Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

BIOSYNTHESIS, CHARACTERIZATION, AND ANTIBACTERIAL ACTIVITY OF SILVER NANOPARTICLES SYNTHESIZED FROM VEGETABLE PEELS

Qurratul Ain Leghari[1], Hasnain Haider Rizvi[2], Muhammad Saleh Zafar Mirza[3], Ali Asgher Shuja[4], Qadeer Ahmed[5], Abida Parveen[6], Raza Rabbani[7], Farah Qayyum[7]

[1]Department of Pharmaceutical Chemistry, Faculty of Pharmacy, Hamdard University, Karachi, Pakistan

[2]Institute of Molecular Biology and Biotechnology, University of Lahore, Lahore, Pakistan

[3]Faculty of Bio-Sciences, Department of Food Science and Human Nutrition, University of Veterinary and Animal Sciences (UVAS), Lahore, Pakistan

[4]Department of Basic Medical Sciences, Faculty of Pharmacy, Salim Habib University, Karachi, Pakistan

[5]Department of Chemistry, Lahore Garrison University, Lahore, Pakistan

[6]Department of Biological Sciences, Superior University Lahore, Pakistan

[7]Institute of Chemistry, Khawaja Fareed University of Engineering and Information Technology Rahim Yar Khan, Punjab, Pakistan

Corresponding Author: Qurratul Ain Leghari, Department of Pharmaceutical Chemistry, Faculty of Pharmacy, Hamdard University, Karachi, Pakistan

Email: qurratulainlaghari@gmail.com

ABSTRACT

Silver nanoparticles (AgNPs) have garnered considerable attention for their potent antibacterial properties, offering promising applications in various fields, including medicine and industry. This study explored the eco-friendly biosynthesis of silver nanoparticles using potato peels (Solanum tuberosum) as a natural reducing and

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

stabilizing agent and evaluated their antibacterial efficacy against pathogenic microorganisms. Potato peels serve as a cost-effective and sustainable source for AgNP synthesis. The reduction of silver ions will be monitored using UV-visible spectroscopy, while the morphology and structural characteristics of the nanoparticles will be analyzed through Fourier Transform Infrared Spectroscopy (FTIR) and X-ray Diffraction (XRD). The antibacterial activity of the synthesized AgNPs against *Pseudomonas aeruginosa* and *Acinetobacter baumannii* will be assessed using a good diffusion assay. The eco-friendly synthesis of silver nanoparticles with notable antibacterial properties highlights their potential applications in biomedical and industrial settings.

Keywords: Silver nanoparticles, Potato Peels, Antibacterial Properties, Medicine, Industry.

INTRODUCTION

Antibiotic Resistance as a problem Antibiotic resistance is a complex issue with multifaceted implications for global health. It arises when bacteria evolve mechanisms to withstand the effects of antibiotics, rendering these medications less effective in treating infections. The overuse and misuse of antibiotics accelerate this process [1]. Overconsumption of antibiotics, often for viral infections where they are ineffective, contributes to resistance. Incomplete antibiotic courses can leave surviving bacteria with a higher likelihood of developing resistance [2]. Resistant infections are harder to treat, leading to prolonged illness, increased healthcare costs, and a higher risk of complications. Routine medical procedures like surgeries, chemotherapy, and organ transplants become riskier due to the potential for antibiotic-resistant infections. The spread of resistant bacteria within communities and healthcare settings poses a significant public health risk [3]. Diseases that will be easily treatable may become deadly, impacting both developed and developing nations. Antibiotic-resistant bacteria can easily spread across borders, emphasizing the need for international collaboration [4]. Global travel and trade facilitate the dissemination of resistant strains, necessitating coordinated efforts to address the issue. Fewer effective antibiotics mean limited treatment options for various bacterial infections The development of new antibiotics is slow due to scientific,

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

regulatory, and economic challenges [5].

Drug Resistance prevalence

Drug resistance, including antibiotic resistance, is a growing global concern. The prevalence of drug resistance varies depending on the type of drug, region, and specific infectious agents. Many bacterial infections are becoming resistant to commonly used antibiotics [7]. The antibacterial resistance of AgNPs could help protect food from microbial contamination *Pseudomonas aeruginosa* and *Acinetobacter* will be used to determine antibacterial activity Drug resistance is not limited to specific countries; it's a global challenge that affects developed and developing nations alike. Resistant infections can spread across borders through travel and trade [8] Drug-resistant infections lead to prolonged illnesses, increased mortality, and higher healthcare costs [9]. The effectiveness of medical procedures like surgeries and cancer treatments is compromised. Developing new drugs is crucial to combat resistance, but the process is slow and faces scientific, regulatory, and economic challenges [10].

