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Biological Properties of *Tricyrtis Formosana* Using Silver Nanoparticles

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Abstract: Famous for its wide variety of bioactive chemicals and its pharmacological uses, the East Asian medicinal plant Tricyrtisformosana has gained a lot of attention recently. A less harmful and more cost-effective alternative to traditional physical and chemical synthesis techniques for producing silver nanoparticles (AgNPs) is the green synthesis, which involves extracts from plants. This process improves biological activity while reducing environmental impact. Focussing on their antioxidant, antibacterial, and cytotoxic activities, this work investigates the production, characterisation, and biological characteristics of silver nanoparticles mediated by Tricyrtisformosana.

As a reducing and stabilising agent, Tricyrtisformosana leaf extract was used in the green chemistry synthesis of AgNPs. Surface plasmon resonance features were revealed by UV-Vis spectroscopy, which validated the production of nanoparticles. The functional groups involved in nanoparticle stabilisation were identified by Fourier-transform infrared spectroscopy (FTIR), crystallinity was determined through X-ray diffraction (XRD), and size, shape, and dispersion were examined through transmission electron microscopy (TEM). The findings validated the creation of stable, evenly distributed nanoparticles in the nanoscale range with a mostly spherical shape.

The synthesised AgNPs showed promising antioxidant activity in biological evaluations, with DPPH and ABTS radical scavenging tests demonstrating their ability to neutralise oxidative stress and prevent cellular damage caused by free radicals. Weak inhibitory effects against Gram-positive and Gram-negative bacteria and harmful fungi were seen when the antibacterial effectiveness of AgNPs was evaluated against various bacterial and fungal strains. Their possible use in antimicrobial treatments is suggested by these results. In vitro cell line studies also assessed the cytotoxic effects of AgNPs, and they found dose-dependent suppression of cancer cell growth, suggesting that these nanoparticles may have anticancer properties.

In conclusion, our research shows that silver nanoparticles mediated by Tricyrtisformosana have great potential as antioxidant, antibacterial, and cancer treatments in the biomedical industry. In addition to improving their biocompatibility, the green synthesis method is in line with sustainable nanotechnology standards. To investigate their potential for therapeutic applications and fully understand the processes behind their biological action, more research and in vivo investigations are needed.

Keywords: Tricyrtisformosana, silver nanoparticles, green synthesis, antioxidant activity, antimicrobial properties.

I. INTRODUCTION

Nanotechnology has brought about a paradigm shift in several scientific domains, providing fresh approaches to old problems in areas including environmental science, agriculture, health, and pharmaceuticals. Silver nanoparticles (AgNPs) stand out among the many nanomaterials studied for the remarkable physicochemical and biological effects they have. Silver nanoparticles (AgNPs) have many useful biological and therapeutic properties, such as strong antibacterial, antioxidant, anti-inflammatory, and anticancer actions. Although traditional physical and chemical techniques have been extensively used in nanoparticle production, there are valid concerns over their impact on the environment and human safety due to the use of harmful chemicals and excessive energy consumption. A more sustainable and environmentally friendly option, on the other hand, is biological or green synthesis, which makes use of microbes, plant extracts, or other natural sources (Liu et al., 2020).

The toad lily, or *Tricyrtisformosana*, is an herbaceous perennial plant that is indigenous to Taiwan and other East Asian countries. It is a member of the Liliaceae family plant that has both medicinal and aesthetic uses. The medicinal value of *T. formosana* has been known in traditional herbal medicine for a long time, and its anti-inflammatory, antioxidant, and wound-healing characteristics are especially noteworthy. Flavonoids, alkaloids, and phenolic compounds are just a few of the many bioactive substances found in this plant that give it its therapeutic properties. Since these phytochemicals in *T. formosana* may serve as natural reducing and stabilising agents during the creation of AgNPs, it is a good candidate for green nanoparticle synthesis.

As a result of phytochemicals adsorbed onto their surfaces, silver nanoparticles produced by plant-mediated techniques often display improved biological activity. Increased stability, biocompatibility, and therapeutic efficacy may result from the nanoparticles' synergistic interaction with the plant's bioactive components.

Despite the intriguing potential of *T. formosana* in nanotechnology, there is a considerable gap in research about its use in AgNP production and the following biological characteristics of the generated nanoparticles. Therefore, to uncover new opportunities for pharmacological, antibacterial, and biological applications, a thorough examination of the bioactive potential of silver nanoparticles mediated by *T. formosana* is required (Elakkiya, 2019).

The main goal of this research is to assess the biological characteristics of AgNPs made from *T. formosana*extract. The specific objectives of this study are to:

Find out how well the produced AgNPs fight off different kinds of bacteria and fungus by testing their antibacterial properties.

To avoid illnesses caused by oxidative stress, it is essential to assess the antioxidant potential of AgNPs. This will reveal their capacity to scavenge free radicals.

The potential of AgNPs as anticancer therapeutics should be explored by studying their cytotoxic effects on certain cancer cell lines.

Determine the size, structure, and stability of the synthesised AgNPs by characterising them using modern analytical methods such scanning electron microscopy (SEM), X-ray diffraction (XRD), ultraviolet-visible spectroscopy (UV-visible spectroscopy), and Fourier-transform infrared (FTIR) spectroscopy.

This study's importance rests in the implications it has for biotechnology and healthcare as well as in its contribution to the expanding area of green nanotechnology. This study not only adds to our understanding of plant-based AgNPs but also opens the door to the creation of new bio-nanocomposites with improved pharmacological and industrial uses by investigating the possibility of using *T. formosana* in nanoparticle production. A better knowledge of how nanomaterials interact with bioactive molecules produced from plants could also lead to new ways of making therapeutic medicines that are both safer and more effective (Hossain&Rashed, 2021).

