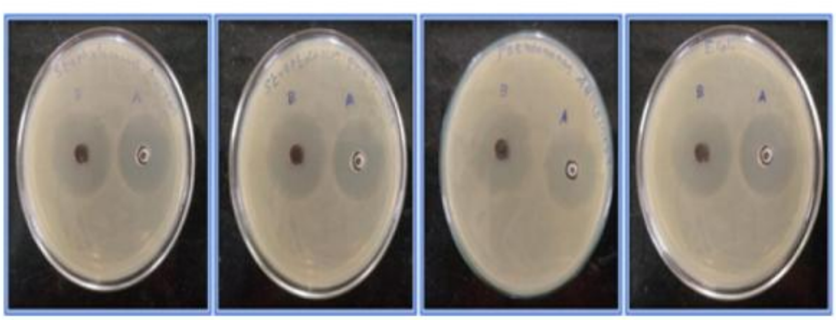


Table 1: Shows the antibacterial activity of biosynthesized gold nanoparticles.

S.NO	Name of the microorganisms	Zone of inhibition	
		Gold nanoparticles	Control
1.	*Staphylococcus aureus (ATCC-25923)*	4.9mm	4.5mm
2.	*Pseudomonas aeruginosa (ATCC-10231)*	5.6mm	5.2mm
3.	*Streptococcus pneumoniae (ATCC-49619)*	6.2mm	5.8mm
4.	*Escherichia coli (ATCC-11229)*	6.6mm	6.2mm

Anti-fungal activity: To test if *S. rowleyanus's* gold nanoparticle was effective against fungi, the following procedures were conducted. After the SDA had been sterilized, it was transferred to a fresh Petri dish. Once the medium had hardened, 8 mm diameter holes were made in the agar plates using sterile gel puncture. The wells were supplemented with 40 microliters of a 2 mg/l gold nanoparticle solution and 4 mg/l concentrations. Each well was injected with the fungal discs in an inverted arrangement. Next, the plates were incubated at a temperature of 28 °C for a period of 70-94 hours. Amphotercin B was administered to the control group. The percentage of growth inhibition was determined by comparing the fungal colony diameter after incubation at 28 °C to the control fungal diameter. The antifungal investigation was conducted using triplicate analysis. The following formula was used to ascertain the percentage of growth inhibition:

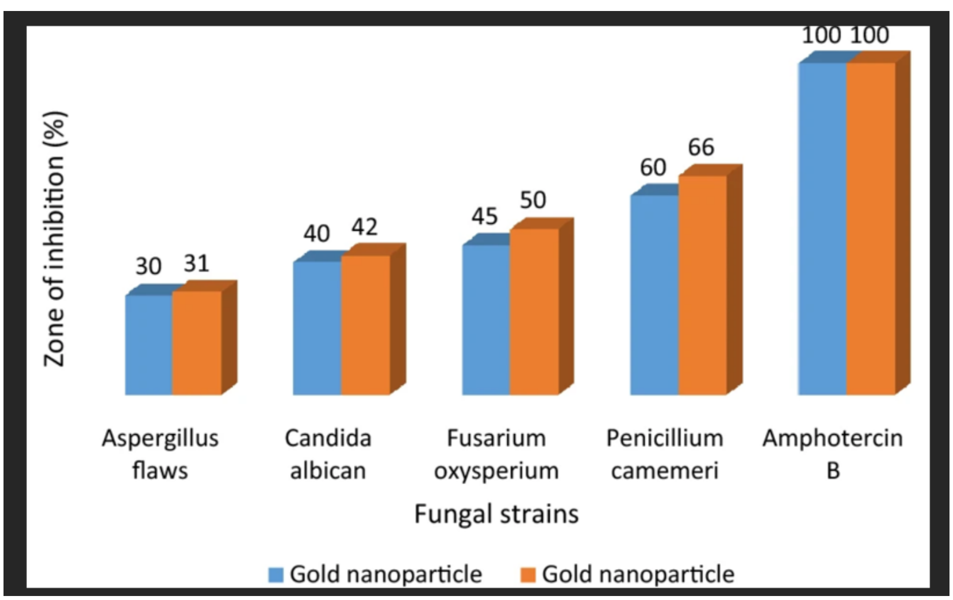
Table 2. Fungal species

Term	Description
PGI	Percent growth inhibition
FDC	Fungal colony diameter in control
FDT	Fungal colony diameter in treatment

Term	Description
Formula	PGI = (FDC − FDT) / FDC × 100

Anti-fungal investigation of gold nanoparticles: Regarding the fungal species mentioned in Table 2, Figure 7 shows that the synthesized gold nanoparticle was effective against "Aspergillus defects, *Candida albican*, *Fusarium oxysperium*, and *Penicillium camemeri*." The zone of inhibition against Aspergillus defects was 30% at a level of 2 mg/l, and 66% against *Penicillium camemeri* at a concentration of 4 mg/l for the gold nanoparticles. The test fungus is more effectively inhibited by increasing the concentration of gold nanoparticles. The selected pathogenic fungi for humans were "Aspergillus flaws, Candida albicans, *Fusarium oxysperium*, and *Penicillium camemeri*" in descending order of the enhanced effectiveness of the synthesized gold nanoparticle. The antifungal assessment of the synthesized gold nanoparticles from *S. rowleyanus* leaves shown notable activity, in line with previous studies on the antifungal activities of gold nanoparticles from other plants against many pathogenic human fungus.