No treatment Carbapenem drug post-burn infection

Carbapenem-resistant infections following burn injuries present a formidable challenge in medical treatment [11]. Burn injuries compromise the skin's natural barrier, rendering patients highly susceptible to infections. Traditionally, carbapenem drugs will serve as a last line of defense against multidrug-resistant bacteria [12]. However, the reality of post-burn infections lies in the lack of effective carbapenem treatment options. Carbapenem-resistant strains, often associated with healthcare settings, pose a serious threat to the management of burn-related infections [13]. Antimicrobial resistance has emerged as one of the most pressing global health threats of the 21st century Among the numerous challenges posed by AMR, the rise in carbapenem resistance stands out as a serious concern due to the limited availability of effective and safe alternative antimicrobial treatments[14]. Recognizing the rapid emergence and dissemination of carbapenem-resistant gram-negative pathogens is a significant clinical challenge. The potency of carbapenems against multidrug-resistant gram-negative pathogens has long been established, making the rise in resistance even more alarming [15]. Moreover, the dearth

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

of viable alternative antibiotics amplifies the difficulty in containing multidrug-resistant strains The overall carbapenem resistance rate of the Gram-negative bacteria was 38% for imipenem and 46% for meropenem *Acinetobacter baumannii, Klebsiella pneumonia,* and *Pseudomonas aeruginosa* topped the list of carbapenem-resistant species [16]. This study revealed a prevalence rate of 4.5% for carbapenem resistance (13,262 out of 292,742 infections). Among these carbapenem-resistant infections, 60.3% were caused by *Pseudomonas aeruginosa,* 22% by *Acinetobacter baumannii,* and 17.7% were caused by Klebsiella pneumonia [17]. Furthermore, a recent multicenter study in 2023 illustrated the highest level of carbapenem resistance among *Acinetobacter baumannii (*92%) and *Pseudomonas aeruginosa* (88%) isolates [18]. While *Klebsiella pneumoniae* (37%), and *Escherichia coli* (14%) exhibited a lower level of resistance [19]. Indeed, the World Health Organization (WHO) has issued a global priority list of antibiotic-resistant bacteria that require critical attention for research and development of new antibiotics [20].

Chemical synthesis of nanoparticles

Various reducing agents can be used in the synthesis of silver nanoparticles, including chemical reagents or natural sources like plant extracts [21]. Common reducing agents include sodium borohydride (NaBH4), hydrazine, citrate, and polyphenols found in natural extracts. Stabilizing agents such as polyvinylpyrrolidone (PVP), sodium citrate, and surfactants like cetyltrimethylammonium bromide (CTAB) are often employed to prevent agglomeration and stabilize the nanoparticles [22]. Silver nanoparticles are typically synthesized using a silver salt precursor, commonly silver nitrate (AgNO3). The precursor solution is prepared by dissolving a specific amount of AgNO3 in a suitable solvent, usually deionized water [23]. The concentration of the silver precursor solution can vary depending on the desired size and concentration of the nanoparticles. The silver precursor solution is mixed with the reducing agent under controlled conditions. This can be done by adding the reducing agent directly to the precursor solution or by slowly adding the precursor solution to the reducing agent solution. The reaction conditions, including temperature, pH, and reaction time, are optimized to facilitate the reduction of