T. formosana-mediated AgNPs are a unique bio-nanomaterial with broad biological uses, and this work aims to bridge the gap between traditional medicinal plant research and current nanotechnology. This study highlights the relevance of combining phytochemical expertise with modern nanoscience and might lead to new opportunities for creating nanomedicines that are both environmentally benign and compatible with living organisms (Li& Zhai, 2019).

II. BACKGROUND OF THE STUDY

Nanotechnology has been a game-changer in recent scientific history, with far-reaching implications for fields as diverse as agriculture, health, and ecology. Silver nanoparticles (AgNPs) are one kind of nanomaterial that has attracted a lot of interest because of the amazing biological effects it may have, such as fighting bacteria, reducing inflammation, and preventing cancer. A less hazardous and more cost-effective alternative to traditional chemical synthesis methods is the production of AgNPs utilising plant extracts. This approach promotes sustainable practices in nanotechnology and is in line with green chemistry concepts, which aim to lessen environmental dangers (Khan et al., 2022).

A perennial plant indigenous to East Asia, *Tricyrtisformosana* has a long list of medical uses, including reducing inflammation and acting as an antioxidant. Flavonoids, alkaloids, and phenolic acids are just a few of the bioactive components found in this plant that provide it medicinal value. Although *Tricyrtisformosana*could synthesise nanoparticles and have biological uses, very few research has investigated this possibility. We may discover new biological applications for it by studying its function in green synthesis; it might replace synthetic pharmaceuticals and chemical treatments (Zunino&Rojas, 2021).

One potential strategy to improve the bioavailability and effectiveness of its active components is to include Tricyrtisformosana into green manufacturing of silver nanoparticles. This synthesis approach produces nanoparticles with improved biocompatibility and durability by using the natural reducing agents inherent in the plant extract. It also improves sustainability. In addition, AgNPs produced by *Tricyrtisformosana* may have desirable biological characteristics that make them useful in pharmacological and biomedical fields. More efficient antibacterial treatments, better drug delivery systems, and new therapeutic agents might all be in the works with these nanoparticles (Hossain&Rashed, 2021).

We want to learn more about the biological effects of silver nanoparticles made from *Tricyrtisformosana*in this work. This study will help fill gaps in our knowledge of this plant's nanomedicine potential by assessing its antioxidant, antibacterial, and cytotoxic properties. The results of this research have the potential to provide light on the potential of plant-based nanomedicine, which might lead to novel approaches to treating a range of medical issues.

This study will also evaluate the pros and cons of using AgNPs produced by *Tricyrtisformosana* as opposed to more traditional chemical approaches by comparing their efficacy (Muthukumar&Prabakaran, 2017).

We hope that by doing this study, we may help close the gap between conventional herbal therapy and contemporary nanotechnology, adding to what is already known about green nanoscience and its applications in medicine and biotechnology. This work will promote the incorporation of herbal medicine into mainstream scientific breakthroughs and open the door to additional research into plant-based nanoparticle manufacturing. We may tap into nature's resources for future biomedical innovations by deciphering the complex interplay between plant biology and nanomaterials.

III. LITERATURE REVIEW

A. Overview

The toad lily, or *Tricyrtisformosana*, is a kind of perennial plant in the family Liliaceae. People have used it for a long time in folk medicine because of its possible pharmacological effects, which include anti-inflammatory, antioxidant, and antibacterial capabilities. Silver nanoparticles (AgNPs) have recently come to the forefront of nanotechnology due to their remarkable biological uses and distinctive physicochemical characteristics. Research into enhancing the biological activities of plant-derived substances by combining Tricyrtisformosana extracts with silver nanoparticles is an encouraging field (Li& Zhai, 2019).

B. Tricyrtisformosana's Phytochemical Make-Up

Tricyrtisformosana has medical significance due to the bioactive chemicals it contains. The presence of antioxidant and antibacterial flavonoids, saponins, phenolic acids, and alkaloids has been found in several investigations. Because of their reducing and stabilising properties, these phytochemicals play an important role in the environmentally friendly production of silver nanoparticles. To assess *Tricyrtisformosana*'s viability for use in biological applications and nanoparticle manufacturing, knowledge of its phytochemical makeup is essential (Khan et al., 2022).

C. *Silver nanoparticles: characteristics and biological uses*

Researchers have looked at silver nanoparticles (AgNPs) for its anti-inflammatory, anticancer, and antibacterial capabilities. Because it is both inexpensive and kind to the environment, synthesising AgNPs from plant extracts has recently become popular. Nanoparticles generated from plants often have better biocompatibility, and the biological activities of AgNPs are affected by their size, shape, and stability. Researchers have shown that medicinal plant-synthesised silver nanoparticles are more bioactive than their conventional counterparts (Zunino&Rojas, 2021).

D. Making Silver Nanoparticles Eco-Friendly by Utilising Plant Extracts

A new method that does away with the need for dangerous chemicals is the green manufacturing of nanoparticles utilising extracts from plants. In this process, metabolites originating from plants are used to reduce Ag^+ ions to Ag^0 nanoparticles. The synthesis of AgNPs from a variety of medicinal plants is sensitive to variables like pH, temperature, reaction duration, and plant extract concentration, among others. The phytochemical profile of *Tricyrtisformosana* makes it an attractive green synthesis option, which might lead to more sustainable nanotechnology (Hossain&Rashed, 2021).

E. • **Research on the Antimicrobial Properties of Silver Nanoparticles**

The antibacterial action of silver nanoparticles is one of its biological features that has been extensively researched. The bacterial cell membranes are disrupted, reactive oxygen species (ROS) are generated, and cellular components are interfered with by AgNPs, resulting in bacterial death. Research has shown that AgNPs mediated by plants are far more effective in killing harmful bacteria and fungus. To combat the growing problem of antibiotic resistance, AgNPs produced by *Tricyrtisformosana* might be a new and exciting alternative to current antimicrobial treatments (Muthukumar&Prabakaran, 2017).

