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BIOLOGICAL ACTIVITY OF SILVER NANOPARTICLES USING Amargo (Quassia Amara) EXTRACTS

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ABSTRACT
Copper nanoparticles (CuNPs) have gained considerable attention for their potent biological activities, including antimicrobial, antioxidant, and anticancer properties. The use of plant extracts for the green synthesis of nanoparticles offers an eco-friendly and cost-effective alternative to conventional methods. Quassia amara (Amargo), a medicinal plant known for its bioactive compounds such as quassinoids and flavonoids, has potential as a reducing and stabilizing agent in nanoparticle synthesis. This study explores the biological activity of CuNPs synthesized using Quassia amara extract.
Methods:*Silver nanoparticles were synthesized by mixing aqueous Quassia amara leaf extract with copper sulfate solution under controlled conditions. The synthesis was confirmed by color change and further characterized using UV-Vis spectroscopy, FTIR, XRD, and TEM for determining structural, morphological, and chemical properties. The biological activities of the CuNPs, including antimicrobial (against E. coli, S. aureus, C. albicans), antioxidant (DPPH assay), and cytotoxicity (MTT assay on cancer cell lines), were evaluated.*
Results:*The synthesized CuNPs exhibited a characteristic absorption peak at ~570 nm in UV-Vis spectroscopy, confirming nanoparticle formation. FTIR analysis showed functional groups from plant extract involved in stabilization, and TEM images revealed spherical nanoparticles with an average size of 15–30 nm. The CuNPs demonstrated significant antimicrobial activity, especially against Staphylococcus aureus, with a clear zone of inhibition. DPPH assay confirmed strong antioxidant potential, and cytotoxicity tests showed dose-dependent inhibition of cancer cell viability.*
Conclusion:*Silver nanoparticles synthesized using Quassia amara extract possess promising biological properties, making them suitable candidates for biomedical and pharmaceutical applications. This green synthesis approach provides a sustainable method for producing functional nanomaterials with therapeutic potential.*
KEYWORDS: *Metallic nanoparticles, Anti-microbial activity, Microbial pathogens.*

INTRODUCTION:

Numerous fields, including environmental science, agriculture, and medicine, have found revolutionary uses for nanotechnology. The exceptional biological activities of silver nanoparticles (AgNPs), such as their antibacterial, antioxidant, anti-inflammatory, and anticancer effects, as well as their distinctive physicochemical characteristics, have garnered significant interest among nanomaterials. There have been environmental and health concerns raised by the use of toxic chemicals and high energy consumption in traditional methods of synthesising AgNPs.
A sustainable, low-cost, and environmentally friendly solution to these problems is green synthesis, which makes use of plant extracts. Natural reducing and capping agents in nanoparticle synthesis can be found in medicinal plants' abundance of bioactive compounds like tannins, alkaloids, phenolics, terpenoids, and flavonoids.
Amargo, whose scientific name is Quassia amara, is a tropical medicinal plant with anti-inflammatory, anti-parasitic, and antimicrobial characteristics. An ideal material for environmentally friendly nanoparticle synthesis, it is abundant in quassinoids and other phytochemicals with potent biological activities.
The purpose of this research is to utilise Quassia amara leaf extract to create silver nanoparticles and then test their biological effects. Through the integration of Q. amara's medicinal qualities with AgNPs' extensive bioactivity, this study delves into an innovative, environmentally friendly nanomaterial that could find use in pharmaceuticals, biomedicine, and environmental health (Arif et al.,2022).

Background of the study:

Quassia amara, commonly known as Amargo, is a small tropical tree or shrub native to Central and South America, particularly found in countries like Brazil, Suriname, and Costa Rica. Belonging to the Simaroubaceae family, the plant has been traditionally used in herbal medicine for centuries due to its broad spectrum of pharmacological properties. Its common name "Amargo," meaning "bitter" in Spanish, reflects its intensely bitter taste, which is primarily due to its high content of quassinoids (Bantho et al.,2023).

The plant contains several biologically active compounds, including quassinoids (such as quassin and neoquassin), alkaloids, flavonoids, and phenolic compounds. These phytochemicals contribute to its well-documented medicinal properties such as antimicrobial, anti-inflammatory, antimalarial, anthelmintic, insecticidal, and anti-cancer activities. In traditional medicine, Q. amara has been used to treat digestive disorders, fever, intestinal worms, skin infections, and liver conditions. Modern pharmacological studies have confirmed many of these traditional uses and have shown that Quassia amara exhibits strong antimicrobial and cytotoxic effects, making it a promising source for bioactive compounds in pharmaceutical and biomedical applications. These properties also make it a suitable candidate for green synthesis of nanoparticles, where its phytochemicals can act as natural reducing and stabilizing agents in the formation of metal nanoparticles (Manoj et al.,2024).

Given its medicinal richness and eco-friendly nature, Quassia amara offers significant potential in nanotechnology, particularly in the biosynthesis of silver nanoparticles with enhanced biological functionality.

Nanotechnology has become a rapidly evolving field with extensive applications in various scientific domains, particularly in biomedical research. Among the different metal-based nanoparticles, silver nanoparticles (AgNPs) are the most widely studied due to their excellent biological activities, including antimicrobial, antifungal, antioxidant, anti-inflammatory, and anticancer properties. These properties are primarily attributed to their high surface area-to-volume ratio and the ability to interact with microbial membranes and intracellular components. Conventional chemical and physical methods used for synthesizing AgNPs often involve hazardous reagents, high energy input, and generate toxic by-products, which limit their applicability in environmental and biomedical fields. In response, green synthesis methods have gained attention for being safer, more sustainable, and environmentally benign. Among green synthesis methods, the use of plant extracts has proven to be an effective and eco-friendly approach due to the presence of naturally occurring phytochemicals that serve as both reducing and stabilizing agents during nanoparticle formation (Manoj et al.,2023).

Quassia amara, commonly known as Amargo, is a medicinal plant native to tropical America and widely used in traditional medicine for its anti-parasitic, antimicrobial, anti-inflammatory, and digestive properties. It contains potent bioactive compounds such as quassinoids, alkaloids, saponins, and flavonoids, which may enhance the biological potential of silver nanoparticles when used in their synthesis. The combination of Q. amara's bioactive constituents with the therapeutic capabilities of AgNPs could result in a powerful nanomaterial with enhanced biological effects. This study, therefore, focuses on the green synthesis of silver nanoparticles using Quassia amara extract and evaluates their biological activities. Understanding this synergy may contribute to the development of novel, plant-based nanomaterials for biomedical and pharmaceutical applications (Frontiers,2022).

