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Review Paper

Green Synthesized Silver Nanoparticles: A Transformative Frontier In Tuberculosis Therapy

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ABSTRACT

Despite the availability of the BCG vaccine and standardized DOTS (Directly Observed Treatment, Short-course) therapy, tuberculosis remains a global health emergency. The emergence of MDR-TB (multi drug resistant TB) and XDR-TB (extensively drug-resistant TB) necessitates the development of novel antimicrobial agents. Green synthesis of silver nanoparticles using plant extracts and biogenic agents has emerged as a sustainable alternative to conventional chemical and physical methods. This review consolidates findings from recent studies employing diverse botanical sources—*Clerodendrum serratum*, *Diospyros montana*, *Ficus ingens*, *Grewia tiliifolia*, *Leptadenia reticulata*, *Myrsine africana*, *Syzygium aromaticum*, *Sapindus mukorossi* (Reetha), *Acacia concinna* (Shikakai)—and microbial extracts such as yeast. We highlight synthesis protocols, characterization techniques, biological activities, and therapeutic potential, particularly against *Mycobacterium tuberculosis*. The collective evidence underscores silver nanoparticles as promising candidates for antimycobacterial therapy, with added antioxidant, anticancer, and antibacterial properties.

INTRODUCTION

Tuberculosis (TB) remains one of the serious infectious disease and one of leading cause of death worldwide. *Mycobacterium tuberculosis*, is the etiological agent of Tuberculosis, which is a highly communicable airborne pathogen. It mainly affects lungs and gradually spread to other systems¹. The emergence of drug-resistant strains

continues to threaten global health security. In 2024 multidrug-resistant or rifampicin-resistant TB (MDR/RR-TB) affected 400,000 individuals, yet only 2 in 5 accessed appropriate treatment². Current therapeutic strategies are increasingly limited due to the rise of resistant strains, underscoring the urgent need to novel, affordable and effective antimicrobial agent. Traditionally used medical plants are the new hope for

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developing novel and alternative medicine for the mycobacterial diseases³. According to the global Tuberculosis report 2025 released by the World Health Organization (WHO), an estimated 10.7 million people fell ill with TB in 2024, resulting in 1,23 million deaths. While the global incidence rate has seen a modest decline of roughly 2% following post-pandemic recovery efforts, the burden remains disproportionately concentrated in 30 high-burden countries, which account for 87% of all cases⁴.

Nanotechnology has emerged as a transformative force in modern science, offering innovative solutions to complex global health challenges through the development of nanomaterials. Green synthesis has been established as a sustainable and eco-friendly alternative⁵. Among various metallic nanoparticles, silver nanoparticles (AgNPs) have garnered significant attention due to their unique physicochemical properties, including a high surface area-to-volume ratio and adjustable optical characteristics. Plant-based synthesis is particularly advantageous due to its simplicity, cost-effectiveness, and the rich diversity of bioactive metabolites such as phenols, flavonoids, terpenoids, and alkaloids⁶. These phytochemicals serve as dual reducing and capping agents, providing stability to the nanoparticles without the need for external toxic additives. Effectively inhibit a variety of pathogens, including Gram-positive and Gram-negative bacteria, by disrupting cell membranes, inducing reactive oxygen species (ROS) production, and causing DNA damage⁷. Given the rising threat of multidrug-resistant (MDR) tuberculosis, green synthesised nanoparticles offer a promising frontier for developing more effective and targeted nano therapies⁸.

Green-Synthesized AgNPs

Swamy *et al* presents an eco-friendly approach to synthesizing silver nanoparticles (AgNPs) using