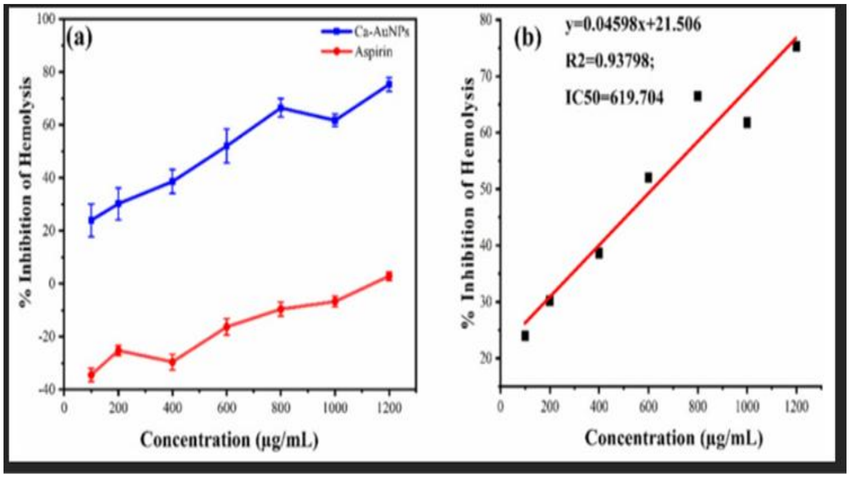
Figure 7. Antifungal activity of synthesized gold nanoparticle against selected fungal strains



Anti Inflammatory activity: Researchers examined the anti-inflammatory effects of AuNPs using a membrane stabilization test that is based on the suppression of heat-induced hemolysis assay. For this experiment, EDTA tubes were used to preserve human blood samples collected from healthy persons. The packed RBCs were washed using centrifugation three times with saline (0.85% NaCl) after 15 minutes of centrifugation of the blood sample at 3000 rpm. Based on the measured blood volume, an optimal saline concentration of 10% (v/v) was prepared. To investigate the anti-inflammatory effect, the heat-induced hemolytic test was used. Various amounts of AuNPs, ranging from 100 to 1200 µg/mL, were added to a 10% v/v solution of red blood cells. A blank was created by adding aspirin and a control was made by substituting saline for the test sample. Each of these reaction tubes was heated to 56 °C in a water bath for 30 minutes. The reaction tubes may be separated at 2500 rpm for 5 minutes after cooling them with running water after incubation. The supernatant was collected to assess the absorbance at 560 nm. Eq. 2 was used to measure the percentage of inhibition of hemolysis after the experiment was repeated three times:

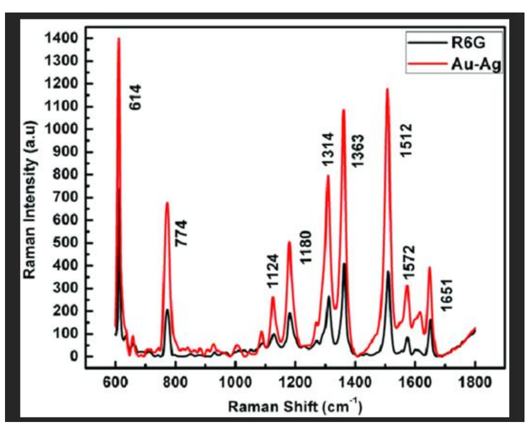
Inflammation is the usual outcome of protein denaturation. Oxidation and inflammation are complementary processes because free radicals, which cause cell damage, also generate inflammation. Red blood cell membrane stabilization and hemolysis suppression are known to occur in a dose-dependent way with salicylic acid and anti-inflammatory medications. The stabilization of the erythrocyte membrane by nanoparticles is believed to be a sign of the stabilization of the lysosomal membrane, as the outermost layer is thought of as a lysosomal membrane mimic. Synthesized AuNPs employing chlorogenic acid (polyphenol) had less toxicity and better anti-inflammatory efficacy than chlorogenic acid alone. The eco-friendly nanoparticles supposedly prevented NF-kB translocation, which lowered levels of inflammatory cytokines and inflammation-related genes. This study tested the hypothesis that AuNPs had anti-inflammatory characteristics by measuring their ability to inhibit heat-induced hemolysis. The % inhibition of hemolysis of AuNPs and aspirin was calculated using Equation 2. Figure 8 (a) shows that aspirin was used as the reference medicine in this study. At a dosage of 1200 µg/mL, it decreased hemolysis by 2.9%. On the other hand, the suppression of hemolysis was dose dependent for AuNPs in the concentration range of 100-1200 µg/mL. A concentration of 1200 µg/mL of AuNPs resulted in a 75.25 percent suppression of hemolysis, as shown in Figure 8 (b). The IC-50 value was 619.704 µg/mL. It is believed that AuNPs may inhibit hemolysis by changing the cell surface-to-volume ratio, but the precise mechanism by which they achieve this is yet unknown. Cell size and the interplay of membrane proteins might undergo changes as a consequence. In addition to inflaming and damaging tissues, AuNPs may also inhibit the release of neutrophil lysosomal materials (including proteases and bactericidal enzymes) at the site of injury.