Purpose of the study:

The purpose of this study is to explore the green synthesis of silver nanoparticles (AgNPs) using Quassia amara (Amargo) plant extracts and to evaluate their biological activities. Specifically, the study aims to investigate the antimicrobial, antioxidant, and cytotoxic properties of the synthesized AgNPs. By utilizing the phytochemical constituents of Q. amara as natural reducing and stabilizing agents, this research seeks to develop an eco-friendly, cost-effective, and sustainable method for producing biologically active silver nanoparticles.

This study also intends to assess the synergistic effects between the therapeutic properties of Q. amara and the known bioactivities of AgNPs, thereby contributing to the advancement of plant-based nanotechnology for potential applications in pharmaceuticals, healthcare, and environmental science.

LITERATURE REVIEW:

Silver nanoparticles (AgNPs) have been extensively studied for their broad-spectrum biological activities and their growing relevance in nanomedicine, environmental science, and biotechnology. Numerous studies have demonstrated that AgNPs exhibit potent antimicrobial, antioxidant, anti-inflammatory, and anticancer properties due to their high surface-area-to-volume ratio and unique physicochemical characteristics. The biological activity of AgNPs largely depends on their size, shape, surface charge, and method of synthesis (Bamgbose et al.,2021).

In recent years, green synthesis of nanoparticles using plant extracts has emerged as a promising and environmentally friendly approach, offering several advantages over conventional chemical and physical methods. Plant-mediated synthesis avoids the use of toxic chemicals and high energy inputs and instead relies on naturally occurring phytochemicals in plants, such as flavonoids, alkaloids, terpenoids, phenolics, and saponins, which act as reducing and capping agents. Several plants, including Azadirachta indica, Ocimum sanctum, and Camellia sinensis, have been successfully used in the green synthesis of AgNPs. Quassia amara, commonly known as Amargo, is a tropical plant traditionally used for its medicinal properties, particularly for treating fever, digestive disorders, parasitic infections, and skin conditions. The plant is rich in quassinoids, especially quassin and neoquassin, as well as other phytochemicals that contribute to its pharmacological activities. Studies have confirmed that Q. amara possesses significant antimicrobial, antioxidant, insecticidal, and antitumor properties. Although Q. amara is widely recognized in herbal medicine, its potential in nanotechnology is still underexplored. However, similar plants with comparable phytochemical profiles have been used in nanoparticle synthesis and have shown enhanced biological effects. For example, plant extracts rich in quassinoids and polyphenols have been found to enhance the stability and bioactivity of synthesized AgNPs (Javaid et al.,2023).

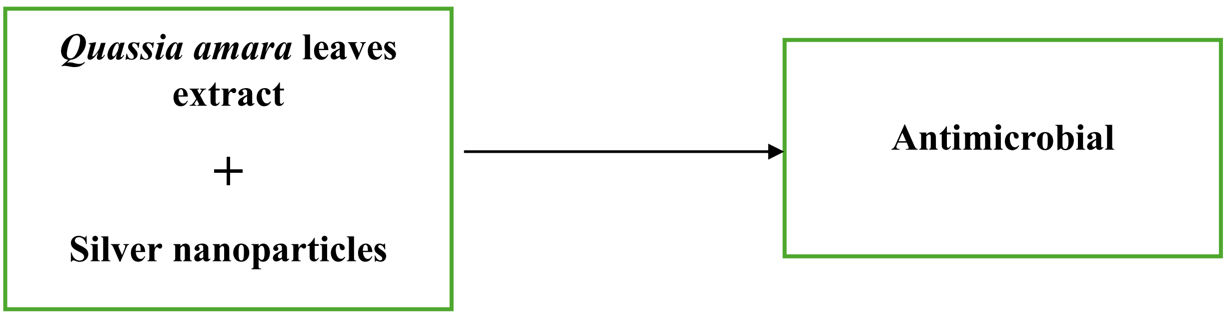
Recent investigations into the biological activity of green-synthesized AgNPs have revealed strong antibacterial effects against both Gram-positive and Gram-negative bacteria, as well as antifungal and antiviral properties. Furthermore, AgNPs synthesized using plant extracts have demonstrated dose-dependent antioxidant activity through mechanisms such as free radical scavenging. Cytotoxic effects of AgNPs on cancer cells have also been reported, suggesting their potential role in cancer therapy. Despite these promising findings, studies focusing specifically on the use of Quassia amara in the biosynthesis of silver nanoparticles remain limited. Therefore, there is a clear need to explore this novel approach to nanoparticle synthesis, with the aim of combining the medicinal value of Q. amara with the potent bioactivity of AgNPs. This study contributes to the existing body of literature by evaluating the biosynthesis, characterization, and biological activity of silver nanoparticles synthesized using Quassia amara extracts, and aims to support the development of sustainable nanomaterials for biomedical applications (Rajak et al.,2023).

Research questions:

1. How effective is Quassia amara extract in the green synthesis of silver nanoparticles in terms of stability, size, and morphology?
2. What are the antimicrobial properties of silver nanoparticles synthesized using Quassia amara extract against selected bacterial and fungal strains?
3. Do the biosynthesized silver nanoparticles exhibit significant antioxidant activity compared to the plant extract alone?
4. What is the cytotoxic or anticancer potential of the silver nanoparticles synthesized using Quassia amara extract on selected human cancer cell lines?

RESEARCH METHODOLOGY:

Conceptual Framework:



Hypothesis:

The combination of Quassia amara extract with silver nanoparticles significantly enhances antimicrobial properties due to the synergistic interaction between the bioactive plant compounds and the intrinsic antimicrobial activity of silver. Quassia amara is known to contain phytochemicals such as quassinoids, flavonoids, and alkaloids, which have natural antimicrobial effects. These compounds can interfere with microbial cell walls, inhibit metabolic processes, and disrupt microbial enzyme activity. When used in the green synthesis of silver nanoparticles, the plant extract not only facilitates the reduction and stabilization of the nanoparticles but also contributes additional antimicrobial functionality. Silver nanoparticles are already well recognized for their ability to attach to microbial membranes, penetrate cells, generate reactive oxygen species, and inhibit DNA replication. The presence of Q. amara phytochemicals on the nanoparticle surface enhances these effects, resulting in greater microbial inhibition. This synergistic relationship leads to more potent, stable, and broad-spectrum antimicrobial agents compared to either Quassia amara extract or silver nanoparticles used individually. The result is a nanomaterial with significantly improved antibacterial and antifungal activity, making it highly suitable for medical, pharmaceutical, and environmental applications (Okka et al.,2022).

On the basis of the above discussion the researcher formulated the following hypothesis, which will investigate the relationship between Antimicrobial properties and Quassia amara extract combined with silver nanoparticles.