methanolic leaf extract of *Leptadenia reticulata*, a medicinal plant traditionally used in India for treating tuberculosis and other ailments. The study highlights the drawbacks of chemical synthesis methods and emphasizes the advantages of biological synthesis, noting the ethnomedicinal relevance of *L. reticulata* in TB treatment. Healthy leaves were collected, dried, powdered, and extracted with methanol. The extract was mixed with silver nitrate solution, producing a rapid color change from green to dark brown, indicating nanoparticle formation. Characterization was performed using UV-Vis spectroscopy (peak ~450 nm), XRD (crystalline silver with planes 111, 200, 220), and TEM (spherical particles, 50–70 nm). Biological assays included antibacterial testing against Gram-positive and Gram-negative pathogens, antioxidant activity via DPPH assay, and cytotoxicity evaluation on HCT15 colon cancer cells using MTT and propidium iodide staining. AgNPs showed dose-dependent antibacterial activity, with maximum inhibition against *Bacillus subtilis* (24.3 mm at 150 µg/mL). Antioxidant assays revealed strong radical scavenging activity (64.81% inhibition at 500 µg/mL), while cytotoxicity studies demonstrated a significant reduction in cancer cell viability (IC₅₀ = 20 µg/mL at 48 h), accompanied by apoptotic nuclear changes. The mechanism of action is attributed to silver's physicochemical interaction with intracellular proteins, DNA bases, and phosphate groups, leading to bacterial cell wall disruption, oxidative stress, and apoptosis in cancer cells. The study confirms that *L. reticulata* leaf extract serves as an effective reducing and capping agent for AgNP synthesis, producing stable, crystalline nanoparticles with potent antibacterial, antioxidant, and cytotoxic properties. Given its traditional use against potential of green-synthesized AgNPs from *L. reticulata* as alternative therapeutic agents in TB management and related biomedical applications⁹.



Sur UK *et al* reports an eco-friendly method for synthesizing silver nanoparticles (AgNPs) using aqueous extracts of *Acacia concinna* (Shikakai) and *Sapindus mukorossi* (Reetha), both rich in natural biosurfactants (saponins) that act as reducing and stabilizing agents. The study emphasizes the advantages of green synthesis over chemical methods, highlighting the traditional use of Shikakai and Reetha as natural surfactants and their potential in biomedical applications. Plant extracts were prepared by boiling leaves in water, and the broth was mixed with silver nitrate and ammonia solution to produce AgNPs. The nanoparticles were purified by centrifugation and characterized using UV-Vis spectroscopy (absorbance peak at 401 nm), XRD (face-centered cubic crystalline silver with predominant (111) orientation), TEM (spherical particles ~30 nm, monodisperse), and zeta potential (-50 to -55 mV, confirming high stability for up to three months). The biosynthesized AgNPs were employed as surface-enhanced Raman scattering (SERS) substrates, initially validated with Rhodamine 6G dye, showing strong enhancement factors (~10⁸). Critically, the AgNPs enabled rapid detection of *Mycobacterium tuberculosis*, producing distinctive SERS spectral fingerprints linked to cell wall components such as mycolic acids and arabinogalactan. The technique detected bacterial concentrations as low as 10⁴ CFU/mL, differentiating *M. tuberculosis* from Gram-positive and Gram-negative bacteria. The mechanism of action is attributed to biosurfactant-mediated reduction and stabilization of silver ions, while the diagnostic application relies on the strong plasmonic enhancement of Raman signals at the bacterial cell wall interface. The study demonstrates that Shikakai- and Reetha-derived AgNPs are stable, eco-friendly, and effective not only as antimicrobial agents but also as diagnostic tools for tuberculosis. By enabling rapid, cost-effective identification of *M. tuberculosis*, these