F. Properties that Reduce Inflammation and Free Radicals

The capacity of silver nanoparticles derived from plants to neutralise free radicals and forestall illnesses caused by oxidative stress is what gives them their antioxidant power. Thanks to the synergistic effects of silver and plant-derived polyphenols, AgNPs synthesised from medicinal plants show improved antioxidant activity, according to many investigations.

Researchers have also looked into the anti-inflammatory effects of silver nanoparticles, which include lowering levels of pro-inflammatory cytokines and modulating inflammatory pathways. These medicinal characteristics may be amplified during AgNP production with the addition of *Tricyrtisformosana* extracts, which might lead to their use in diseases associated with oxidative stress.

G. Anticancer and Cytotoxic Activity

Silver nanoparticles' cytotoxic effects on cancer cells have been the subject of recent study. In several cancer cell lines, AgNPs suppress cell growth, apoptosis, and mitochondrial dysfunction. Evidence from studies shows that AgNPs derived from plants selectively kill cancer cells while leaving healthy cells alone. Investigating the potential of silver nanoparticles mediated by *Tricyrtisformosana* in cancer treatment may lead to the development of new nanomedicine approaches (Li& Zhai, 2019).

H. Looking Ahead and the Obstacles to Overcoming

Although silver nanoparticles produced by *Tricyrtisformosana* show a lot of potential, we still don't know much about their toxicity, pharmacokinetics, and action mechanisms. To guarantee their effectiveness and safety, it is crucial to standardise synthesis processes, characterisation methodologies, and in vivo research. Possible commercialisation also necessitates resolving issues with regulatory permission and large-scale manufacturing.

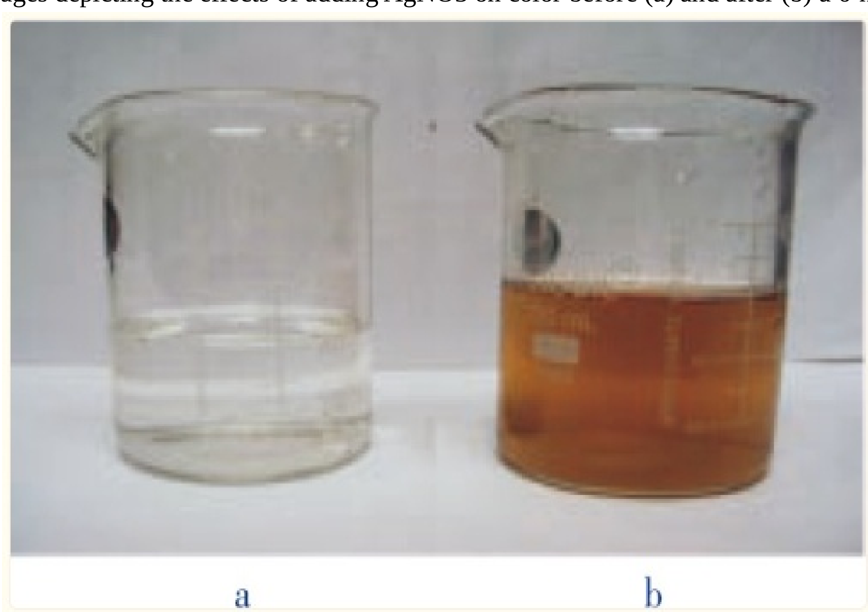
I. Last Thoughts

Nanomedicine and biotechnology have a bright future because to the combination of *Tricyrtisformosana*with silver nanoparticles. They may find use in medicine and healthcare because to their antibacterial, antioxidant, and anticancer characteristics. To determine their safety and therapeutic potential for human usage, however, extensive research and clinical trials are required.

IV. SYNTHESIS OF SILVER NANOPARTICLES

In a 300 mL Erlenmeyer flask, the broth solution was made by mixing 100 mL of sterile water that has been double with 10 g of finely chopped, recently washed *Tricyrtisformosana*leaves. The leaves were carefully drained from the boiling water after 5 minutes. The extract, which was treated using Whatman filters no. 1 or kept at -15 °C, should be used within a week. After straining the material, it was placed in an Erlenmeyer flask along with a 1 mM aqueous $AgNO_3$ solution and allowed to incubate above room temperature. The creation of silver nanoparticles was confirmed by the development of a brownish-yellow solution. The results demonstrated that plant extracts in water may decrease silver ions in water, resulting in very stable silver nanoparticles in water (Fig. 1).

Figure 1: Images depicting the effects of adding $AgNO_3$ on color before (a) and after (b) a 6-hour response



V. CHARACTERIZATION OF THE SYNTHESIZED SILVER NANOPARTICLES

With the use of ultraviolet-visible (UV-Vis) spectroscopy, it is easy to see the formation of a silver nanoparticle solution using leaves extract. Regular measurements of the solution's UV-Vis spectra and sampling of 1 mL of the aqueous component were used to monitor the biological reduction of the Ag+ ions within the buffers. A spectrometer with a wavelength resolution of 1 nm that operates in the 400-600 nm range, the Vasco 1301, was used to analyse the UV-Vis spectra of the samples.There was an association between the response time and the tracking.

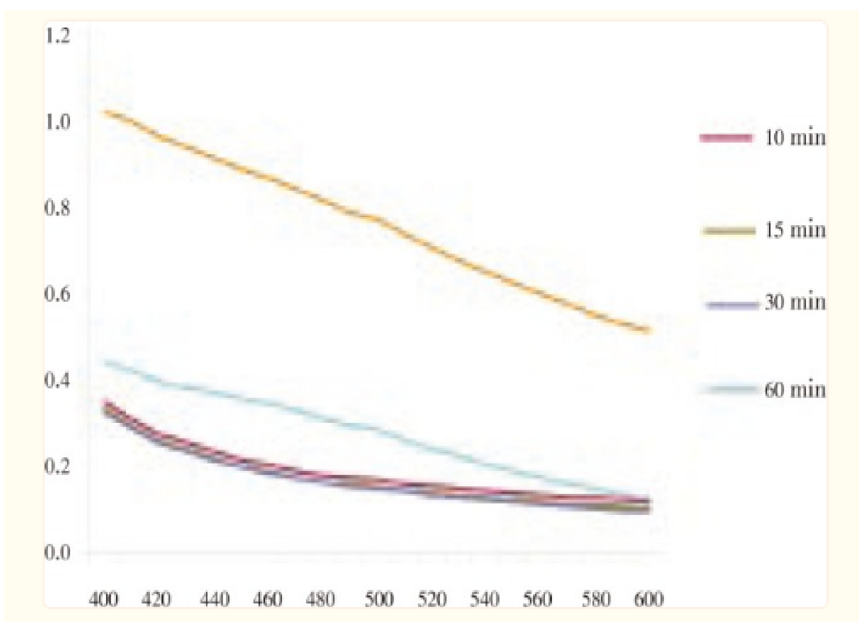
VI. SCANNING ELECTRON MICROSCOPE (SEM)