H_{01}: "There is no significant relationship between Antimicrobial properties and Quassia amara extract combined with silver nanoparticles."

H_1 : "There is a significant relationship between Antimicrobial properties and Quassia amara extract combined with silver nanoparticles."

Research design:

Collection: Within the scope of the research project, the substances that were utilised were silver nitrate of laboratory quality and extract of Quassia amara. The experiment took advantage of a wide range of agents and other compounds that were of laboratory quality.

Microorganisms Used:

Microbiology Postgraduate laboratory at the University was the source of the bacteria that were isolated. These bacteria included Staphylococcus aureus, Escherichia coli, Bacillus subtilis, and Pseudomonas aeruginosa. It was necessary to sub-culture the bacteria multiple times in order to obtain pure cultures.

Active constituents and synthesis mechanisms of silver nanoparticles:

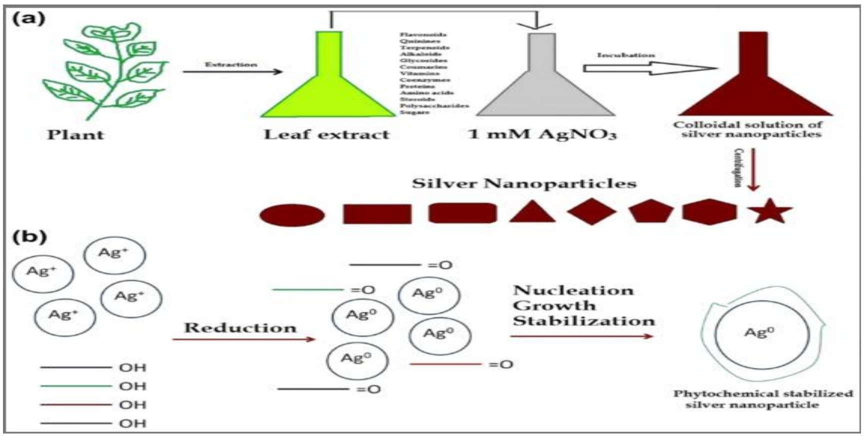
Quassia amara contains a rich profile of bioactive phytochemicals that actively contribute to the green synthesis of silver nanoparticles. These compounds serve both as reducing and stabilizing agents during the nanoparticle formation process. Among the most significant constituents are quassinoids, flavonoids, alkaloids, phenolic compounds, and tannins. These molecules possess functional groups such as hydroxyl and carbonyl groups, which are capable of donating electrons to silver ions (Ag^+), thereby reducing them to elemental silver (Ag^0). In the synthesis process, when an aqueous extract of Quassia amara is added to a silver nitrate ($AgNO_3$) solution, the color change of the mixture usually indicates the formation of silver nanoparticles. This visual transformation is the result of surface plasmon resonance, a property characteristic of metallic nanoparticles. The phytochemicals in the extract not only reduce the silver ions but also surround the newly formed nanoparticles, acting as capping agents that prevent agglomeration and provide surface stability (Haridas et al.,2022).

The mechanism typically involves three stages: reduction, nucleation, and stabilization. Initially, the bioactive compounds reduce Ag^+ to Ag^0. This is followed by the nucleation of silver atoms to form small clusters, which then grow into nanoparticles. Finally, the phytochemicals bind to the surface of the particles, stabilizing them and controlling their shape and size. The capping layer of plant-derived molecules also imparts additional biological functionality to the nanoparticles, enhancing their antimicrobial, antioxidant, and possibly anticancer properties.

Thus, the synthesis of silver nanoparticles using Quassia amara extract is not only a sustainable and eco-friendly approach but also results in the production of biologically active nanoparticles with enhanced therapeutic potential (Omega et al.,2024).

Preparation of silver nanoparticles

"A solution of 5 milliliters of filtered bio leaves and a solution of pure aqueous silver nitrate are combined and agitated for one hour to produce silver nanoparticles from silver nitrate. The solution's color varies from yellow to brownish-yellow to deep brown when Ag+ nanoparticles are reduced to Ag0; the specific shade depends on the investigated factors, such as the concentration of the extract. When the silver nanoparticles become brown, it means the synthesis is complete. Altering the concentration of an extract from Quassia amara extract yields silver nanoparticles.



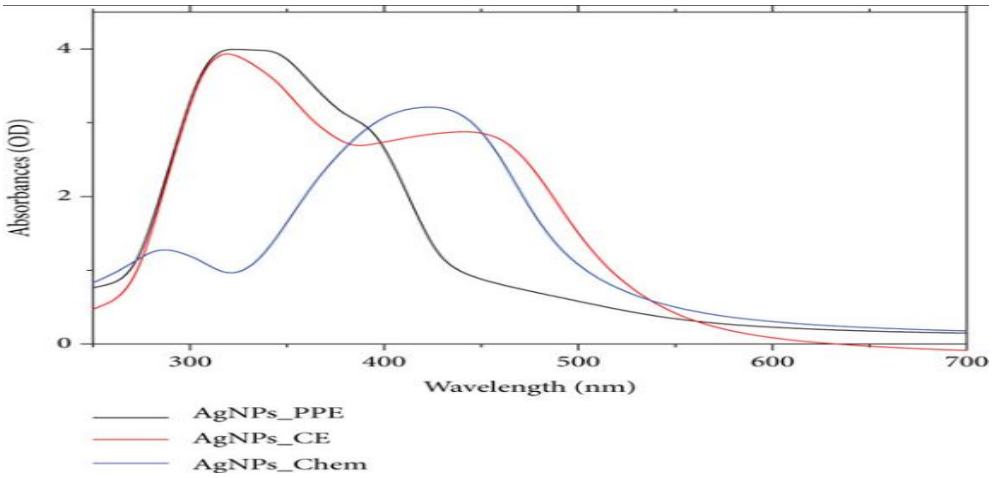
Visible observation

Demonstrates a mixture of silver nanoparticles that were produced from extracts in different volumes, including five millilitres, ten millilitres, fifteen millilitres, twenty millilitres, and twenty-five millilitres. It can be observed that the colour of the reaction mixture shifts after one hour, and this shift is determined by the amount of Quassia amara extract present. The colour of the reaction mixture changes from a light brown to a reddish-brown colour when the concentration of the extract is increased from 5 millilitres to 25 millilitres.

