



GREEN SYNTHESIS OF BOVINE SERUM ALBUMIN CONJUGATED SILVER NANOPARTICLES FROM THE AQUEOUS LEAF EXTRACT OF *JATROPHA GLANDULIFERA* ROXB. (EUPHORBIACEAE) AND EVALUATION OF ANTI-MICROBIAL ACTIVITIES

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ABSTRACT

Nanotechnologies exhibit significant potential in the field of medicine, including in imaging techniques and diagnostic tools, implants, tissue-engineered constructs. Nanoparticles are involved in the targeted drug delivery system, where the medicament is selectively targeted or delivered only to its site of action. Albumin protein found in human blood has no immunogenicity as an endogenous protein and ensure its biocompatibility for albumin-based nanoparticles. The present study reports the green synthesis of Bovine serum albumin (BSA), Conjugated silver nanoparticles (SNPs) using aqueous leaf extract of *Jatropha glandulifera* Roxb with silver nitrate solution as an antiseptic and cauterizing agent, where albumin solution as a plasma volume expander and oncotic agent. For this purpose, SNPs are prepared by the bio reduction method and allowed to interact with the native BSA to form protein-conjugated nanoparticles. Specifically, they are a type of metal-based nanoparticle. The synthesized BSA conjugated SNPs were analyzed through UV-Visible, FT-IR Spectroscopy,

NMR, FESEM and Dynamic light scattering. They were spherical in shape with an average size of 50-90 nm. Different in-vitro antimicrobial activities of the synthesized Nano composites of *Jatropha glandulifera* Roxb. were carried out. The diameter of inhibition zones

around the disc of one gram positive and one-gram negative bacterial strains viz. *Staphylococcus aureus*, *Escherichia coli*. and antifungal activity of *Candida albicans* and *Aspergillus Niger* has highest antimicrobial activity. It is concluded that the green synthesis of BSA conjugated SNPs creates a stabilized Nano bio- conjugate which has high plasma protein binding capacity that shows maximal bioavailability without any side effect.

KEYWORDS: Silver nanoparticles, Bovine Serum Albumin, *Jatropha glandulifera* Roxb., UV; FT-IR; NMR; FESEM; DLS, Antimicrobial activity.

1. INTRODUCTION

Nanotechnology is defined as the engineering and application of functional systems at the molecular and atomic scale.^[1] It encompasses the precise manipulation of atoms and molecules for the development of novel materials and devices. Owing to its interdisciplinary nature, nanotechnology integrates concepts from physics, chemistry, biology, and engineering.^[2] Over the past decades, it has emerged as a transformative field with applications in healthcare, diagnostics, materials science, and biotechnology.^[3]

In the biomedical domain, nanotechnology is particularly significant in early disease detection and targeted drug delivery. Nanocarrier-based systems facilitate the controlled and site-specific release of therapeutic agents, thereby enhancing drug bioavailability and minimizing systemic side effects.^[4] Such systems are employed for the delivery of small-molecule drugs, nucleic acids, and messenger ribonucleic acid (mRNA). Nanoparticles, which typically range in size from 1-100 nm, consist of synthetic or semi-synthetic polymers and can encapsulate, entrap, or adsorb drugs within their matrix.^[5] The ideal nanoparticle delivery platform is characterized by biocompatibility, biodegradability, non-toxicity, and sterilizability, while simultaneously improving solubility, stability, and therapeutic efficacy.^[6]

Beyond drug delivery, nanotechnology contributes substantially to tissue engineering and regenerative medicine. Scaffold-free and scaffold-assisted nanoparticle-based systems promote osteogenesis, tissue regeneration, and neural repair.^[7] Furthermore, nanosensors enable the detection of pathological conditions such as cancer,^[8] Alzheimer's disease,^[9] and pacemakers^[10] can adapt dynamically to physiological environments and provide real-time health monitoring.^[11] Additionally, nanomaterials exhibit potent antimicrobial activity, offering novel solutions against multidrug-resistant infections.^[12]

Nanoparticles can be synthesized through chemical, physical, and biological methodologies. Conventional chemical routes are advantageous due to their rapid production and high yield, yet they often require stabilizing agents that generate toxic by-products, rendering the process environmentally unsustainable. Consequently, the paradigm of green nanotechnology has gained momentum.^[13] Green synthesis relies on eco-friendly, sustainable, and cost-effective resources such as plants, microorganism, and natural polymers, thereby eliminating the use of hazardous chemicals and high-energy input.^[14]