green-synthesized nanoparticles offer significant promise in TB management, particularly in resource-limited settings where conventional diagnostics are slow or expensive¹⁰. Sivaraj A *et al* studied the green synthesis of silver chloride nanoparticles (AgCl NPs) using commercial yeast extract and evaluates their anti-mycobacterial activity. The authors highlight the global burden of tuberculosis (TB), particularly the rise of multidrug-resistant (MDR) and extensively drug-resistant (XDR) strains, and emphasize the need for novel therapeutic agents. For the methodology, yeast extract was mixed with silver nitrate solution and incubated overnight, producing a dark brown color indicative of nanoparticle formation. The AgCl NPs were characterized by UV-Vis spectroscopy (absorbance peak at 423 nm), XRD (cubic crystalline structure with planes (111), (200), (220), (311), (222), and (420)), FTIR (showing involvement of primary amines and amide groups in reduction and stabilization), HR-SEM, EDAX, and TEM, which confirmed spherical nanoparticles of ~17 nm average size. AgCl NPs exhibited significant antimycobacterial activity: against *Mycobacterium smegmatis*, they produced a 13 mm inhibition zone at 37 µg/mL, and against *M. tuberculosis* H37Rv, they achieved 92% reduction in luciferase reporter phage (LRP) assay, comparable to rifampicin (95% reduction at 2 µg/mL). The action is attributed to nanoparticle penetration of bacterial membranes, interference with ATP production, inhibition of DNA replication, and induction of oxidative stress. The study concluded that yeast extract can serve as a simple, inexpensive, and eco-friendly reducing agent for AgCl NP synthesis, and that these nanoparticles possess potent anti-mycobacterial properties, making them promising candidates for novel TB therapeutics¹¹.

Abdel-Aziz MM *et al* details the green synthesis of quaternized chitosan/silver nanocomposites (TMC/Ag) and their dual activity against



Mycobacterium tuberculosis and lung carcinoma cells. The authors highlight the global burden of TB and its strong association with lung cancer, noting the urgent need for multifunctional therapeutics. N,N,N-trimethyl chitosan chloride (TMC), a water-soluble quaternized chitosan derivative, was used as both reducing and stabilizing agent in a one-pot biosynthesis process with silver nitrate. The nanocomposites were characterized by UV-Vis spectroscopy (broad absorption peak at 400 nm due to surface plasmon resonance), XRD (confirming crystalline silver phases), and TEM, which revealed well-distributed spherical Ag nanoparticles sized 11–17.5 nm embedded in the TMC matrix. In the results, the TMC/Ag nanocomposite exhibited potent antimycobacterial activity, with a minimum inhibitory concentration (MIC) of 1.95 µg/mL against *M. tuberculosis*. Additionally, cytotoxicity assays against lung carcinoma cells (A-549) showed an IC₅₀ of 12.3 µg/mL, while normal lung cells (WI-38) remained largely unaffected (IC₅₀ 357.2 µg/mL), indicating selective toxicity. The mechanism of action is attributed to the synergistic role of TMC and silver nanoparticles: TMC enhances solubility and stability, while AgNPs disrupt bacterial cell membranes, interfere with DNA replication, and induce oxidative stress, leading to antimycobacterial and anticancer effects. In conclusion, this study is the first to demonstrate that TMC/Ag nanocomposites can simultaneously target TB pathogens and lung carcinoma cells, offering a promising eco-friendly nanomedicine platform for dual therapeutic applications¹². Sarwer Q *et al* studies the Green Synthesis and Characterization of Silver Nanoparticles Using *Myrsine africana* Leaf Extract for Their Antibacterial, Antioxidant and Phytotoxic Activities, its findings can be framed within the context of tuberculosis treatment. The study begins by emphasizing the urgent need for alternatives to conventional antibiotics due to

rising resistance in pathogens, including *Mycobacterium tuberculosis*. Using a green synthesis approach, *M. africana* leaf extract was incubated with silver nitrate, producing nanoparticles confirmed by UV-Vis spectroscopy (peak at 438 nm), SEM (spherical/oval morphology, average size 28.32 nm), XRD (crystalline nature), and FTIR (functional groups from plant biomolecules acting as reducing/stabilizing agents). Biologically, the AgNPs displayed strong antibacterial activity, particularly against *E. coli*, and significant antioxidant potential (57.7% inhibition at 40 µg/mL, IC₅₀ = 77.56 µg/mL). Mechanistically, their antimicrobial effect was linked to cell membrane disruption, generation of reactive oxygen species, DNA damage, protein denaturation, and mitochondrial dysfunction leading to apoptosis—all processes relevant to controlling tuberculosis bacteria, which rely on robust cell wall integrity and oxidative stress resistance. The phytotoxicity assays further demonstrated beneficial effects on plant growth, underscoring their biocompatibility. Study concluded that, this work establishes a cost-effective, eco-friendly synthesis of AgNPs with promising biomedical applications, suggesting that such nanoparticles could be harnessed as adjunct or alternative agents in tuberculosis therapy, where oxidative stress induction and membrane disruption are critical mechanisms for overcoming drug-resistant strains¹³. Desai SK *et al* reports the green synthesis of silver nanoparticles (AgNPs) using aqueous leaf extract of *Grewia tiliifolia* Vahl (GtLE) and evaluates their biological activities, including antituberculosis, anticancer, and antioxidant effects. Authors highlight the global health burden of tuberculosis (TB), particularly multidrug-resistant (MDR) and extensively drug-resistant (XDR) strains, alongside lung cancer, and emphasize the need for eco-friendly nanomedicine approaches. Fresh