The deepest, darkest shade is achieved with a 15 ml concentration of Quassia amara extract. When the extract concentration drops to 20–25 ml, the hue becomes hardly noticeable, almost like a faint brown. A deeper brown coloration of the reaction mixtures occurred at a Quassia amara extract concentration of 15 ml, indicating an increase in the number of silver nanoparticles. When the concentration of Quassia amara extract goes above 15 ml, the reaction mixtures become a pale brown hue, which means that the number of silver nanoparticles has decreased. Agglomeration of the generated silver nanoparticles occurs at higher concentrations of Quassia amara extract. Aggregating silver nanoparticles reduces their stability. More and more silver nanoparticles are being produced as the reaction time increases exponentially," as shown by the reaction mixes becoming a darker shade of brown.

UV–visible spectral analysis:

The ultraviolet-visible absorption spectrum of silver nanoparticles at five different concentrations are displayed here after they have been incubated for a day at room temperature. The concentrations are as follows: 5, 10, 15, 20, and 25 ml respectively. The absorbance band, also known as the surface plasmon resonance band, can be observed at 410, 420, 435, 422, and 418 nm, respectively, for concentrations of 5, 10, 15, 20, and 25 ml of silver nanoparticles that are facilitated by Quassia amara. If the concentration of the Quassia amara extract is 15 millilitres, the SPR peak is 435 nanometres, and if the concentration is 25 millilitres, the peak is 418 nanometres, which is the weakest peak.



UV-visible spectroscopy of zinc nanoparticles of Quassia amara extract

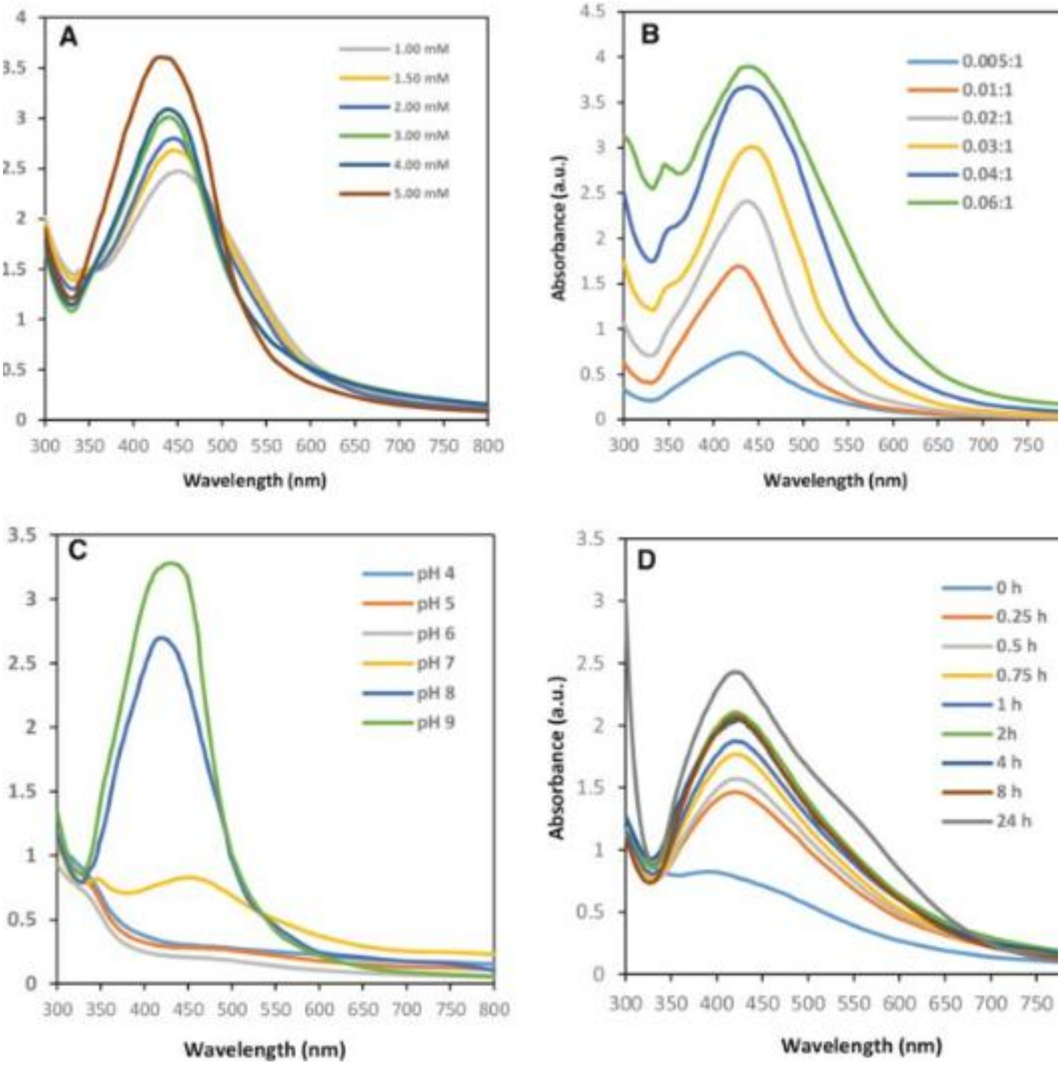
In addition, the red shift takes place as a consequence of an increase in the absorption peak wavelength of the AgNPs. This happens when the intensity of the Quassia amara extract increases from 5 to 15 ml. As can be seen by the red shift, this particular instance illustrates that the typical size of silver nanoparticles is continually growing over the course of time. In addition, a blue shift is observed at concentrations of twenty and twenty-five millilitres of Quassia amara extract. This shift is associated with a decrease in the wavelength at which AgNPs absorb light. This transition to blue highlights the gradual decrease in the average size of the silver nanoparticles that has been occurring over time. The researcher presented the optical band gap value of the Quassia amara extract at each concentration that was tested. It has been observed that the energy band gap decreases and the particle size increases when the total amount of Quassia amara extract decreases from 5 to 15 millilitres. The optical band gap is found to increase at concentrations of 20 and 25 ml of Quassia amara extract, respectively, according to the findings of an XRD examination, which are in agreement with the fact that the increase occurs. Consequently, this proves beyond a reasonable doubt that the nanoparticles of concentrated silver are significantly smaller than the smaller ones (Frontiersin et al.,2022)

Sample	Optical band gap(eV)
5ml	4.9
10ml	4.7
15ml	4.6
20ml	4.7
25ml	4.8

Optical band gap value of silver nanoparticles.