Among various nanomaterials, bovine serum albumin (BSA)-conjugated silver nanoparticles (SNPs) have demonstrated remarkable biomedical potential.^[15] These nanoparticles are synthesized via bio reduction, where silver ions interact with native bovine serum albumin to yield protein-conjugated silver nanoparticles.^[16] SNPs are recognized for their broad-spectrum antimicrobial and antiseptic properties, coupled with reduced cytotoxicity, making them valuable in topical formulations for the treatment of open wounds and burns.^[17]

Bovine serum albumin, a plasma protein with oncotic and volume-expanding agent. Structurally, BSA is a 67kDa polypeptide comprising 583 amino acids, including 59 lysine residues (of which 30-35 are available for crosslinking) and 17 disulfide bonds. Crosslinking process-whether covalent or non-covalent-enhance nanoparticle stability, prevent aggregation, and improve drug-loading capacity. Moreover, these interactions increase bioavailability and therapeutic efficacy without inducing adverse effects.^[18]

BSA conjugated silver nanoparticles exhibit a broad spectrum of pharmacological activities, including anticancer,^[19] antiviral,^[20] antifungal,^[21] anti-inflammatory,^[22] antioxidant,^[23] anti-angiogenic,^[24] and antiplatelet properties. These attributes underscore their potential as multifunctional nanoplatforms in advanced biomedical applications.^[25]

The study deals with green synthesis of Bovine serum albumin conjugated silver nanoparticles using the medicinal plant called *Jatropha glandulifera* Roxb. *Jatropha glandulifera* Roxb. commonly known as Glandular jatropa, Kattamannaku or Adalai and Vellaikattukottai. The plant is a species of shrubs petiole eglandular leaves palmately 3-5-lobed beyond the middle, to 14×10 cm; margins glandular; lobes obovate, serrate, shortly acuminate, cordate at base; stipules branched, with gland tipped hairs, to 25cm. Flowers greenish-yellow; bracts lanceolate, with gland-tipped hairs on the margins sepals free almost

to base; margin slightly dentate petals oblong-obovate, obtuse, hairy on the inside near base stamens 8, outer 5 and inner 3 schizocarp rugose, 15cm across.

The present study was Aim to investigate the Green synthesis of bovine serum albumin conjugated silver nanoparticles and characterized them using UV-visible spectroscopy, FT-IR, NMR, Dynamic light scattering and Field emission scanning electron microscopy and evaluation of antimicrobial activity of synthesized Nano composites of *Jatropha glandulifera* Roxb. were carried out. The diameter of inhibition zones around the disc of gram positive and gram-negative bacterial strains viz. *Staphylococcus aureus*, *Escherichia coli*. and antifungal activity of *Candida albicans* and *Aspergillus niger* was assessed.

2. MATERIALS AND METHODS

2.1. Collection of plant materials

The fresh leaves of *Jatropha glandulifera* Roxb. **Figure No.1** was collected from Thiruvadanai village in Ramanathapuram district, Tamilnadu, India. The leaves were rinsed in water to get rid of the fine dust particles and then leaves were dried in shadow area for a week to thoroughly eliminate the moisture.



Figure No. 1: *Jatropha glandulifera* Roxb.

2.2 Chemical requirements

Silver nitrate (AgNO₃), Bovine Serum Albumin (BSA), potassium hydroxide (KOH), Phosphate buffer saline and methanol were procured from Hi-Media laboratories Pvt., Ltd ., Mumbai.

2.3 Preparation of plant extract

10g of fresh leaves from *Jatropha glandulifera* Roxb. were collected and washed thoroughly with distilled water before extraction. Leaves were pulverized with domestic Grinder. The powder sample of 10gms was blended into 100 ml of distilled water and the mixture was boiled on heating mantle at 60°C for 1 hour. The extraction (**Figure No. 2**) was then cooled and filtered with Whatman filter paper NO.1 and stored at 4°C for further assay.



Figure 2: Plant extract (Aqueous).

2.4 Preparation of BSA Solution

The stock solutions of BSA (10mg/ml) were prepared in double distilled water. From stock solution, the working solution of BSA (1mg/ml) was used in the conjugation with silver nanoparticles.

2.5 Synthesis of Silver Nanoparticles from Plant Leaf extract

To perform the synthesis of silver nanoparticles by bio-reduction method, 10 ml of aqueous leaf extract of *Jatropha glandulifera* Roxb. was added into Erlenmeyer flask, with an addition of 90 ml of 1mM silver nitrate and 0.01M KOH solution was added to make the mixture slightly alkaline. The complete reaction was carried out in a dark room condition without exposure of light sources. The mixture was stirred at 150 revolutions per minute (rpm) on a magnetic stirrer over a hotplate at 50-60°C. The colour change of the reaction solution was observed for the characterization of silver nanoparticles. The reaction mixture was either incubated with BSA solution or stored at 4°C for further use.