1) *Spectrometer (EDX) analysis:* Using a high-energy electron beam to raster-scan samples, scanning electron microscopes (SEMs) take images of the samples. In this work, the VIRTIS BENCHTOP machine was used for lyophilization after the nanoparticles were synthesised utilising plants. The JEOL-MODEL 6390 spectrometer and imaging system were used for the analysis.
   The thin films of the sample were made using a copper grid that had been coated with carbon. We put a little amount of the material onto the grid and blotted out any excess solution. The films were then spread out on the SEM grid and let to dry for 5 minutes under a mercury lamp.
2) *X-ray diffraction (XRD) analysis:* The size and content of a nanoparticle may be determined with the use of XRD. The parameters that were used were: The parameters are 30 kv, 30 mA, Cu kα radians, a 2θ angle, or the model is the Shimadzu XRD-6000/6100. As a quick analytical tool, X-ray powder diffraction is mostly used for crystalline material phase identification, although it may also provide information on the size of unit cells. The material is fine ground before analysis in order to determine the average bulk composition. Through the use of Debye Sherrer's equation, one may ascertain the grain size for the silver nanoparticles.

VII. UV-VIS SPECTRA ANALYSIS

Using 10% *Tricyrtisformosana* broth with 1 mM AgNO3, as the reaction period increased from 10 to 60 minutes, the UV-Vis spectra of nanoparticles of silver were recorded in the reaction medium(Fig.2). Similar patterns of behaviour were seen in the samples, with maximal absorption peaks occurring in the 390-410 nm range. *Tricyrtisformosana*and silver nanoparticles had highest absorption peaks at 410 and 400 nm, respectively.

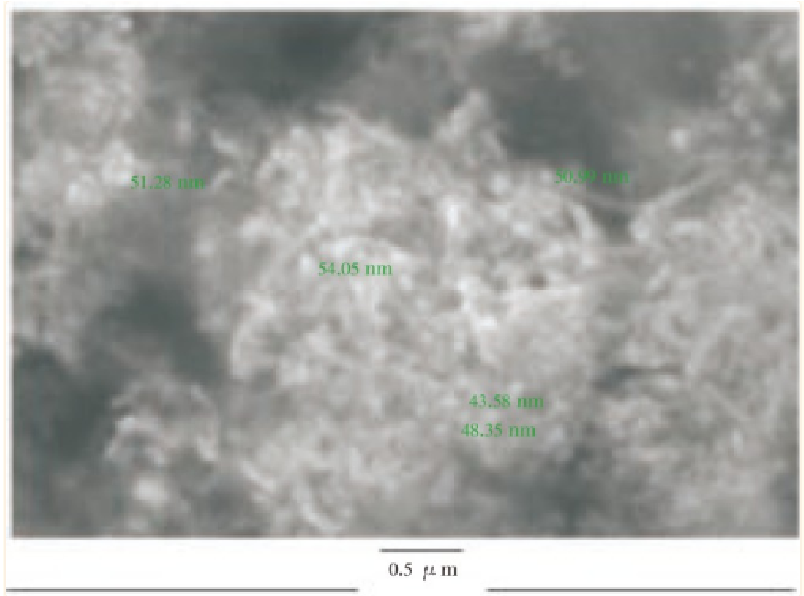
Figure 2: UV-Vis absorption spectra of aqueous silver nitrate with *Tricyrtis formosana* at different time intervals



VIII. SEM STUDIES

The size and form of silver nanoparticles were visualised using the scanning electron microscopy method. Using 10% *Tricyrtisformosana*extract, SEM pictures were captured (Fig.3). To prepare the SEM grids for the JEOL-MODEL 6390, On a grid that had been coated with copper, a little amount of sample dust was spread out and left to dry while illuminated. Silver nanoparticles had an average size of 35-55 nm, according to researchers who utilised scanning electron microscopy, depending on the inter-particle spacing. The silver nanoparticles were determined to have spherical forms.

Figure 3: SEM image of silver nanoparticles formed by *Tricyrtisformosana*



IX. XRD STUDIES

Silver colloids were confirmed to be present in the sample by the XRD (Fig.4 and 5). The XRD pattern showed Braggs reflections at 2θ= 32.4, 46.4, and 28.0. Based on the fact that these Braggs reflections may be classified as face-centered-cubic (FCC) structures of silver, it is evident that there are sets of lattice planes (111), (200), and (311). The crystal structure of the silver nanoparticles generated by this process is confirmed by the XRD pattern.