Time dependent UV–visible spectral analysis

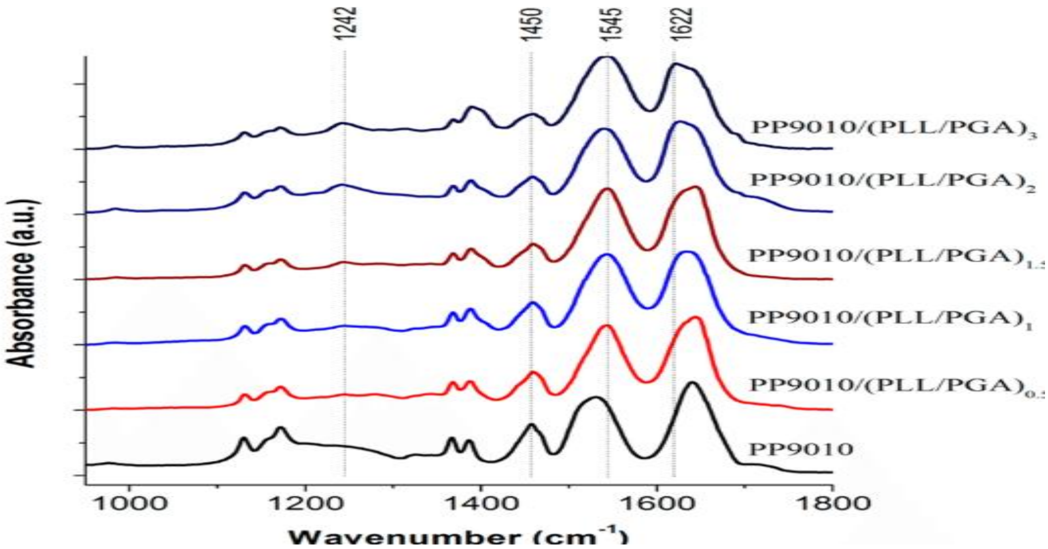
According to the following table, the ultraviolet-visible spectra of silver nanoparticles that were collected from Quassia amara extract at five, ten, fifteen, twenty, and twenty-five millilitres are displayed. Alterations take place in the spectrum over the course of time. The UV-visible spectra of silver nanoparticles are collected at 0, 15, 30, 45, 60, and 24 hours after the reaction has begun. These spectra are collected at three different time intervals. As the reaction mixture is being incubated, the absorbance spectra that include surface resonance demonstrate that there is a consistent increase in the amount of the reactive substance. plasmon resonance, also known as the band. When the reaction time is reduced to zero minutes, the absorption peak intensity decreases. This is due to the fact that there is a reduction in the amount of silver nanoparticles that are produced in the reaction mixture. " This is due to the fact that the duration of the reaction is reduced. As the response time increases from 0 to 60 minutes, the absorption peak strength increases across the board for all dosages of Quassia amara extract. Because of this increase in absorption peak strength, it can be deduced that the combination contains a growing concentration of silver nanoparticles. When the absorption peak "intensity reaches its maximum after twenty-four hours of incubation" from the beginning of the reaction, all of the reaction mixtures have produced silver nanoparticles. This occurs thirty-four hours after the reaction has begun. In light of this, it can be concluded that the reaction as a whole was successful (Arif et al.,2022).



Time dependent UV-visible spectroscopy of zinc nanoparticles using concentration of Quassia amara extract.

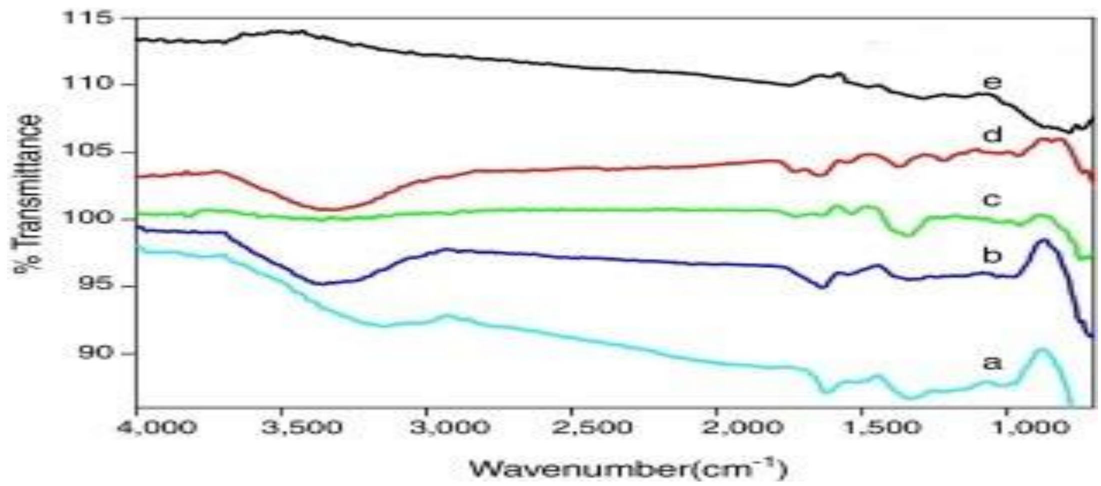
FT-IR analysis:

Spectra of silver nanoparticles in Quassia amara extract can be seen here, shifting over time, at five millilitres, ten millilitres, fifteen millilitres, twenty millilitres, and twenty-five millilitres per millilitre. Additionally, you have the option of collecting the UV-visible spectra of the silver nanoparticles at 0, 15, 30, 45, 60, and 24 hours after the procedure. It is observed that the surface resonance absorbance spectra become more pronounced as the amount of time spent incubating the reaction mixture increases. Plasma's radiation spectrum is described here. Because the absorption peak strength is lower at the zero-minute mark, there are fewer silver nanoparticles extracted from the reaction mixture. This is because the reaction starts at zero minutes. The concentration of silver nanoparticles in the mixture can be determined by observing the increase in the absorption peak intensity for all dosages of Quassia amara extract as the response time increases from 0 to 60 minutes. All of the reaction mixtures have been able to successfully produce silver nanoparticles, as evidenced by the fact that the absorption peak intensity is at its highest at the end of the first day of incubation (Biswas et al.,2020)



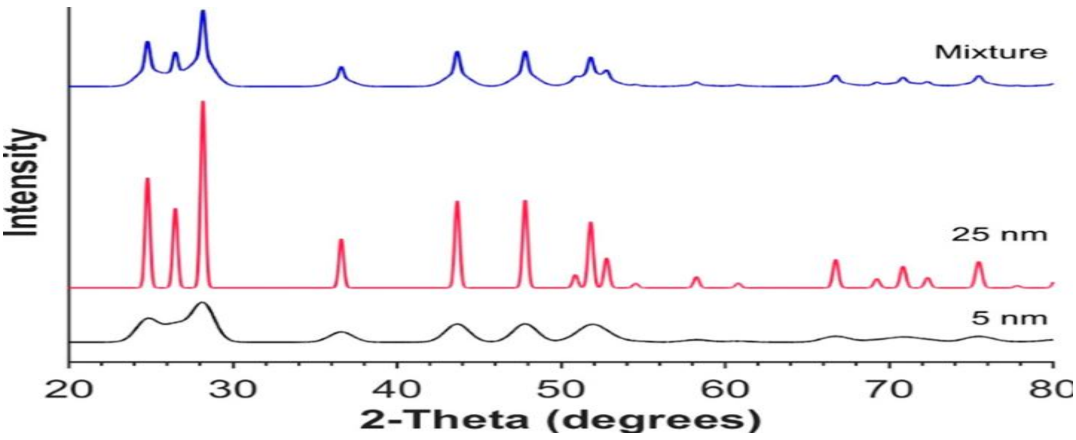
(FT-IR) spectra of Quassia amara extract Extracts