Incubation of SNPs in BSA solution

The synthesized SNPs from *Jatropha glandulifera* aqueous leaf extract by using bio-reduction method was conjugated with BSA (1mg/ml) solution. This mixture of solution containing SNPs and BSA was stored at 4°C before physicochemical characterization studies (**Figure No. 3**). After the incubation period the resultant solution was centrifuged at 10,000

rpm for 15 minutes. The transparent solution was discarded and the pellets of BSA conjugated SNPs were collected and the final solution was dried in Vacuum dryer.



Figure No. 3: The solution change after the addition of silver nanoparticles.

3. Characterization of BSA conjugated SNPs

The synthesis of BSA conjugated SNPs was confirmed using SPECTROPHOTOMETER LAMBDA 35 PERKIN ELMER UV-Visible Spectrophotometer. The biomolecules in *Jatropha glandulifera* leaf extract, responsible for reducing Ag⁺ ions, were identified by FTIR analysis over the range 400 - 4000 cm⁻¹, showing transmittance (%T) versus Wavenumber cm⁻¹ by using FT-IR SPECTRUM 4700 TYPE A PERKIN ELMER SPECTROPHOTOMETER, FTIR helps to identify functional groups present in a sample based on characteristic absorption peaks. NMR provides detailed insights into the complex mixture of metabolites and elucidate the chemical composition and structure of molecules is determined by using BRUKER instrument. Surface morphology was observed through FESEM imaging using a FEI QUANTA-250 FEG instrument. The average particle size of the nanoparticles was calculated with Nano plus software.

3.1 Screening of Antibacterial activities

3.1.1 Antibacterial activity of BSA conjugated SNPs (Disc diffusion method)

The antibacterial potential of *Jatropha glandulifera* Roxb. derived BSA conjugated SNPs was assessed using the disc diffusion technique. Petri dishes (60 mm in diameter) containing Mueller-Hinton agar were inoculated with the respective test microorganism. Sterile discs (6 mm in diameter) were aseptically impregnated with 10 µl of the prepared samples and placed on the agar surface. The plate was maintained at room temperature for 30 minutes to facilitate diffusion of the compounds into the medium. Amoxicillin (10µl/disc) was employed as a positive control, serving as the standard antibiotic reference. The inoculated plates were

incubated at 37°C for 24 hours. Following incubation, the diameter of the inhibition zones was measured in millimeters. Each assay was performed in duplicate to ensure reproducibility of the results.

3.2 Screening of antifungal activities

The antifungal activity of the *Jatropha glandulifera* Roxb- derived BSA conjugated SNPs was evaluated using the disc diffusion method.

Culture media

Sabouraud's dextrose agar and broth (Hi-Media Pvt. Ltd., Bombay, India) were employed as the culture medium.

Fungal strains used

Clinical fungal strains, including candida albicans (MTCC-3498) and Aspergillus Niger (MTCC-961), Were procured from National chemical laboratory (NCL), Pune, Maharashtra, India and served as the test organisms.

Inoculum preparation

The fungal strains were separately cultured in Sabouraud's dextrose broth for 6 hours, and the resulting suspension were adjusted to final concentration of approximately 10^5 CFU/ml.

Determination of antifungal activity

The antifungal activity of *Jatropha glandulifera* Roxb-derived BSA conjugated SNPs were evaluated using the disc diffusion method. Petri plates (60 mm in diameter) were prepared with the standardized fungal suspensions. Sterile discs of 6mm diameter test samples and carefully placed on the agar surface. The plates were left undisturbed at room temperature for 30 minutes to allow compound diffusion. A positive control was prepared using 10µl of Amphotericin B, which served as the standard antifungal disc. Following this, the inoculated plates were incubated at 37°C for 24hrs. After incubation, the antifungal efficacy was assessed by measuring the diameter of the inhibition zones around each disc, recorded in millimeters.

4. RESULTS AND DISCUSSIONS

4.1 UV-visible spectroscopy analysis

The reduction of silver ions to silver nanoparticles was confirmed through UV-visible spectroscopic analysis. It is well established that Silver Nanoparticles (SNPs) exhibit a characteristic dark brown coloration, attributed to surface plasmon resonance (SPR) phenomena in metallic nanostructures. Upon the introduction of aqueous plant extract into the AgNO₃ solution, and it will be incubated with Bovine serum Albumin (BSA), a distinct brown coloration was observed, indicating nanoparticle formation.