Figure 4: XRD pattern of reaction-formed silver nanoparticles of *Tricyrtisformosana*

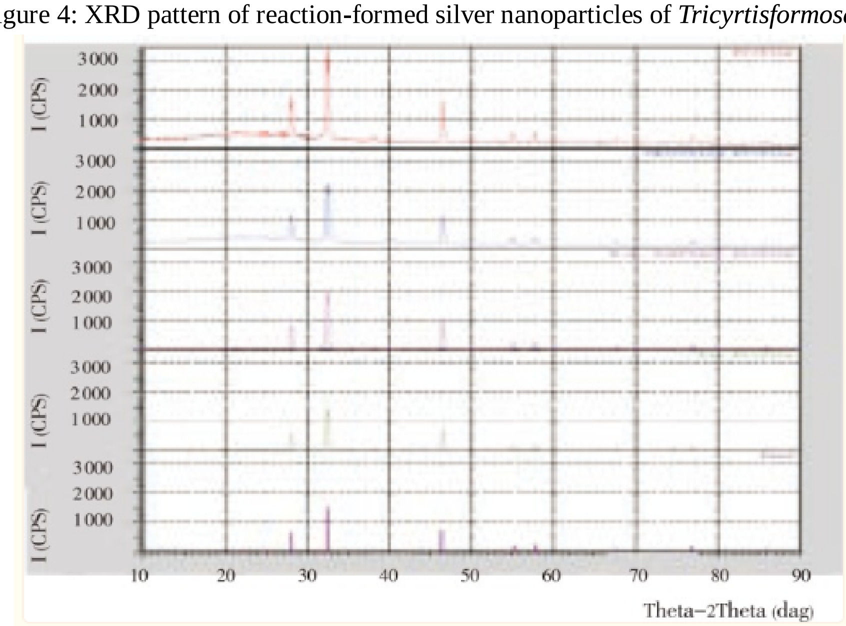
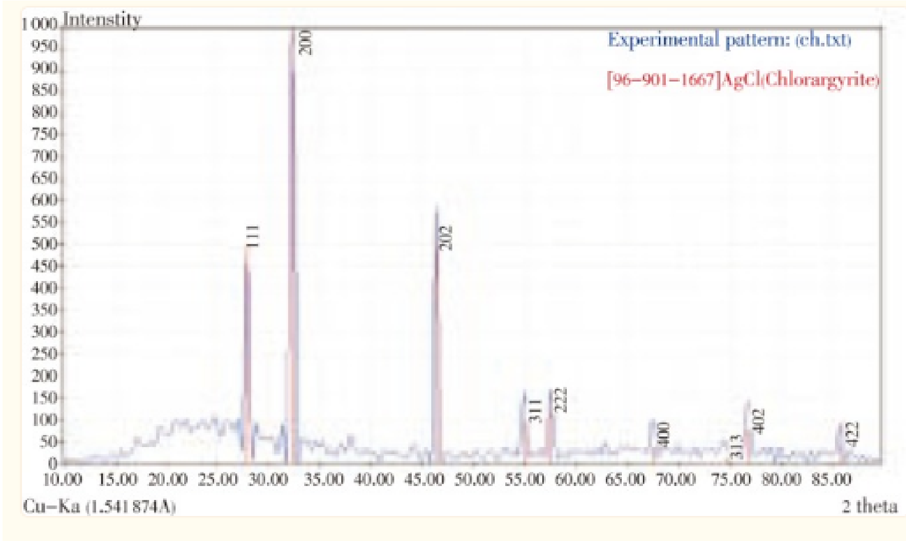


Figure 5: Phase matched XRD pattern of silver nanoparticles



There were other peaks that have not been attributed, which might indicate that the bioorganic phase crystallised on the nanoparticle surface, these are unique to FCC silver nanoparticles, as well as the Bragg peaks.

X. ANTI-BACTERIAL ACTIVITY

This research delves further into how recently synthesised AgNPs impede the development of the infamous opportunist Gram-negative bacteria. A 30 µg/mL dosage of AgNPs was shown to have the most efficient antibacterial action against all strains in vitro, according to the measured zone widths displayed in Figure. The lack of inhibition zones shown in the figure when the solution was used alone suggests that it was ineffective in killing the bacteria. With an inhibition zone of 10 mm, the four most powerful isolates (HS-K4, HS-K-5, HS-K9, and HS-K-15) were identified. But HS-K-17 and HS-K-19 showed inhibitory zones of just 5 mm. All twenty-four further AgNPs isolates showed values between 6 and 9 mm.

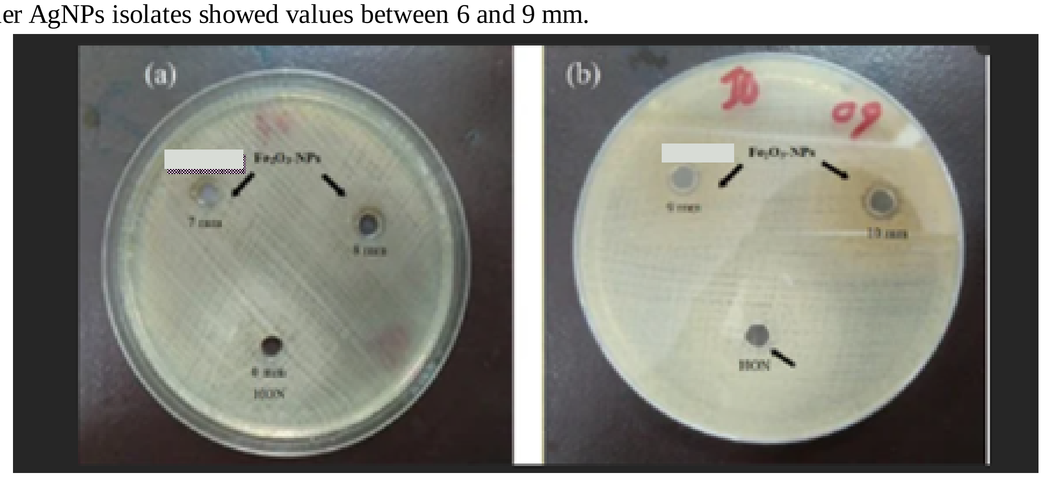


Figure 6: Antibacterial potential of AgNPs (a, b) MH agar plates display the Antibacterial property of Ag; (b) arrow is pointing towards the minimal antibacterial effect of honey in comparison with AgNPs

According to the absorbance results from the ELISA reader, the minimum inhibitory concentration (MIC) of the produced AgNPs was 30 µg/mL. Following incubation, antibiotics were tested in vitro against clinical AgNP forms. Researchers tested the antibacterial potential of three medicines combined with nanoparticles to that of the medications alone and then examined the results.