“Shows the FT-IR spectra of AgNPs at different concentrations (5 ml, 10 ml, 15 ml, 20 ml, and 25 ml) that were used to mediate the Quassia amara extract. The usual absorption bands observed in FT-IR spectra are approximately 700-750 cm−1, 950-980 cm−1, 1000-1150 cm−1, 1200-1300 cm−1, 1330-1370 cm−1, 1500-1550 cm−1, 1600-1650 cm−1, and 3100-3400 cm−1. The bands observed at approximately 700-750 cm−1 may be a result of the stretching vibrations of C-Cl alkyl halides, as stated by Khalil et al. (2014). The bending vibrations of alkenes with a double bond C-H group could be the cause of the bands observed at 950-980 cm−1. The absorption band observed between 1000 and 1150 cm−1 could be caused by the stretching vibrations of carboxylic acids. A connection exists between the N-H bend amines and the bands around 1200-1300 cm−1. The C-N stretch amine group could be responsible for the bands observed between 1330 and 1370 cm−1. The bands that encircle 1500-1550 cm−1 indicate nitro compounds with an N-O asymmetric stretch. Scientific investigations have linked the bands observed between 1600 and 1650 MHz to the stretching vibrations of amines, both primary and secondary. The bands observed at 3100-3400 cm−1 could be caused by the stretching of the C-double bonds in carboxylic acids.



Structure analysis using XRD

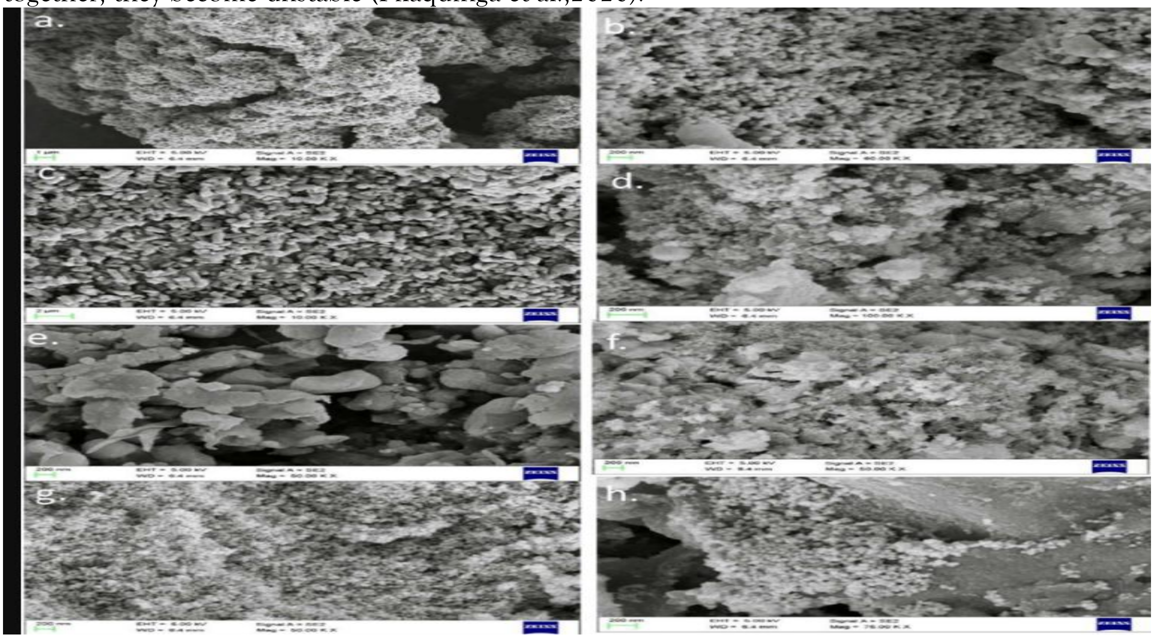
Shows the optical reflectance spectra of several concentrations of Ag nanoparticles bio-synthesised from Quassia amara extract. According to the XRD patterns, bioreducing silver ions generated crystalline silver nanoparticles. Utilising XRD "analysis, one can ascertain the degree of purity, crystallinity, and phase distribution of the resulting silver nanoparticles.



In the 2θ value spectrum, which spans from 30° to 80°, the XRD patterns of silver nanoparticles manifest as five separate peaks. On the cubic face of silver nanoparticles, the standard JCPDS card no. 04-783 for silver indicates the (111), (200), (222), (220), and (311) peaks. The extract may be responsible for the 27° and 32° peaks. One possible explanation for these Bragg's peaks is the capping agent, which served to stabilise the nanoparticles. Using "Debye-Scherrer's equation," one can determine the crystallite sizes of silver nanoparticles by adjusting the amounts of plant extract. A total of 25 millilitres of this extract was used to create silver nanoparticles with average crystallite sizes of 16.1 nm, 16.3 nm, 17.9 nm, 17.8 nm, and 17.7 nm, respectively. As the extract concentration increases from 5 ml to 15 ml, the average particle crystallite size also increases. Concentrations of 20 and 25 ml result in smaller particle crystallites, respectively. The UV-visible spectral analysis may be able to reveal the reduction in particle crystallite size. The produced silver nanoparticles have a crystallite size of 24 nm, which is much smaller than the 28 nm reported by Kokila et al. This shrinkage of the crystallite size improves the characteristics of the silver nanoparticles.