The UV-visible spectrum (Figure No. 4) demonstrated a characteristic absorption maximum of BSA at 280nm. In agreement with previous studies, the appearance of an absorption band within the range of 400-420nm corresponded to the formation of SNPs. Notably, when BSA was incubated with SNPs in an equimolar ratio, a single absorption band emerged between 280nm and 300nm, with no discrete peaks corresponding to either BSA or SNPs. This spectral behavior suggests strong intermolecular interactions between BSA and silver nanoparticles, leading to the formation of nanocomposite in which both constituents are integrated.^[26]

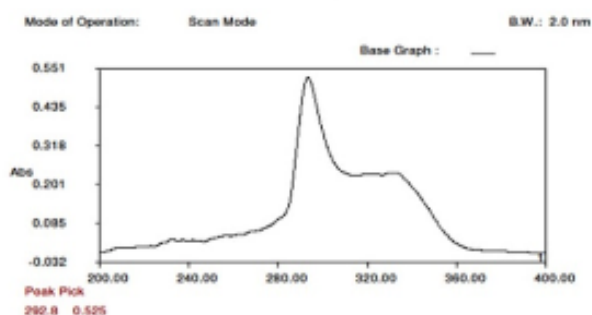


Figure 4: UV-visible spectroscopy analysis.

4.2 Fourier Transform Infrared spectroscopy

The biosynthesized BSA conjugated silver nanoparticles using *Jatropha glandulifera* Roxb. has FTIR spectrum (Figure No. 5). The absorption peaks at 3279 cm⁻¹, 2914 cm⁻¹, 2362 cm⁻¹, 2051 cm⁻¹, 1997 cm⁻¹, 1937 cm⁻¹, 1613 cm⁻¹, 1318 cm⁻¹, 1002 cm⁻¹, 781 cm⁻¹, 462 cm⁻¹, 432 cm⁻¹, 406 cm⁻¹ was illustrated in Figure. The presence of N-H stretching vibration indicating the presence of amine was revealed at peak 3279 cm⁻¹, Whereas 2914 cm⁻¹ reveals the presence of C-H stretching vibration indicating the presence of alkane. The peak 2051 cm⁻¹ reveals the presence of N=C=S stretching vibration indicating the presence of

isothiocyanate. The peaks 1997 cm^{-1} and 1937 cm^{-1} revealed the presence of C=O stretching vibration indicating the presence of carbonyl compounds. The peaks 1613 cm^{-1} and 1318 cm^{-1} has revealed the presence of C=C bending vibration indicating the presence of aldehyde respectively. The presence of C-O-CO stretching vibrations indicating the presence of C=C bending vibration indicating the presence of alkane was revealed at 1002 cm^{-1} . Finally, the peak 781 cm^{-1} reveals the presence of C-Cl or C-Br stretching vibration indicating the presence of halogenated compounds. The FTIR spectrum shows characteristic absorption bands for hydroxy (O-H), Carbonyl(C=O), and alkane(C-H) groups, suggesting the presence of phenolic compounds, Flavonoids, or other oxygenated phytochemicals.^[27]

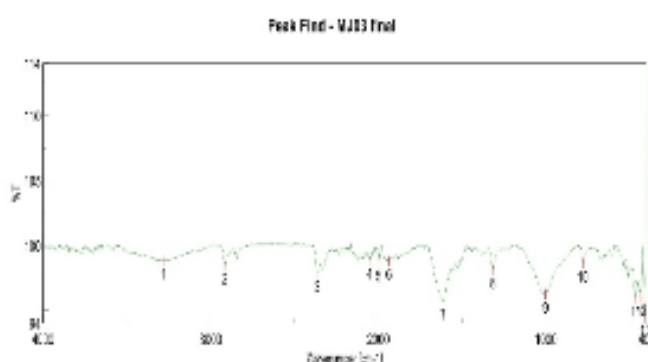


Figure No 5: Fourier Transform Infrared Spectroscopy.

4.3 Nuclear Magnetic Resonance (NMR) analysis

From the NMR (^1H -D₂O as a solvent) analysis, the spectrum mainly shows aliphatic protons. Strong signals in the 1-2.5 ppm region suggest long hydrocarbon chains (alkyl groups), possibly fatty acids, lipids, or polymeric organic material. Absence of peaks at 3-5 ppm (no sugars, alcohol -OH, or methoxy groups detected) and 6-9 ppm no aromatics. The ^1H NMR spectrum indicates a compound dominated by aliphatic hydrogens ($-\text{CH}_2-$, $-\text{CH}_3$ groups), with signals mainly between 1.2-2.6 ppm, suggesting fatty acid chains, aliphatic polymers, or hydrocarbon-like structure Shown in (Figure No.6).^[28]

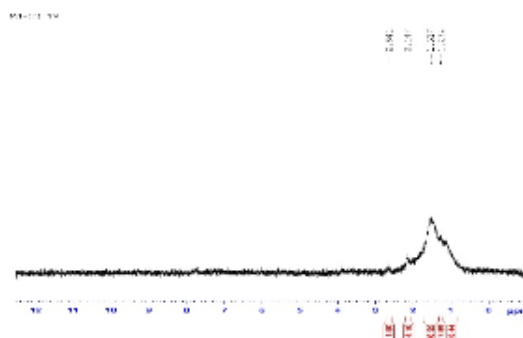


Figure 6: Nuclear Magnetic Resonance Analysis.