Figure 8. Anti-inflammatory activities of AuNPs and Aspirin. Effect on % inhibition of hemolysis of AuNPs and Aspirin in the concentration range 100–1200 µg/mL (a), and the standard line regression graph showing correlation between different concentrations of AuNPs and % inhibition of hemolysis.



Raman Spectroscopy: The non-destructive Raman Spectroscopy method allows for a high-level study of chemical structures, molecular interactions, crystallinity, phase, and polymorphism. The interaction between light and the chemical bonds of a material is the primary component. The Raman technique is based on the scattering of light off of molecules by use of an intense laser beam. Most of the scattered light has the same color or wavelength as the laser's source, and so, it doesn't tell us anything, according to Rayleigh scattering. However, depending on the chemical makeup of the analyte, a very small percentage of the light—approximately 0.0000001%—is scattered at different wavelengths (or colors)—a process called Raman Scatter. A Raman spectrum shows the scattered Raman light at various wavelengths as peaks, and the peaks' positions and intensities. The peaks stand for the vibrations of different molecular bonds. These may be single bonds, such as C-C or C=C, or clusters of bonds, such as the lattice mode, vibrations of a polymer chain, or the breathing mode of a benzene ring.

Figure 9. Raman spectrum of using gold nanoparticles.



DISCUSSION

Gold nanoparticles are easily identifiable by the appearance of an absorption band at wavelengths ranging from 500 to 600 nm. Because the excitation mode of the surface plasmons varies as the nanoparticles increase in size, AuNPs exhibit a distinctive absorbance band. When light waves pass through metal nanoparticles, surface plasmon resonance (SPR) absorption occurs because the electrons in these particles oscillate simultaneously. Nanogold displays surface plasmon resonance (SPR) bands ranging from 530 to 550 nanometres, according to experiments. *Senecio rowleyanus* had an SPR peak at around 540-560 nm. A *Senecio rowleyanus* extract in water was shown to bio-reduce Au ions to AuNPs. A rapid and effective biotransformation into NPs from metal ions was carried out.

The stretching vibrations of OH and NH groups in carbohydrates and proteins might be a reason for bio-reduction, since they produce a noticeable band at 3297 cm^{-1}. Studies using Fourier transform infrared spectroscopy have shown that phytochemicals are the primary agents in the reduction of gold ions. It follows that other phytochemicals are responsible for lowering gold ions, since other investigations have also shown comparable FTIR vibrations. Similar XRD research may have been conducted on other plant-mediated gold nanoparticle production techniques. The crystals' preferred orientation in AuNPs biosynthesised from *Senecio rowleyanus* was determined by the highest intense peak produced by the (1 1 1) plane. So, it was determined that plants produce their own unique kind of nanoparticles, namely gold nanoparticles. The present results confirm the dissemination of similar gold nanoparticles that have been documented before, which were generated by phytosynthesis. A study using HR-TEM on *Senecio rowleyanus* found nanoparticles that were smaller and more uniform in shape than previously seen; similar structures were also found in TEM investigations conducted by other researchers.

It is critical to combat these microorganisms with active treatment techniques since this antimicrobial test uses clinically significant bacteria that cause serious illnesses. Bacteria with a thick peptidoglycan layer are unable to absorb lipophilic substances; bacteria with a thin lipopolysaccharide coating are Gram-negative. Nevertheless, the specific mechanism by which antimicrobials exert their effects remains unknown. The conventional wisdom is that nanoparticles kill cells by altering their structure in the cell wall membrane, which in turn makes the membrane less permeable. The powerful antibacterial effects of the gold nanoparticles mediated by *Senecio rowleyanus* are evident since the nanoparticles produce free radicals. These radicals have the potential to interact with DNA, lipids, and proteins. It was also shown that plant-derived gold nanoparticles had enhanced antibacterial properties.