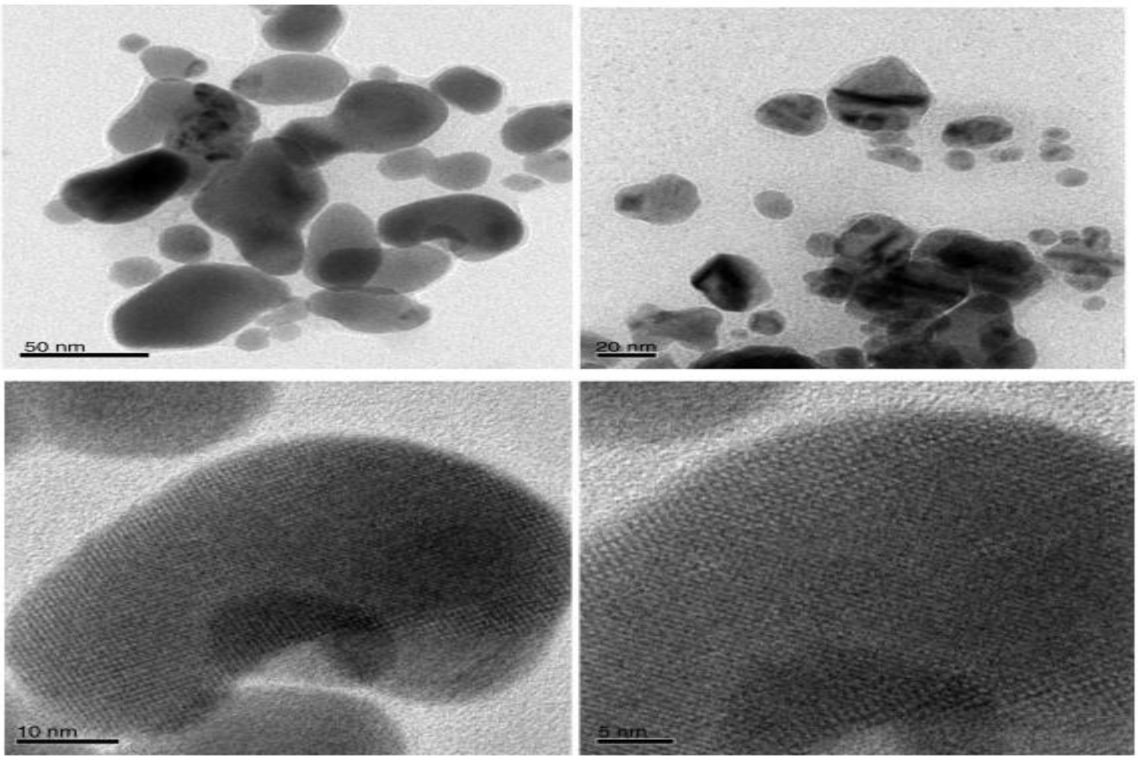
Sem Anaysis

Researchers use scanning electron microscopy (SEM) to study silver nanoparticles' surface morphology and other morphologies. A scanning electron micrograph (SEM) taken at different magnifications shows silver nanoparticles made with extract concentrations of 5, 10, 15, 20, and 25 ml. As the concentration of the extract varies, the size and shape of the spherical silver nanoparticles also change. There are no clumps or uneven particle distribution in 5–15 ml of peel extract. When the extract concentration is more than 15 ml, the particles clump together, as shown by the results. When silver nanoparticles clump together, they become unstable (Pilaquinga et al.,2020).



TEM ANALYSIS

Transmission electron micrographs of silver nanoparticles made from a water-based extract of Quassia amara
is observed. The solution's silver nanoparticles change in size and form as the extract concentration changes. Based on the pictures, it seems that the nanoparticles are mostly round. Additionally, in some areas, there are a few clumped nanoparticles, which might be signs of sedimentation that occurred later on. The typical size of silver nanoparticles ranges from fifteen nanometers to twenty nanometers. The size of the crystallites determined by XRD analysis agrees well “with the findings.



TEM images of zinc nanoparticles using Quassia amara Extracts

Plant Materials Collection and Processing:

A separate farm supplied the fresh Quassia amara. The task of identifying and authenticating the plant species was assigned to the University Department of Pharmacognosy and Natural Medicine. After being thoroughly washed with tap water, the plant leaves were raked to remove any dust or other particles that may have settled on them. Following the extraction of dust, the leaves were left to dry in the shade for a full day. Next, the dried leaves were "pulverised" with an electric blender.

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DATA ANALYSIS:

Extraction Procedure:

After adding 250 mL of distilled water to 50 grammes of "powdered plant material" in a 500 mL conical flask. In order to make sure everything was mixed well, the flask was covered with aluminium foil and shaken constantly on a reciprocating shaker at 150 rpm for 24 hours. The next step was to filter the mixture through Whatman no. 1 filter paper and muslin cloth. "Nanoparticle" synthesis made use of the produced solution.

Synthesis of "Silver Nanoparticles Using Aqueous Extracts of Quassia amara with Model Drug:

In 10 millilitres of water, 0.1 gramme of silver nitrate (AgNO3) was dissolved to create a 1% solution. Then, while stirring continuously with a magnetic stirrer for 5 minutes, 5 mL of the extract was added drop by drop to make a [Ag]+ dispersion. After that, 25 mL of newly made Quassia amara extract (which helps to reduce the pH) was added to the mixture. The mixture was then kept at 40°C for a full day. A Virtis 2KBTXL-75 Benchtop SLC Freeze Dryer was used to lyophilise the resulting suspension of "Silver nanoparticles" for subsequent analysis.

Characterization of Silver Nano-Composites: UV-VIS spectroscopy was utilized to ascertain the Surface Plasmon Resonance (SPR) characteristic of the synthesized silver nanoparticles.

Antimicrobial Studies of Carica Silver-Nanocomposites: "

According to Okeke et al. (2021), the agar well diffusion technique was used to assess the antibacterial activity of silver nanoparticles that were biosynthesised from Quassia amara extract. With the use of a sterile bench hockey stick, 0.1 ml of organism volume was aseptically distributed across the Muller-Hinton agar plate. The plates were allowed to sit on the bench for half an hour to pre-disperse into the medium. To puncture the agar plates, a sterile cock borer measuring 5 mm was used. There was a ranking of the silver nanoparticle concentrations from 100 mg/ml to 500 mg/ml. Each of the agar wells created in the Muller-Hinton agar plates was supplemented with approximately half a millilitre of diluted silver nanoparticle. After the plates had been in the incubator for an hour, they were given another chance to let the extract soak into the medium. There was a 1% silver nitrate group that served as the control. The plates were kept at 37°C for 24 to 48 hours during the incubation process. The inhibition zone width in cm against microbiological isolates was used to evaluate the antimicrobial activity of the silver nanoparticles and the control. In order to ascertain the minimal inhibitory doses, the medium was spiked with various concentrations of 200 mg/ml, 100 mg/ml, 50 mg/ml, and 25 mg/ml. Once that was done, the organisms were evenly distributed onto the plates and then left to incubate at 37°C for a full day. One way to find the minimal inhibitory concentration was to look at the streaking line on the plate; this line represents the lowest concentration of silver nanoparticles that did not cause growth.

RESULT:

Displays the outcomes of the nanoparticle characterisation process. Similarly, the findings of the antibacterial activity of the produced silver nanoparticles are presented in Tables 2 and 3.