4.4 Field Emission Scanning Electron Microscopy (FESEM)

The morphological characteristics of the green-synthesized BSA conjugated silver nanoparticles (SNPs) were examined using Field Emission Scanning Electron Microscopy (FESEM). The **Figure No. 7** represent the FESEM image and The FESEM micrographs confirmed that the synthesized SNPs were uniformly distributed and exhibited a spherical morphology with particle sizes ranging between 50 and 90 nm. The shape and size of the nanoparticles are known to play aa crucial role in determining the optical and electronic behaviors of metallic nanoparticles.^[29]

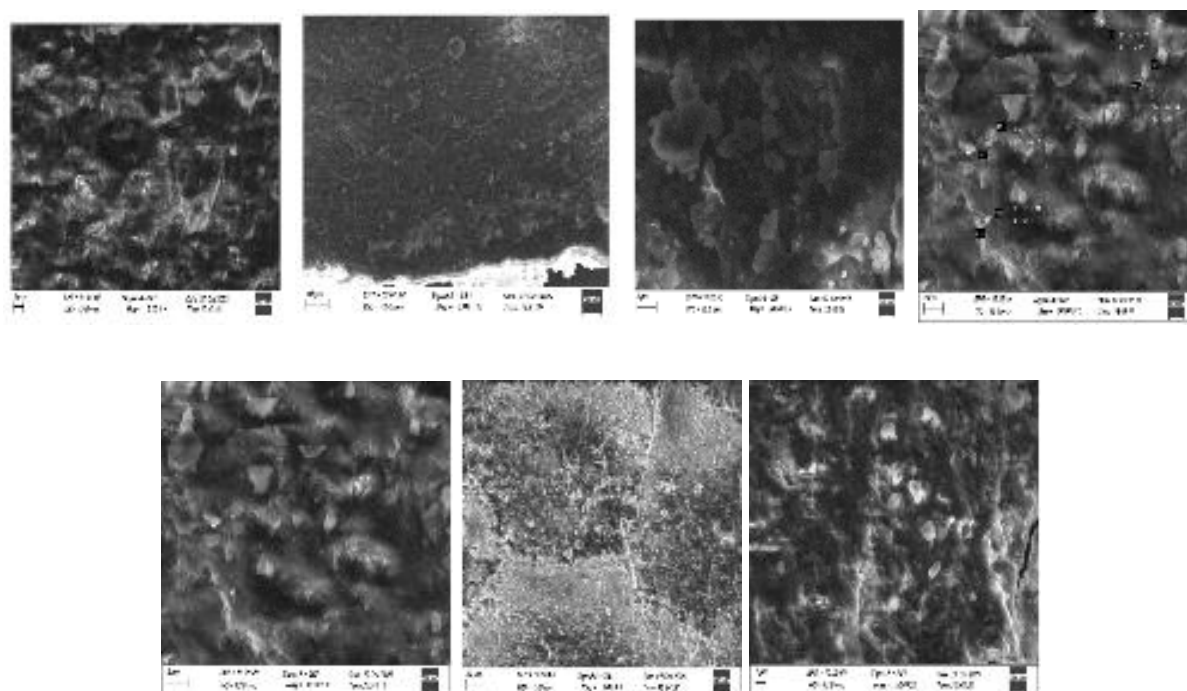


Figure No. 7: SEM image.

4.5 Dynamic Light Scattering

Dynamic Light Scattering (DLS) analysis was carried out to evaluate the particle size of synthesized BSA conjugated silver nanoparticles (SNPs).^[30] The obtained particle size distribution profile revealed that the nanoparticles exhibit a size range around 85.3 nm, with an average particle diameter of approximately 437.5 nm, as illustrated in **Figure No. 8**

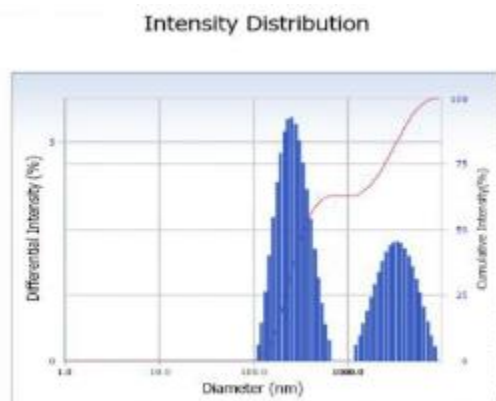


Figure No. 8: Dynamic light scattering.