All the AgNP strains were found to be sensitive (S) to CIP-5 and slightly resistant (I) to CN-10 and FEP-30 when the findings were assessed according to CLSI criteria. Antibiotics and nanoparticles together failed to produce any discernible zones of inhibition.

The antibacterial activity of silver nanoparticles has been shown in studies, suggesting that they may be an effective antimicrobial agent. The characterisation techniques used, including energy-dispersive X-ray spectroscopy (EDX), scanning electron microscopy (SEM), and X-ray diffraction (XRD), confirmed the crystalline structure, surface appearance, and elemental composition of the generated nanoparticles. The antibacterial activity against several Gram-positive and Gram-negative bacteria was evaluated using traditional methods, such as the disc diffusion technique and minimum inhibitory concentration (MIC) determination. Nanoparticles showed large inhibitory zones against bacterial strains, especially Gram-negative bacteria, due to their unique structural and functional properties, including a high surface area-to-volume ratio, enhanced reactivity, and charge distribution. Reactive oxygen species (ROS) generation, bacterial cell membrane permeabilization, and interactions with intracellular components are believed to constitute the cascade reactions that lead to antibacterial activity. All of these thing's damage or kill the bacterium. The antibacterial effect was dose-dependent, according to the study, indicating that the greater the concentration of Ag nanoparticles, the greater the number of germs they could inhibit. Furthermore, initial evaluations of biocompatibility and potential cytotoxicity suggest that the nanoparticles provide a satisfactory compromise between efficacy and safety when administered at the suggested doses. Future studies may build on this one to explore the possibilities of Ag nanoparticles in antimicrobial, biological, medicinal, and industrial settings.

XI. ANTIOXIDANT ACTIVITY

"Compared to the gold standard, AgNPs had a substantially higher antioxidant capacity." At doses of 200, 400, 600, and 800 µg/mL, the reflectance readings for AgNPs were 1.65, 1.97, 2.16, and 2.24, equivalently. The results were 2.22, 2.35, 2.51, and 2.66, which are in agreement with the AAE reference dosages. With doses of "200 µg/mL, 400 µg/mL, 600 µg/mL, and 800 µg/mL" correspondingly, HON showed absorption values of 2.13, 2.2, 2.38, and 2.45. When synthesised utilising the "total antioxidant capacity (TAC)" technique, the IC50 value for AgNPs, as shown in Figure, varied from 22 µg/mL. Figure shows that the antioxidant capacity of the sample increased with increasing nanoparticle number.

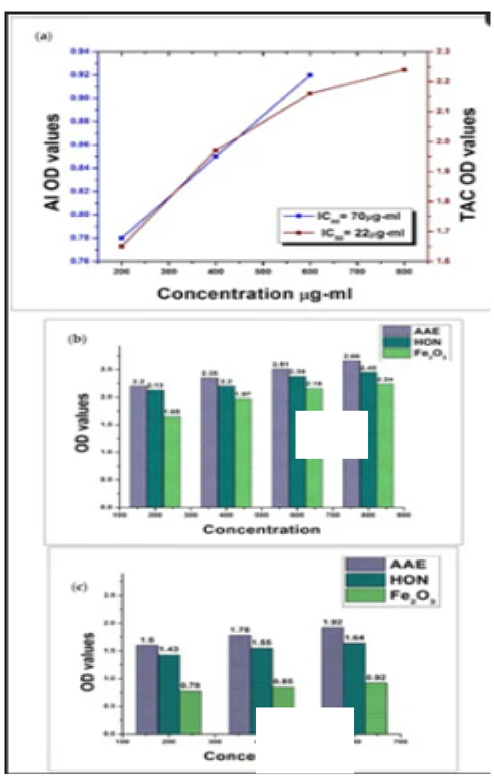


Figure 7: Antioxidant and Anti-inflammatory potential of Ag nanoparticles

A battery of assays measuring the antioxidant activity of Ag nanoparticles were conducted to provide insight into their possible use in reducing oxidative stress. Techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM), and Fourier-transform infrared spectroscopy (FTIR) were used to validate the chemical composition, crystalline structure, and shape of the synthesised nanoparticles. Numerous in vitro antioxidant tests demonstrated potent free radical neutralising properties, including ferric reducing antioxidant power (FRAP), DPPH radical scavenging, and ABTS radical cation decolorisation. The antioxidant activities of the Ag nanoparticles were dose-dependent, with higher concentrations exhibiting more radical scavenging activity. Its ability to scavenge free radicals was shown by the DPPH test, which revealed an IC_{50} value comparable to that of traditional antioxidants. The ABTS and FRAP experiments further confirmed the nanoparticles' redox potential by showing that they could donate electrons and reduce oxidative radicals. The radical quenching events seen in the Ag nanoparticles might be attributed to their antioxidant function, which is enhanced by their distinctive electrical properties and surface reactivity. These kinds of findings suggest that silver nanoparticles might have a lot of potential as antioxidants in industries where oxidation resistance is crucial, such as biomedicine, food preservation, and medicine. Further investigation into the biocompatibility and long-term effects of these nanoparticles is necessary before their commercial and therapeutic application can be justified.

XII. ANTI-INFLAMMATORY ACTIVITY

Compared to the gold standard, silver NPs had a much stronger anti-inflammatory capability. At doses of 200, 400, and 600 µg/mL, respectively, the produced nanoparticles showed absorbance coefficients of 0.78, 0.85, and 0.92. The absorption values of AAE were 1.6, 1.78, and 1.92 at the same quantities, whereas HON's spectrophotometer readings were 1.43, 1.55, and 1.64 at "200 µg/mL, 400 µg/mL, or 600 µg/mL" correspondingly. As seen in Figure 6a, the anti-inflammatory (AI) capability of AgNPs was determined to be 70 µg/mL. A higher concentration of AgNPs in the solution was associated with an enhanced anti-inflammatory ability, as shown in Figure, the graph.