Antimicrobial Studies :

Both "Gram-positive and Gram-negative bacteria were tested for the antibacterial activity of silver nanoparticles and were effectively inhibited by the produced silver nanoparticles. There is evidence that silver can kill germs. Infections were treated with diluted silver nitrate solutions as early as the nineteenth century. For that reason, the study's control system consisted of a "silver nitrate solution.

Distilled water(mL)	AgNO3(g)	Reducing Agent(Quassia amara extract)(mL)	Colour	SPR Peak Change (nm)
10	0.1	5	Reddish Brown	435

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The table above" outlines the quantities of distilled water, AgNO3, and Quassia amara extract used in the synthesis process, along with the observed color change and the surface plasmon resonance (SPR) peak wavelength of the resulting silver nanoparticles".
The table below illustrates the zones of inhibition observed for each microorganism when treated with both the control (silver nitrate solution) and the Quassia amara silver Nano-composite.

Table 2. **Antimicrobial activities of Silver nanoparticles synthesized.**

Microorganism Control (Silver Nitrate)	**Zone of Inhibition(CM) Quassia amara Silver Nano-composite**	
Pseudomonas aeruginosa	1.0 cm	1.5 cm
Escherichia coli	1.5 cm	1.5 cm
Bacillus subtilis	1.5 cm	1.5 cm
Staphylococcus aureus	1.2 cm	1.3 cm

Table 3. Minimum inhibitory concentration of Medicago sativa silver nano-composites

Microorganism Control (Silver Nitrate Solution)	**Minimum Inhibitory Concentrations(mg/ml)** Quassia amara **Silver Nano-composite**	
Pseudomonas aeruginosa	100 mg/ml	25 mg/ml
Escherichia coli	100 mg/ml	50 mg/ml
Bacillus subtilis	100 mg/ml	100 mg/ml
Staphylococcus aureus	100 mg/ml	100 mg/ml

Both the Quassia amara silver Nano-composite and the control (a silver nitrate solution) were found to inhibit the concentrations of various microorganisms, as shown in the table. Pseudomonas aeruginosa, Escherichia coli, Bacillus subtilis, and Staphylococcus aureus all had inhibition zones of 1.5 cm, 1.5 cm, and 1.3 cm, respectively, on agar plates, demonstrating the extract's antibacterial activity. Between 25 and 100 mg/ml was the silver nanoparticles' minimum inhibitory concentration (MIC). Bacillus subtilis and Staphylococcus aureus were the least sensitive, while Pseudomonas aeruginosa was the most sensitive, with a minimum inhibitory concentration (MIC) of 25 mg/ml. Results demonstrate that silver nanoparticles produced by Quassia amara effectively targeted all four of the tested pathogen strains: Pseudomonas aeruginosa, Escherichia coli, Bacillus subtilis, and Staphylococcus aureus.

DISCUSSION:

The fast biosynthesis of silver nanoparticles with Quassia amara extract has been the subject of much debate, with many important points covered. These include the method of synthesis, the nanoparticles' characterisation, their antimicrobial characteristics, and possible uses.

Synthesis Process: Use of Quassia amara extract in the biosynthesis of AgNPs is an environmentally friendly and long-term viable option. The extract's bioactive components help reduce silver ions to nanoparticles by acting as capping agents and reducing agents. When contrasted with traditional chemical synthesis methods, this approach has many benefits, such as being easier, cheaper, and less harmful to the environment.

Characterization of Nanoparticles: Thorough characterisation is performed on the synthesised "silver nanoparticles" to validate their formation and evaluate their characteristics. Researchers can learn a lot about nanoparticles' optical characteristics from methods like ultraviolet-visible spectroscopy; for example, the Surface Plasmon Resonance (SPR) phenomenon causes a distinctive absorption peak at 435 nm. Nanoparticle size, shape, crystallinity, and chemical composition can be better understood with the use of supplementary characterisation techniques such as transmission electron microscopy, X-ray powder diffraction, and Fourier transform infrared spectroscopy.

Antimicrobial Properties: The antimicrobial efficacy of the synthesised silver nanoparticles is one of the most important points of the discussion. The nanoparticles are highly effective in killing various harmful microbes, including bacteria like Staphylococcus aureus, Escherichia coli, Bacillus subtilis, and Pseudomonas aeruginosa. Interactions between nanoparticles and microbial cells cause oxidative stress, disruption of cell membranes, and interference with cellular processes, all of which contribute to the antimicrobial action mechanism.

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Comparative Analysis: A comparative analysis "may be conducted to evaluate the antimicrobial efficacy of the Quassia amara silver nanoparticles against conventional antimicrobial agents. This comparison can highlight the potential advantages of using nanoparticles, such as broader spectrum activity, lower toxicity, and reduced likelihood" of resistance development.

Potential Applications: The discussion may also explore potential applications of Quassia amara silver nanoparticles beyond antimicrobial therapy. These nanoparticles have promising potential in various fields, including biomedical applications such as wound healing, drug delivery, and medical device coatings. Additionally, they may find utility in environmental remediation, catalysis, and food preservation.

Challenges and Future Directions: Despite the "promising results, challenges such as nanoparticle stability, scalability of synthesis, and regulatory considerations should be addressed. Future research directions may include optimizing synthesis parameters, elucidating the mechanisms of antimicrobial action, exploring synergistic effects with other natural extracts, and conducting in vivo studies to assess biocompatibility" and therapeutic efficacy.

Overall, the discussion on the" synthesis, characterization, antimicrobial properties, and potential applications of Quassia amara silver nanoparticles underscores their significance as a promising antimicrobial agent with diverse biomedical and environmental applications".

CONCLUSION:

Based on the findings of the research conducted on the biological activity of silver nanoparticles that were synthesised using extracts from Quassia amara (Amargo), it can be concluded that there is a significant potential for environmentally friendly and efficient applications in the fields of biomedicine and antimicrobials. It has been demonstrated through research that the phytochemicals that are found in Quassia amara play a significant part in the environmentally friendly synthesis of silver nanoparticles. These phytochemicals serve as both reducing and stabilising agents. The nanoparticles that were produced through biosynthesis have been shown to have enhanced biological activities, particularly powerful antimicrobial effects against a wide variety of pathogenic microorganisms when tested. Not only does the synergy between the natural compounds of Quassia amara and silver ions improve the effectiveness of the nanoparticles, but it also reduces the amount of harsh chemicals that are required in the preparation of the nanoparticles. The utilisation of this approach not only contributes to the development of environmentally friendly nanotechnology but also highlights the potential of plant-based methods in the advancement of nanomedicine.

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