Figure No 9: Antibacterial activity a) *E. coli*, b) *Staphylococcus aureus*.

4.6 Antibacterial activity

The antibacterial efficacy of the synthesized BSA conjugated silver nanoparticles was assessed against selected bacterial strains. Gram- positive bacteria, *Staphylococcus aureus* (MTCC 7443), along With a Gram-negative strain, *Escherichia coli*. (MTCC 443). were employed as test organism (**Figure No. 9**). All microbial strains were obtained from the microbial type culture collection (MTCC), Chandigarh, India. The bacterial cultures were incubated at 37C and preserved on nutrient agar slants (Difco, USA) at 4C for subsequent experimental use. The maximum inhibition zone of 8 mm against *E.coli*, as summarized in Table No 1.

Table No. 1: Zone of inhibition.

Samples	Concentration (μl)	Organisms/ Zone of Inhibition (mm)	
		Staphylococcus aureus	E. coli
A (Silver nitrate)	10 μl	0	0
B (Amoxicillin)	10 μl	9	8
C (Plant extract)	10 μl	7	8
D (Nanoparticles)	10 μl	6	7

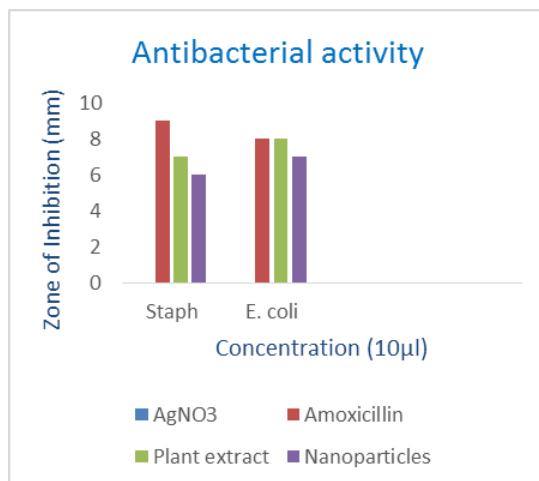


Figure No. 10.

4.7 Anti- fungal activity

The antifungal susceptibility assay results for the tested samples against the selected fungal strains are presented in Figure No 10. The findings revealed that among all the samples, Sample D exhibited the most potent antifungal efficacy, displaying the maximum inhibition zone of 7mm against candida albicans, as summarized in Table No 2.

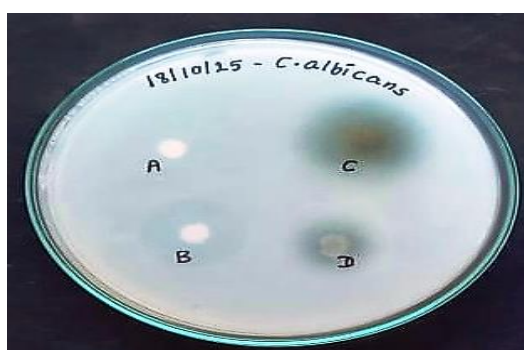
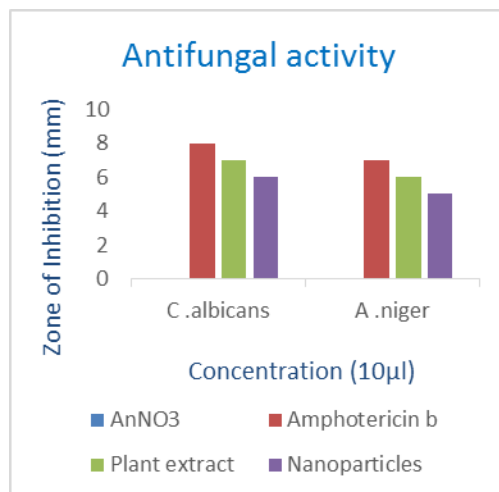
a) *Aspergillus Niger*.b) *Candida albicans*

Table No. 2: Zone of inhibition.