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

silver ions (Ag^{+}) to elemental silver (Ag^{0}) nanoparticles [24]. The reduction process involves the transfer of electrons from the reducing agent to the silver ions, leading to their reduction and subsequent formation of silver nanoparticles. As the reduction reaction proceeds, nucleation occurs, leading to the formation of small silver nuclei. These nuclei act as seeds for further nanoparticle growth. The size, shape, and distribution of the nanoparticles can be controlled by adjusting various parameters such as the concentration of the silver precursor, the ratio of reducing agent to silver ions, and the reaction temperature [25]. The growth of nanoparticles continues until the reaction reaches equilibrium or until the supply of silver ions or reducing agents is depleted. To prevent the agglomeration or aggregation of silver nanoparticles, stabilizing agents are often added during or after the synthesis process [26]. These agents adsorb onto the surface of the nanoparticles, providing steric or electrostatic repulsion between them and maintaining their stability in solution. Stabilizing agents also help to control the growth and size distribution of nanoparticles, leading to uniform and well-dispersed particles. The synthesized silver nanoparticles are characterized using various analytical techniques to determine their size, shape, morphology, and optical properties [27]. Common characterization techniques include UV-Vis spectroscopy, which measures the absorption spectrum of the nanoparticles, providing information about their size and concentration. Other techniques such as transmission electron microscopy (TEM), scanning electron microscopy (SEM), and dynamic light scattering (DLS) can be used to visualize the nanoparticles and analyze their size distribution and morphology [28].

Biosynthesis of silver nanoparticles

Potatoes peels *(Solanum tuberosum)* will be collected from vegetable waste. Discard contamination and residue, it will be completely washed with regular water multiple times before being flushed with refined water. The wiped peels will be dried into order or disposed get rid of moisture [29]. The dehydrated potato peels will be managed into fine particle composition or put away in a container till more usage. A proportion of 30 g of fine particles will be boiled for 50 min at 65°C in 250 mL refined water to get ready for plant derivation. It was then, at that point, put away in a refrigerator and dim spot without

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

troubling for 3 h [30]. separated with the help of Buckner pipe utilizing channel paper (Whatman channel paper no. 1) or a suction pump. The gained derive will be preserved at 4 c in the container. 1 mM of silver nitrate (AgNO3) liquid preparation Will be organized as pointed out by the essential for producing AgNPs. For the preparation of silver nanoparticles, 50 mL of liquid preparation of AgNO3 will be added to 1.5 mL of potato peels [31]. The mix will be boiled for 30 min at 65°C, followed by hatch for 24 h at room temperature. Based on color change hatched extract of potato (Solanum tuberosum) peels showed the generated of AgNPs. Biosynthesized nanoparticles will be visually examined followed by various techniques, like UV-vis spectroscopy, Fourier transform infrared spectroscopy (FITR), and X- Rays diffraction (XRD) [32]. Biological processes are receiving more focus than physical and chemical methods for the synthesis of nanoparticles. The utilization of natural sources for the synthesis of nanoparticles has obtained sufficient attention due to their eco-friendly and sustainable nature. Among the different sources, potato strips have arisen as a promising possibility for biosynthesized silver nanoparticles. Biosynthesis process, and antibacterial activity of silver nanoparticles derived from potato peels [33]. Nanotechnology has emerged as one of the enormous and offering interesting elements and has broad applications in different areas like horticulture, food, and biomedicine the improvement of an ecologically protected and maintainable biochemical method [34]. Nanoparticles are consistently connected with the organization of drug preparation, electrical, mechanical, and beauty care products, optical action, screening, and various sectors. Potato peels often disposed of as waste, are rich in bioactive compounds, for example, phenolic mixtures, flavonoids, and nutrients. These compounds not only add to the healthy benefit of potatoes but also process reducing and stabilizing properties, making them ideal possibility for nanoparticle synthesis. Overall, a ton of squander from food is made or quick monopolization, administration of food will be developed into an extraordinary issue as a well just like an efficient weight food waste debasement show the appearance of CO2 and methane. Reutilizing food squander has developed into a major for restriction waste or expanding the worth of food crops [35]. People can't use all pieces of food crops, so