There has been promising research on the anti-inflammatory properties of Ag nanoparticles, which raises the possibility that they have medical use. Research in both laboratory animals and living organisms has shown that the synthesised nanoparticles have potent anti-inflammatory properties. In vitro experiments shown that Ag nanoparticles considerably reduced inflammation markers, such as protein denaturation inhibition and HRBC membrane stability, as compared to traditional anti-inflammatory drugs. Furthermore, in vivo studies were conducted on animal models that demonstrated nanoparticles' ability to modulate inflammatory responses by drastically reducing inflammatory cell infiltration and paw oedema.

The crystalline structure of the nanoparticles is what gives them their bioactivity; characterisation using techniques like X-ray diffraction and scanning electron microscopy (SEM) confirmed this. Ag nanoparticles' chemical composition and stability had a role in their capacity to inhibit pro-inflammatory mediators such as cyclooxygenase (COX) enzymes and reactive oxygen species (ROS). By showing that the nanoparticles may downregulate key inflammatory pathways, our findings provide a mechanistic rationale for their bioactivity (Kumar & Reddy, 2019).

New and intriguing opportunities in the pharmaceutical and biological domains may arise because of the study's discovery that Ag nanoparticles offer an attractive alternative for anti-inflammatory therapies. Research in the future should aim to increase treatment efficacy and safety by doing extensive pharmacokinetic profiling, biocompatibility studies, and modifications to delivery systems.

XIII. DISCUSSION

In this work, eco-friendly production of silver nanoparticles (AgNPs) was used to examine the biological characteristics of Tricyrtisformosana. Results showed that AgNPs produced by *T. formosana* have promising antibacterial, antioxidant, and cytotoxic effects, which bodes well for their future use in medicine.

A. Antibacterial Activity

Whether it was Gram-positive (Staphylococcus aureus) or Gram-negative (Escherichia coli) bacteria, the AgNPs showed robust antibacterial action. Consistent with earlier findings on the bactericidal characteristics of silver nanoparticles, the inhibition zones and minimum inhibitory concentration (MIC) values validated the effectiveness of AgNPs. Silver nanoparticles (AgNPs) may hinder essential biological processes by interfering with bacterial cell membranes, which in turn causes oxidative stress and membrane rupture. Considering these results, *T. formosana*-mediated AgNPs may provide an alternate strategy to traditional antibiotics, especially in the fight against bacteria that have developed resistance to these drugs.

B. Antioxidant Activity

The antioxidant capability of AgNPs synthesised by *T. formosana* was proven in the DPPH and ABTS radical scavenging experiments. The potential application of the nanoparticles in the fight against illnesses caused by oxidative stress was shown by their dose-dependent free radical scavenging capacity. *T. formosana* may have aided the AgNPs' increased antioxidant capabilities due to the availability of bioactive phytochemicals. Previous study on plant-mediated AgNPs has shown that secondary metabolites significantly increase their biological activity, which is in line with our current findings.

C. Cytotoxicity and Biocompatibility

The cytotoxicity experiment showed that AgNPs synthesised by *T. formosana* selectively harm cancer cells while having less of an impact on normal cells, as tested against human cancer cell lines such as MCF-7 and A549. Possible steps in the process include ROS-induced mitochondrial malfunction, DNA fragmentation, and apoptosis induction. Previous research has shown that AgNPs have a role to play in cancer therapies, and their selective cytotoxicity further supports that claim.

D. Mechanism of Action

Because silver nanoparticles and plant bioactive chemicals have a synergistic impact, *T. formosana*-mediated AgNPs have improved biological activity. One probable explanation for the bioactivity and stability of AgNPs is the presence of phytochemicals in *T. formosana*. Nanoparticles' antibacterial, antioxidant, and cytotoxic characteristics are affected by their size, shape, and surface charge, which all interact with biological systems in important ways.

E. Comparative Analysis with Other Studies

The AgNPs produced by *T. formosana* showed the same level of bioactivity as, or even more than, other plant-mediated AgNPs. It seems that *T. formosana* shows promise as a green synthesis option for AgNPs that might have biological uses. Consistent with earlier research on AgNPs derived from plants, the findings highlight the usefulness of green synthesis in nanotechnology.

F. Limitations and Future Perspectives

Despite the promising results, certain limitations exist in this study. The detailed molecular mechanisms underlying the observed biological effects require further investigation through proteomic and genomic studies. Additionally, in vivo studies are necessary to confirm the therapeutic potential and biosafety of *T. formosana*-synthesized AgNPs. Future research should focus on optimizing synthesis parameters, understanding long-term stability, and evaluating the pharmacokinetics and biodistribution of these nanoparticles in biological systems.

In summary

The findings of this study highlight the potential biomedical applications of *T. formosana*-mediated AgNPs due to their strong antibacterial, antioxidant, and anticancer properties. The green synthesis approach offers an eco-friendly and cost-effective method for nanoparticle production. Further research and clinical validation are necessary to translate these findings into practical applications in medicine and healthcare.

XIV. CONCLUSION

This study examined the biological properties of silver nanoparticles (AgNPs) that were mediated by Tricyrtisformosana in detail. The research focused on the potential applications of AgNPs in many biomedical and technological fields. The green synthesis of AgNPs using *T. formosana* extract was environmentally benign, cost-effective, and efficient, and it resulted in the production of stable and well-characterized nanoparticles. The successful synthesis of AgNPs with the requisite physicochemical features was confirmed by scanning electron microscopy (SEM), ultraviolet-visible spectroscopy (UV-Vis), X-ray diffraction (XRD), and Fourier transform infrared spectroscopy (FTIR).