Samples	Concentration (µl)	Organisms/ Zone of Inhibition (mm)	
		Aspergillus Niger	Candida albicans
A (Silver nitrate)	10 µl	0	0
B (Amphotericin b)	10 µl	8	8
C (Plant extract)	10 µl	6	7
D (Nanoparticles)	10 µl	4	5



5. CONCLUSION

Jatropha glandulifera Roxb leaf extract proved to be suitable for eco-friendly synthesis of BSA conjugated silver nanoparticles (SNPs). The reduced silver ions by the leaf extract were coated with Bovine serum albumin, leading to the formation of stable, spherical nanoparticles. Both the concentration of the leaf extract and the silver ions were found to significantly influence the synthesis process of SNPs. Characterization techniques, including UV-Visible spectroscopy, FESEM, and particle size analysis, confirmed the successful formation, size, and shape of the nanoparticles. ^1H NMR spectrum indicates that the compound (BSA conjugated SNPs) is predominantly aliphatic, likely comprising fatty acids, lipids, or hydrocarbon-like structures, with no aromatic or polar groups present. The FT-IR analysis demonstrated the stability and formation of the biosynthesized SNPs, providing insights into the chemical and molecular interactions involved in nanoparticle synthesis.

The antibacterial activity of the BSA capped silver nanoparticles was evaluated against Gram positive bacteria, *Staphylococcus aureus* (MTCC 7443) as well as Gram negative bacterium, *Escherichia coli* (MTCC 443), resulting in the minimal concentration of sample that produces the maximal zone of inhibition. Antifungal studies indicated good activity against the test organism, with *Candida albicans* showing the highest sensitivity to the synthesized

nanoparticles. Flavonoids in the *Jatropha glandulifera* Roxb leaf extract exhibit potent antimicrobial activity through multiple mechanisms, highlighting its potential as a natural antimicrobial agent. In eco-friendly synthesis of BSA conjugated SNPs has high plasma protein binding capacity that shows maximal bioavailability without any side effect.

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REFERENCES

1. Hashemnia S, Zarei H, Mokhtari Z, Mokhtari MH. An investigation of the effect of PVP-coated silver nanoparticles (SNPs) on the interaction between clonazepam and bovine serum albumin based on molecular dynamics simulations and molecular docking. *J Mol Liquids*, 2021; 323: 114915.
2. Khan SA, Shahid S, Lee CS. Green synthesis of gold and silver nanoparticles using leaf extract of *Clerodendrum inerme*; characterization, antimicrobial, and antioxidant activities. *Biomolecules*, 2020; 10(6): 835.
3. Morales-Lozoya V, Espinoza-Gómez H, Flores-López LZ, Sotelo-Barrera EL, Núñez-Rivera A, Cadena-Nava RD, et al. Study of the effect of the different parts of *Morinda citrifolia* L.(noni) on the green synthesis of silver nanoparticles and their antibacterial activity. *Appl Surface Sci.*, 2021; 537: 147855.
4. Devipriya R Majumder. Waste to health: Bioleaching of nanoparticles from e-waste and their medical applications. *Indian J appl research*, 2013; 3(2): 2249-555.
5. Hassan Korbekandi, Siavash Irvani. Silver Nanoparticles. *Nanotechnology and nanomaterials*, 2012; 5-16.
6. Brigger I, Dubernet C, Couvreur P. Nanoparticles in cancer therapy and diagnosis. *Adv Drug Deliv Rev.*, 2012; 64: 24–36.
7. Kuppusamy P, Yusoff MM, Maniam GP, Govindan N. Biosynthesis of metallic nanoparticles using plant derivatives and their new avenues in pharmacological applications-An updated report. *Saudi Pharm J.*, 2016; 24(4): 473-84.
8. Pradhan B, Patra S, Behera C, Nayak R, Patil S, Bhutia SK, et al. Enteromorpha compressa extract induces anticancer activity through apoptosis and autophagy in oral cancer. *Mol Biol Rep.*, 2020; 47: 9567-78.