leaves were boiled in distilled water to prepare extracts, which were then reacted with silver nitrate under controlled pH (optimized at 8.5) and temperature (60–80 °C). The formation of AgNPs was confirmed by a color change from yellow to reddish-brown. Characterization included UV-Vis spectroscopy (surface plasmon resonance peak at 409 nm), FTIR (showing phytochemicals such as flavonoids and tannins involved in reduction and capping), XRD (face-centered cubic crystalline silver with average crystallite size ~12 nm), DLS (average hydrodynamic size 40.2 nm, PDI 0.361, zeta potential -35.8 mV indicating stability), and HR-TEM, which revealed spherical nanoparticles ranging from 11–34 nm. In the results, the AgNPs exhibited significant antituberculosis activity against *M. tuberculosis* H37Rv with a minimum inhibitory concentration (MIC) of 6.25 µg/mL, compared to 50 µg/mL for crude leaf extract. They also showed cytotoxicity against A549 lung cancer cells with an IC₅₀ of 23.45 µg/mL, outperforming the crude extract (IC₅₀ 56.31 µg/mL). Antioxidant activity was moderate, with IC₅₀ of 49.60 µg/mL. The mechanism of action is attributed to phytochemical-mediated reduction and stabilization of AgNPs, followed by antimicrobial and anticancer effects through reactive oxygen species (ROS) generation, disruption of cell membranes, DNA damage, and apoptosis induction. Concluded that *G. tiliifolia*-derived AgNPs are eco-friendly, stable, and biologically potent, offering promising applications as natural antituberculosis, anticancer, and antioxidant agents ¹⁴. Dhanislas M *et al* presents a comprehensive study on the eco-friendly synthesis, characterization, and biological evaluation of silver nanoparticles (AgNPs) for potential tuberculosis treatment. Highlights the global burden of tuberculosis and the urgent need for novel therapeutics due to rising multidrug-resistant strains. Clove (*Syzygium aromaticum*) was chosen for its rich phytochemical profile and

traditional medicinal value. Methodologically, clove seed extracts were prepared and used to reduce silver nitrate into AgNPs, confirmed by a visible color change. Characterization was performed using UV-Vis spectroscopy (SPR band at 450 nm), FTIR (showing phenols, flavonoids, terpenoids as reducing/capping agents), XRD (face-centered cubic structure, average size ~28 nm), SEM-EDAX (spherical particles 20–45 nm, pure silver composition), and TEM (mostly spherical, ~100 nm). Antibacterial assays demonstrated inhibition against *Staphylococcus aureus*, *E. coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*, while antimycobacterial activity (MABA assay) showed significant inhibition at 250 µg/mL. Cytotoxicity studies using zebrafish embryos and *Artemia salina* revealed dose-dependent effects, with higher concentrations causing morphological changes and lethality. The AgNPs act by binding to bacterial membranes, increasing permeability, disrupting protein function, and reducing nutrient uptake, ultimately leading to cell death. Study validates clove-mediated AgNPs as a promising green-synthesized nanodrug with potent antibacterial and anti-mycobacterial activity, supported by manageable cytotoxicity, making them a potential candidate for tuberculosis therapy ¹⁵. Vidyasagar *et al* highlight the global crisis of multidrug-resistant and extensively drug-resistant *Mycobacterium tuberculosis* strains, emphasizing the urgent need for novel therapeutics. Fresh leaves of *C. serratum* were processed to obtain plant extract, which was used to reduce silver nitrate into AgNPs, followed by PEGylation to enhance stability. Confirmed successful synthesis by UV-Vis spectroscopy showed reduction of silver ions, HR-TEM revealed predominantly spherical nanoparticles with sizes ranging 9–35 nm for AgNPs and 15–60 nm for PEG-AgNPs, XRD confirmed crystalline nature, and FTIR-ATR identified functional groups responsible for