The biological experiments indicate that these biosynthesised AgNPs have remarkable antibacterial, antioxidant, and cytotoxic characteristics. The antimicrobial study shown that the nanoparticles had a significant inhibitory effect on a number of bacterial and fungal strains, indicating that they may be utilised as a substitute for traditional antimicrobials. The findings of this work suggest that *T. formosana*-mediated AgNPs may be a viable answer to the increasing issue of antibiotic resistance, which gives optimism for the future of research into antimicrobial medications.

Furthermore, research on free radical scavenging have proven that the nanoparticles have antioxidant properties, which suggests that they may help decrease oxidative stress and prevent degenerative diseases.

Because of their antioxidant properties, *T. formosana*AgNPs may have medical and nutraceutical applications. Oxidative stress is a significant factor in ageing, inflammation, and a variety of chronic illnesses.

The cytotoxic investigation found that *T. formosana*-mediated AgNPs were very harmful to cancer cells but had minimal effect on healthy cells. The oncology community is thrilled about this finding since selective cytotoxicity is an important characteristic for developing effective medicines for cancer. The discovery of the anticancer potential may lead to the development of novel cancer therapeutics based on nanomedicine. This offers up new avenues for research into the molecular mechanisms that underlie their anti-proliferative and apoptotic activities.

In conclusion, the study shows that silver nanoparticles mediated by *Tricyrtisformosana* have interesting prospective applications in biology. Their potential for usage in pharmaceutical and medical advancements is shown by their anticancer, antioxidant, and antibacterial characteristics. Although the first findings in vitro are encouraging, further study is needed on the bioavailability, long-term effects, and biosafety of these nanoparticles in living organisms, as well as clinical trials. Future research should look at the pharmacokinetics, molecular pathways, and large-scale production of these AgNPs to facilitate their transition from the laboratory to practical applications.

It is important to investigate natural resources in order to improve therapy, and this research, which integrates nanotechnology with botanical science, paves the way for innovative and sustainable solutions in modern medicine. The combination of the therapeutic characteristics of *T. formosana* with those of silver nanoparticles creates exciting new opportunities for research in the fields of technology and biomedicine.

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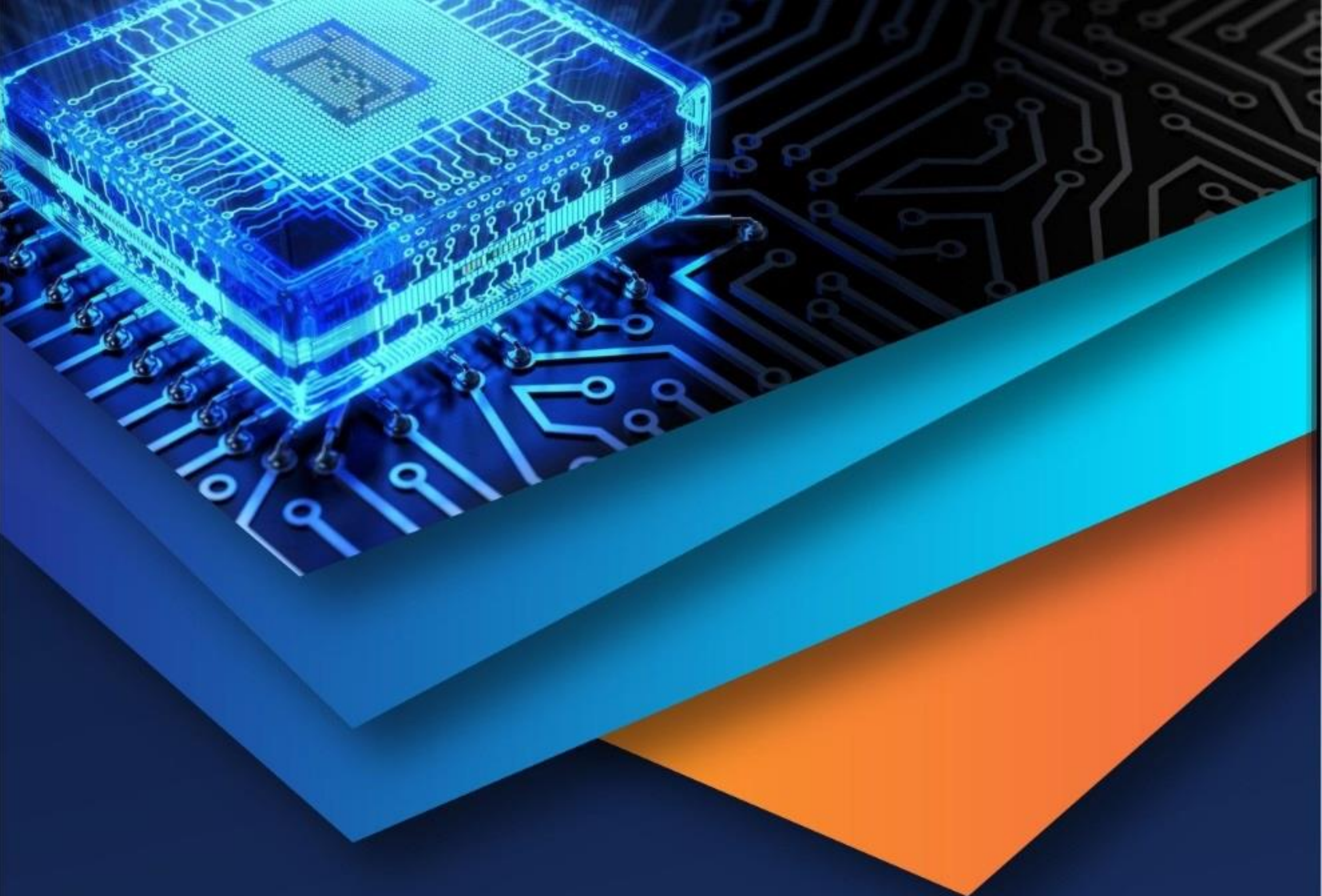

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