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

waste parts, for example, peels will be changed to important items or resources for the synthesis of nanomaterials. Analyze the properties of silver nanoparticles. The biosynthesis process includes the reduction of silver nanoparticles. (ag+) present in silver precursor by the bioactive compound in the potato peels removed. the reducing agent acts as both a reducing or anchoring agent working with the arrangement and adjustment of silver nanoparticles. The decision and reducing agent, temperature, or pH during the synthesis process play a vital in determining the traits of the resulting nanoparticles, including size, shape, and surface charge. characterization techniques like UV-visible spectroscopy, X Rays diffraction (XRD), transmission electron microscopy (TEM), and Fourier-charge infrared spectroscopy (FTIR) are utilized to analyze the properties of silver nanoparticles UV-visible spectroscopy is utilized to screen the development of AgNPs given the surface plasmon reverberation phenomena, while XRD offers data about the crystalline nature of the nanoparticles [36]. TEM offers insight into the size and morphology, and FTIR helps identify the functional group engaged in the reduction and stabilization process of the development of AgNPs utilizing vegetable peels, vegetable-based composite substances are creatures applied to fabricate reasonable manufactured AgNPs, which are gaining interest in more cost-effective, or they observe as to naturally valuable because of minor usage of harmful synthetic compounds [37]. The presence of antioxidants or antibacterial properties in plant extract is observed reason for the utilization an antimicrobial activity. The vegetable peels or organic products that are generally discarded in the waste hold various necessary compounds [38]. These compounds could be used as raw materials to make AgNPs. The products of the soil peels inhibit polyphenol structures that are a quarter more plentiful than in their well-rounded parts AgNPs that are generated biologically will be found too more successful, productive, or reasonable. Potato *(Solanum tuberosum)* is an important widely unusual crop ingested around the world. Potato peels contain enormous amounts of components that have germ-free, antibacterial, and cancer-prevention agent activity. Bioactive parts found in phenolic acids like gallic acids, are useful in cancer prevention agent exercises and are found in potato peels [39]. The antimicrobial action of AgNPs combined with

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

potato peel extract is attributed to the cooperative impact of different bioactive compounds present in the peels. Phenolic compounds, flavonoids, and other secondary metabolites add to the general antimicrobial sustainability. The particular mechanism of action includes the penetration of nanoparticles into microbial cells, including oxidative stress, disturbing cell membranes, and interfering with vital cellular processes. In the clinical field, silver nanoparticles will be shown guaranteed as antimicrobial specialists for wound dressings, coatings on clinical devices, and drug delivery systems. Their capacity to conflict with multidrug-safe microorganisms makes them significant in disposed to difficulties related to anti-infection resistance. The significant synthetic ingredients in potato peels that add antimicrobial traits are quinones, tannins, and coumarins. Additional extra lipid content and other bioactive components in potatoes the environmentally synthesis nanoparticles for human purposes. Plant-mediated silver nanoparticles utilizing different plant peel extracts, including potato-derived, and assessed their antimicrobial activity. The antibacterial properties will show nanoparticles incorporated from potato peel derived [40]. The synthesis of silver nanoparticles synthesized from potato peels holds potential for practical implementation contributing to the advancement of innovative and sustainable solutions in various domains.

Methodology

Collection of potato peel

Potatoes peels (Solanum tuberosum) were collected vegetable waste. Discard of contamination and residue, it was completely washed with regular water to multiple times prior to being flushed with refined water. The wiped peels were dried in to order or dispose get rid of moisture.

Preparation of peel extract

The dehydrated potato peels were managed into fine particle composition or put away in a container till more usage. A proportion of 30 g of fine particles was boiled for 50 min at 65°C in 250 mL refined water to get ready for plant derived. It was then, at that point, put away in a refrigerator and dim spot without troubling for 3 h. separated with the help of Buckner pipe utilizing channel paper (Whatman channel paper no. 1) or a suction pump.

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

The gained derive will be preserved at 4 c in a container.

Synthesis of silver nanoparticles using Microwave-assisted sol-gel method

preparation of precursor solution for synthesizing **silver nitrate** nanoparticles using the microwave-assisted sol-gel method:

Selection of Precursors

Choose sliver-containing precursor chemicals suitable for the desired phase of sliver nitrate nanoparticles. Common precursors include silver nitrate, and iron (III) chloride.

Chemical Handling and Safety

Ensure proper safety measures are followed when handling precursor chemicals. Use appropriate personal protective equipment (PPE) such as gloves, goggles, and lab coat. Work in a well-ventilated laboratory hood to prevent exposure to fumes or vapors.

Weighing of Precursors

Accurately weigh the required amount of iron precursor using a calibrated analytical balance. The amount of precursor used was depend on the desired concentration.

Solvent Selection

Choose a suitable solvent for dissolving the iron precursor. Common solvents include ethanol, distilled water, or a mixture of solvents depending on the solubility of the precursor and desired reaction conditions.

Dissolution of Precursor

Transfer the weighed sliver precursor into a clean and dry glass beaker or flask. Add the chosen solvent slowly to the precursor while stirring continuously to ensure complete dissolution. Apply gentle heating if necessary to facilitate dissolution, but avoid boiling the solvent.