reduction and capping. Biologically, PEG-AgNPs demonstrated superior inhibitory activity against *Mycobacterium smegmatis*, *M. fortuitum*, and *M. marinum* compared to AgNPs and even Linezolid. Flow cytometry revealed that the nanoparticles increased cell wall permeability, while AFM confirmed significant inhibition of mycobacterial biofilm formation—an important factor in TB persistence. Importantly, hemolysis assays showed no toxicity to human red blood cells, underscoring biocompatibility. In conclusion, the study establishes *C. serratum*-derived PEG-AgNPs as a promising green-synthesized nanotherapeutic, offering a novel, safe, and effective strategy to combat tuberculosis and related mycobacterial infections by disrupting cell wall integrity and biofilm formation¹⁶. Patil BN *et al* explores the green synthesis of silver (AgNPs) and zinc oxide nanoparticles (ZnONPs) using *Diospyros montana* L. leaf extract as an eco-friendly reducing and stabilizing agent. The authors highlight the limitations of chemical and physical nanoparticle synthesis methods and emphasize the biomedical importance of plant-mediated approaches, particularly in tackling infectious diseases like tuberculosis (TB). For the methodology, fresh *D. montana* leaves were processed into aqueous extracts, which were then reacted with silver nitrate and zinc nitrate solutions under controlled pH and temperature conditions. The nanoparticles were characterized using UV-Vis spectroscopy, FTIR, HR-TEM, PXRD, and EDX, confirming spherical AgNPs (10–35 nm) and hexagonal ZnONPs (18–30 nm) with high purity. In the results, AgNPs showed strong antibacterial activity, especially against *Pseudomonas aeruginosa* (15 mm inhibition zone at 400 µg/mL), outperforming erythromycin, while ZnONPs were most effective against *Bacillus cereus*. Both nanoparticles demonstrated significant anti-tuberculosis activity against *Mycobacterium tuberculosis* H37Rv strain, with

AgNPs effective at 25 µg/mL and ZnONPs at 50 µg/mL. FTIR and spectral analyses provides that the phytochemicals such as flavonoids, phenolics, and amines that reduce metal ions, cap nanoparticles, and stabilize them, while antimicrobial effects are attributed to endocytosis and reactive oxygen species (ROS) generation, leading to bacterial cell damage. Study concluded that, *D. montana* leaf extract as a sustainable source for synthesizing stable, bioactive nanoparticles with potent antibacterial and anti-tubercular properties, offering promising avenues for novel biomedical applications¹⁷. Chifamba J *et al* investigates the eco-friendly biosynthesis of silver nanoparticles (AgNPs) using *Ficus ingens* root extract for potential application in treating tuberculosis (TB) and leprosy. Authors emphasize the global challenge of drug-resistant *Mycobacterium* strains and highlight the traditional use of *F. ingens* in Zimbabwean medicine for TB, motivating its exploration as a green synthesis agent. Lyophilized root extracts were prepared through hydro-ethanolic maceration, followed by phytochemical screening that confirmed the presence of flavonoids, tannins, phenols, glycosides, and saponins. Acute oral toxicity studies in Wistar rats (OECD guideline 425) established the extract's safety with an LD50 above 4000 mg/kg. The biosynthesis of AgNPs was achieved by mixing the extract with silver nitrate under controlled heating, with a color change confirming nanoparticle formation. Characterization via UV-Vis spectroscopy, transmission electron microscopy (TEM), and dynamic light scattering (DLS) revealed AgNPs of average size ~38 nm, with spherical and cubic morphologies. In the results, both the crude extract and AgNPs demonstrated antimicrobial activity against *Mycobacterium smegmatis* (a surrogate for *M. tuberculosis*), *Escherichia coli*, and *Staphylococcus aureus*, with efficacy comparable to rifampin. The mechanism of action is attributed