9. Bhanjadeo MM, Baral B, Subudhi U. Sequence-specific B-to-Z transition in self-assembled DNA: A biophysical and thermodynamic study. *Int J Biol Macromol*, 2019; 137: 337-45.
10. Basarkar A, Singh J. Poly (lactide-co glycolide) polymethacrylate nanoparticles for delivery of intramuscular plasmid encoding interleukin-10 to prevent autoimmune diabetes in mice. *Pharm Res.*, 2009; 26: 72–81.
11. Roy K, Mao HQ, Huang SK, Leong KW. Oral gene delivery with chitosan DNA nanoparticles generates immunologic protection in a murine model of peanut allergy. *Nat. Med.*, 1999; 5: 387–391.
12. Furno F, Morley KS, Wong B, Sharp BL, Arnold PL, Howdle SM et al. Silver nanoparticles and polymeric medical devices: a new approach to prevention of infection. *J Antimicrob Chemother*, 2004; 54: 1019–1024.
13. Amatya R, Hwang S, Park T, Chung YJ, Ryu S, Lee J, et al. BSA/silver nanoparticle-loaded hydrogel film for local photothermal treatment of skin cancer. *Pharm Res.*, 2021; 38: 873-83.
14. Barbir R, Jimenez RR, Martín-Rapún R, Strasser V, Domazet Jurašin D, Dabelić S, et al. Interaction of differently sized, shaped, and functionalized silver and gold nanoparticles with glycosylated vs. nonglycosylated transferrin. *ACS Appl Mater Interfaces*, 2021; 13(23): 27533-47.
15. Casals E, Pfaller T, Duschl A, Oostingh GJ, Puntès V. Time evolution of the nanoparticle protein corona. *ACS Nano*, 2010; 4(7): 3623-32.
16. Wilson DS, Dalmaso G, Wang L, Sitaraman SV, Merlin D, Murthy N. Orally delivered thioketal nanoparticles loaded with TNF- α – siRNA target inflammation and inhibit gene expression in the intestines. *Nat. Mater*, 2010; 9: 923–928.
17. Mano Priya M, Karunai Selvia B, John Paul JA. Green Synthesis of Silver Nanoparticles from the Leaf Extracts of *Euphorbia Hirta* and *Nerium Indicum*. *Digest. J. Nanomat. Biostruct*, 2011; 6(2): 869–877.
18. A. K. Mittal, Y. Chisti, U. c. Banerjee “Synthesis of metallic nanoparticles using plants” *Biotechnol. Adv.*, 2013; 31: 346-356.
19. Zhao Z, Li G, Liu QS, Liu W, Qu G, Hu L, et al. Identification and interaction mechanism of protein corona on silver nanoparticles with different sizes and the cellular responses. *J Hazardous Mater*, 2021; 414: 125582.
20. Pradhan B, Nayak R, Patra S, Bhuyan PP, Dash SR, Ki JS, et al. Cyanobacteria and algae-derived bioactive metabolites as antiviral agents: Evidence, mode of action, and

- scope for further expansion: A comprehensive review in light of the SARS-CoV-2 outbreak. *Antioxidants*, 2022; 11(2): 354.
21. M. Ip, S. L. Lui, V. K. M. Poon, I. Lung, and A. Burd, “Antimicrobial activities of silver dressings: an in vitro comparison,” *Journal of Medical Microbiology*, 2006; 55(1): 59–63.
 22. Young IS, Woodside JV. Antioxidants in health and disease. *J Clin Pathol.*, 2001; 54(3): 176-86.
 23. Pradhan B, Patra S, Dash SR, Satapathy Y, Nayak S, Mandal AK, et al. In vitro antidiabetic, anti-inflammatory and antibacterial activity of marine alga *Enteromorpha compressa* collected from Chilika lagoon, Odisha, India. *Vegetos*, 2022; 35(3): 614-21.
 24. J. s. Kim, E. Kuk, K. N. Yu, J. H. Kim, S. J. Park, H. J. Lee, et al “Antimicrobial effects of silver nanoparticles” *Nanomed. Nanotechnol.*, 2007; 3: 95-101.
 25. S. Gurunathan, J. Raman, S. N. Abd Malek, P. A. John, S. Vikineswary “Green synthesis of silver nanoparticles using *Ganoderma neojaponicum* Imazeki: a potential cytotoxic agent against breast cancer cells” *Int. J. Nanomed.*, 2013; 8: 4399 4413.
 26. K. Saranya Devi, V. Subha, R. S. Ernest Ravidran, Sahadevan Renganathan “Green synthesis and characterization of silver nanoparticles using leaf extract of *Capparis Zeylanica*” *Asian Journal of Pharmaceutical and clinical Research*, 2014; 7(sup 2): 2.
 27. N. Supraja, B. Avinash and T. N. V. K. V Prasad “Green synthesis and characterization of silver nanoparticles from *Gymnema sylvestre* leaf extract: study of Antimicrobial activities” *International Journal of current microbiology and applied science*, Vol 6 Number, 2017; 3: 530-540.
 28. Asmathunisha, N., Kathiresan, K., Anburaj, R., & Nabeel, N. A. (2010) Synthesis of antimicrobial silver nanoparticles by callus leaf extracts from saltmarsh plant *Sesuvium portulacastrum* L. *Colloids Surf B Biointer*, 79: 488–493.
 29. H. Wei, H. Xu “Nanowire-based plasmonic waveguide and devices for integrated nanophotonic circuits, *Nanophotonics*, 2012; 1(2): 155 169.
 30. Ghorbani H. R Biosynthesis of silver nanoparticles using *Salmonella typhirium* *Journal of nanostructure in Chemistry*, 2013; 29-32.