Homogenization of Solution

Stir the precursor solution thoroughly using a magnetic stirrer or a glass rod until a homogeneous solution is obtained. Ensure that no undissolved particles or aggregates are present in the solution.

Microwave Irradiation

Place the container containing the precursor solution in a microwave reactor capable of

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

providing controlled microwave irradiation. Subject the precursor solution to microwave radiation at an appropriate power and duration, typically ranging from a few minutes to several tens of minutes. Examine the temperature of the solution during microwave irradiation to prevent overheating and ensure uniform heating.

Observation of Sol Formation

During microwave irradiation, observe the formation of the sol, which is indicated by the appearance of a homogeneous, colloidal suspension of nanoparticles. The sol may exhibit characteristic changes in color, viscosity, or transparency as the nanoparticles nucleate and grow within the solution.

Cooling and Stabilization

After microwave irradiation, allow the soil to cool to room temperature to stabilize the nanoparticles. During cooling, the sol may undergo further particle growth or aggregation, resulting in changes in the properties of the sol.

Characterization

Optionally, characterize the sol using techniques such as dynamic light scattering (DLS), zeta potential measurement, or spectroscopic analysis to determine the particle size distribution, stability, and chemical composition.

Storage

Store the prepared sol in a sealed container to prevent evaporation or contamination. Protect the sol from light and temperature variations, as these factors can affect the stability and properties of the nanoparticles in the soil.

Calcination

Preparation of Calcination Equipment

Preheat a muffle furnace or a suitable calcination oven to the desired temperature. The temperature was depended on the specific phase and properties of sliver nitrate nanoparticles being synthesized.

Transfer of Gel

Transfer the gel containing the silver nitrate nanoparticles onto a clean and dry crucible or ceramic boat suitable for calcination. Ensure that the gel is spread evenly and thinly to

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

facilitate uniform heating and prevent agglomeration during calcination.

Loading into Furnace

Place the crucible or ceramic boat containing the gel into the preheated furnace. Position the crucible or boat in the center of the furnace chamber to ensure uniform heating.

Calcination Process

Gradually increase the temperature of the furnace to the desired calcination temperature. Typically, the calcination temperature for iron oxide nanoparticles ranges from 600°C to 800°C, depending on the desired phase composition, crystallinity, and properties. Maintain the calcination temperature for a specified duration, typically ranging from 1 to 4 hours, to ensure complete conversion of the gel into sliver nitrate nanoparticles.

Cooling Process

After the desired calcination duration, turn off the furnace and allow the samples to cool naturally inside the furnace chamber to room temperature. Avoid rapid cooling to prevent thermal shock and cracking of the nanoparticles.

Removal of Samples

Samples cooled to room temperature, carefully remove the crucible or ceramic boat from the furnace using heat-resistant gloves or tongs. Handle the samples with care to avoid damage or contamination.

Characterization of Nanoparticles

Optionally, characterize the synthesized iron oxide nanoparticles using various analytical techniques such as X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR)

Evaluation of antibacterial activity

The antimicrobial properties of silver nanoparticles were generally observed for their potential against multidrug-resistant isolates including *Pseudomonas aeruginosa* and *Acinetobacter baumanni* Well diffusion assay checked the antibacterial activity of synthesized nanoparticles as opposed to MDR-selected isolates. The evaluation of antibacterial activity from vegetable peels involves a comprehensive process aimed at understanding the potential of these natural extracts in combating bacterial infections.

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

Vegetable peels, often discarded as waste, can be rich sources of bioactive compounds with antimicrobial properties. Common vegetables such as potatoes, carrots, and cucumbers have peels that may contain compounds like phenols, flavonoids, and essential oils known for their antimicrobial properties. The identification of specific bioactive compounds is crucial. Techniques like chromatography and spectroscopy can be employed to identify and quantify the presence of antimicrobial compounds. Understanding the composition of the peel extracts aids in determining their potential efficacy against bacteria. Bacterial strains relevant to post-burn infections, such as *Staphylococcus aureus* or *Pseudomonas aeruginosa*, are chosen for testing. These strains are cultured and maintained in a laboratory setting, ensuring their viability and purity for subsequent experiments. The evaluation of antibacterial activity from vegetable peels is a multifaceted process that involves extraction, identification, bacterial culture preparation, and rigorous testing methods. This research contributes to our understanding of the potential application of natural sources in addressing post-burn infections, providing a basis for further studies and the potential development of antimicrobial agents.