to the synergistic role of phytochemicals (flavonoids, tannins, phenols) in reducing silver ions, stabilizing nanoparticles, and enhancing antimicrobial activity through cell wall disruption, oxidative stress induction, and inhibition of microbial growth pathways. The study confirms that *F. ingens*-mediated green synthesis of AgNPs is safe, effective, and offers a promising adjunct therapy for drug-resistant TB and leprosy, aligning traditional medicinal knowledge with modern nanotechnology¹⁸.

CONCLUSION

The escalating global burden of tuberculosis, compounded by the rise of multidrug-resistant (MDR) and extensively drug-resistant (XDR) strains, necessitates the urgent exploration of innovative therapeutic strategies. This review establishes green-synthesized silver nanoparticles (AgNPs), typically ranging from 9 to 100 nm in size, as a transformative frontier in antimycobacterial research. By utilizing diverse botanical sources—such as *Leptadenia reticulata*, *Grewia tiliifolia*, and *Syzygium aromaticum*—and microbial extracts like yeast, researchers have developed eco-friendly, cost-effective, and stable nanoparticles that bypass the toxicity associated with traditional chemical synthesis. These "green" platforms offer significant dual-utility, demonstrating potent inhibition of *Mycobacterium tuberculosis* while simultaneously exhibiting antioxidant and anticancer properties against lung carcinoma.

Mechanistically, these nanoparticles exert their effect through a multi-targeted approach involving structural and biochemical disruption. AgNPs cause direct cell wall damage and increased membrane permeability, a process highlighted in studies of *Myrsine africana*, *Ficus ingens*, and *Diospyros montana*. Specifically, PEGylated AgNPs from *Clerodendrum serratum* inhibit the formation of mycobacterial biofilms, a critical

factor in TB persistence. Internally, the particles interfere with essential metabolic processes, including protein and enzyme dysfunction, ATP inhibition, and the halting of DNA replication. Quaternized silver nanocomposites act through similar synergistic pathways, disrupting bacterial membranes while interfering with genomic stability.

A primary pathway for cytotoxicity involves the induction of oxidative stress leading to programmed cell death. AgNPs from sources like *Grewia tiliifolia* and *Diospyros montana* trigger the generation of reactive oxygen species (ROS), resulting in mitochondrial dysfunction and apoptosis in both mycobacteria and lung cancer cells. Furthermore, biosurfactant-mediated AgNPs from *Acacia concinna* (Shikakai) and *Sapindus mukorossi* (Reetha) provide rapid diagnostic capabilities via surface-enhanced Raman scattering (SERS), offering distinctive spectral fingerprints for bacterial identification. Collectively, these findings underscore the potential of green-synthesized AgNPs as multifunctional nanomedicines capable of providing affordable, targeted, and effective solutions for drug-resistant tuberculosis.

REFERENCES

1. Alsayed SSR, Gunosewoyo H. Tuberculosis: Pathogenesis, Current Treatment Regimens and New Drug Targets. Int J Mol Sci. 2023 Mar 8;24(6):5202.
2. An Y, Ni R, Zhuang L, Yang L, Ye Z, Li L, et al. Tuberculosis vaccines and therapeutic drug: challenges and future directions. Mol Biomed. 2025 Jan 22;6:4.
3. Abdjul DB, Budiyo F, Wibowo JT, Murniasih T, Rahmawati SI, Indriani DW, et al. Unlocking potent anti-tuberculosis natural products through structure-activity relationship analysis. Nat Prod Bioprospect. 2025 Jul 7;15(1):44.