CONCLUSION

When compared to alternative synthesis techniques, the waste-to-riches concept's approach is more advantageous to the environment, requires less raw materials, and is easy to implement at a low cost. The *Senecio rowleyanus* plant has been extensively characterized and shown to be an effective source of gold nanoparticles. These particles are stable enough for application in biomedicine, with a hydrodynamic average particle diameter of 65 nm. The antibacterial effect of gold nanoparticles synthesized by *Senecio rowleyanus* was shown. Potentially useful in the nano biopharma and biomedical sectors, synthetic AuNPs made from *Senecio rowleyanus* extract have great therapeutic anti-microbial characteristics and allow for excellent drug administration.

LIMITATION OF THE STUDY

The potential for changes in the composition of the extracts used to generate the gold nanoparticles from *Senecio rowleyanus*, which would impact their antibacterial capabilities, is one of the limitations of this line of inquiry. There may be limitations on the scale of laboratory synthesis, which might impact reproducibility. It is also unclear how exactly nanoparticles combat the various germs. Because this study only examined a tiny fraction of their microorganism database, its findings may not apply to the wider public.

REFERENCES

1. Alodaini, H. A., & Ranganathan, V. (2022). Anti-microbial and anti-cancer activity of gold nanoparticles phytofabricated using clerodin enriched Clerodendrum ethanolic leaf extract. Journal of King Saud University–Science, 34(4), 101989.
2. Alsareii, S. A., Alamri, A. M., Alwadai, H. H. A., Mahnashi, M. H., Shaikh, I. A., Shettar, A. K., & Mannasaheb, B. A. (2025). Cassia sericea leaf extract for eco-friendly synthesis of silver and gold nanoparticles with boosted wound healing and antimicrobial potential. Arabian Journal for Science and Engineering, 1–20.
3. Aly Khalil, A. M., Saied, E., Mekky, A. E., Saleh, A. M., Al Zoubi, O. M., & Hashem, A. H. (2024). Green biosynthesis of bimetallic selenium–gold nanoparticles using Pluchea indica leaves and their biological applications. Frontiers in Bioengineering and Biotechnology, 11, 1294170.
4. Asker, A. Y. M., & Al Haidar, A. H. M. (2024). Green synthesis of gold nanoparticles using Pelargonium graveolens leaf extract: Characterization and anti-microbial properties (An in-vitro study). F1000Research, 13, 572.

5. Chappalathottil Sethumadhavan, S., & Pottail, L. (2019). Acorus calamus gold nanoparticles as enhanced antimicrobial agents for transdermal patches. Micro & Nano Letters, 14(4), 367–372.
6. Chowdhury, M. A., Hossain, N., Kchaou, M., Nandee, R., Shuvho, M. B. A., & Sultana, S. (2021). Scope of eco-friendly nanoparticles for anti-microbial activity. Current Research in Green and Sustainable Chemistry, 4, 100198.
7. Dash, S. S., Sen, I. K., & Dash, S. K. (2022). A review on the plant extract mediated green syntheses of gold nanoparticles and its anti-microbial, anti-cancer and catalytic applications. International Nano Letters, 12(1), 47–66.
8. Hatipoğlu, A. (2021). Rapid green synthesis of gold nanoparticles: Synthesis, characterization, and antimicrobial activities. Progress in Nutrition, 23, e2021242.
9. Hlapisi, N., Songca, S. P., & Ajibade, P. A. (2024). Morphological and structural properties of silver/chlorargyrite nanoparticles prepared using Senecio madagascariensis leaf extract and interaction studies with bovine serum albumin. MRS Advances, 9(10), 830–836.
10. Keskin, C., Atalar, M. N., Firat Baran, M., & Baran, A. (2021). Environmentally friendly rapid synthesis of gold nanoparticles from Artemisia absinthium plant extract and application of antimicrobial activities. Journal of the Institute of Science and Technology, 11(1), 365–375.
11. Pawar, C. A., Sharma, A. K., Prasad, N. R., Suryawanshi, S. S., Nazeruddin, G. M., Shaikh, V. S., ... & Shaikh, Y. I. (2022). A comparative study on anti-microbial efficacies of biologically synthesized nano gold using Bos taurus indicus urine with pharmaceutical drug sample. Current Research in Green and Sustainable Chemistry, 5, 100311.
12. Sekar, V., Al-Ansari, M. M., Narenkumar, J., Al-Humaid, L., Arunkumar, P., & Santhanam, A. (2022). Synthesis of gold nanoparticles (AuNPs) with improved anti-diabetic, antioxidant and anti-microbial activity from Physalis minima. Journal of King Saud University–Science, 34(6), 102197.