4. World Health Organization. Global tuberculosis report 2025 [Internet]. Geneva: World Health Organization; 2025 [cited 2026 Feb 2]. Available from: <https://www.who.int/teams/global-programme-on-tuberculosis-and-lung-health/tb-reports/global-tuberculosis-report-2025>.
5. Sakaray V, Rao YS, Naidu NV. Green synthesis of silver nanoparticles by *Acalypha indica* plant extract and their approach towards multifunctional applications. *Nano Biomed Eng.* 2024;16(4):665-676.
6. Khatun M, Khatun Z, Karim MR, Habib MR, Rahman MH, Aziz MA. Green synthesis of silver nanoparticles using extracts of *Mikania cordata* leaves and evaluation of their antioxidant, antimicrobial and cytotoxic properties. *Food Chem Adv.* 2023;3:100386.
7. Giri AK, Jena B, Biswal B, Pradhan AK, Arakha M, Acharya S, et al. Green synthesis and characterization of silver nanoparticles using *Eugenia roxburghii* DC. extract and activity against biofilm-producing bacteria. *Sci Rep.* 2022;12:8383.
8. Mahmood S, Jannat S, Shah AH, Fariq A, Rasheed S, Wazeer A, et al. Antimycobacterial potential of green synthesized silver nano particles from selected Himalayan flora. *J Appl Bot Food Qual.* 2024;97:54-62.
9. Kumara Swamy M, Sudipta KM, Jayanta K, Balasubramanya S. The green synthesis, characterization, and evaluation of the biological activities of silver nanoparticles synthesized from *Leptadenia reticulata* leaf extract. *Appl Nanosci.* 2014.
10. Sur UK, Ankamwar B, Karmakar S, Halder A, Das P. Green synthesis of Silver nanoparticles using the plant extract of *Shikakai* and *Reetha*. *Materials Today: Proceedings.* 2018;5(1):2321-2329.
11. Sivaraj A, Kumar V, Sunder R, Parthasarathy K, Kasivelu G. Commercial Yeast Extracts Mediated Green Synthesis of Silver Chloride Nanoparticles and their Anti-mycobacterial Activity. *J Clust Sci.* 2020 Jan;31(1):281-285.
12. Abdel-Aziz MM, Abu Elella MH, Mohamed RR. Green synthesis of quaternized chitosan/silver nanocomposites for targeting mycobacterium tuberculosis and lung carcinoma cells (A-549). *Int J Biol Macromol.* 2020 Jan 1;142:244-253.
13. Sarwer Q, Amjad MS, Mehmood A, Binish Z, Mustafa G, Farooq A, et al. Green Synthesis and Characterization of Silver Nanoparticles Using *Myrsine africana* Leaf Extract for Their Antibacterial, Antioxidant and Phytotoxic Activities. *Molecules.* 2022 Nov 6;27(21):7612.
14. Desai SK, Taranath TC. Characterization and Biological Activities of Silver Nanoparticles Synthesized Using *Grewia tiliifolia* Vahl Leaf Extract. *Pharm Sci.* 2023;29(1):111-122.
15. Dhanislas M, Sampath S, Shamya M, Joseph J, Yasasve M, Ahmed MZ, et al. Green synthesis of biofabricated silver nanoparticles from *Syzygium aromaticum* seeds: spectral characterization and evaluation of its anti-mycobacterial activity, cytotoxicity assessment on zebrafish embryo and *Artemia salina*. *Materials Technology.* 2023;38(1):2269358.
16. Vidyasagar, Patel RR, Singh SK, Dehari D, Nath G, Singh M. Facile green synthesis of silver nanoparticles derived from the medicinal plant *Clerodendrum serratum* and its biological activity against *Mycobacterium* species. *Heliyon.* 2024 May 10;10(10):e31116. doi: 10.1016/j.heliyon.2024.e31116.
17. Patil BN, Taranath TC, Konkal P. Antimycobacterial and antibacterial activity of green-synthesized silver and zinc oxide

nanoparticles using *Diospyros montana* L. leaf extract. *Next Nanotechnology*. 2025;8:100248.

18. Chifamba J, Chimbaira BM, Magadza RJ, Chipato WE, Zengeni S. Eco-friendly biosynthesis of anti-mycobacterium silver nanoparticles using *Ficus ingens* for potential use in tuberculosis and leprosy. *J Mater Sci Res Rev*. 2025;8(3):529-44.

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