RESULT

. **UV Spectrophotometer Analysis with Silver Nanoparticles from Potato Peels**

The UV spectrophotometer is a confirmatory test for the synthesis of silver nanoparticles (AgNPs) and their conjugation with Sorafenib and Folic Acid. The average peak of silver nanoparticles synthesized from potato peels typically lies between 300-400 nm, with a common peak observed around 380 nm. Silver nanoparticles conjugated with Sorafenib show a characteristic peak around 270 nm after performing tests at 20-minute intervals. Similarly, silver nanoparticles conjugated with Folic Acid exhibit a peak around 290 nm. These shifts in absorbance are indicative of successful conjugation of the drugs with the silver nanoparticles, and the UV spectrum provides an essential confirmation of the synthesis and interaction between the silver nanoparticles and the drugs. The UV data can also help in monitoring the stability of the conjugated nanoparticles over time

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

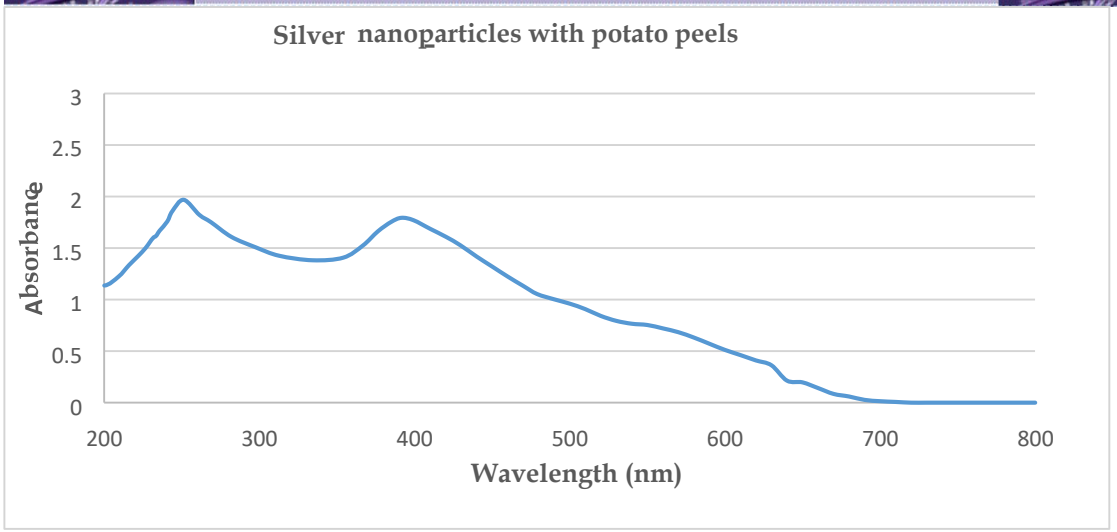


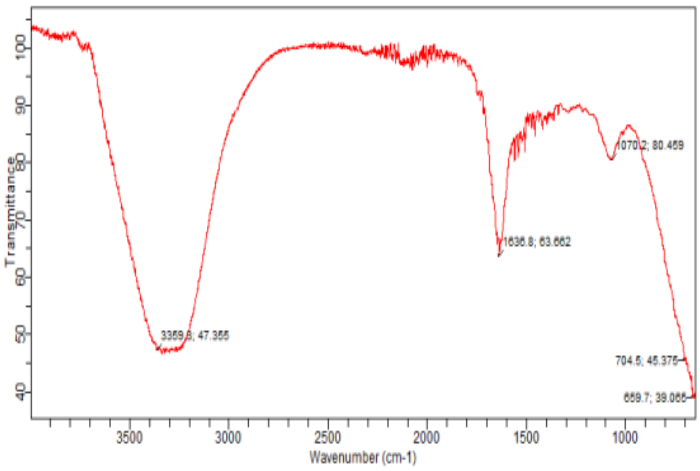
Figure 01: UV analysis of sorafenib-Folic Acid-ZnS NPs

FTIR Analysis with Silver Nanoparticles and Potato Peels

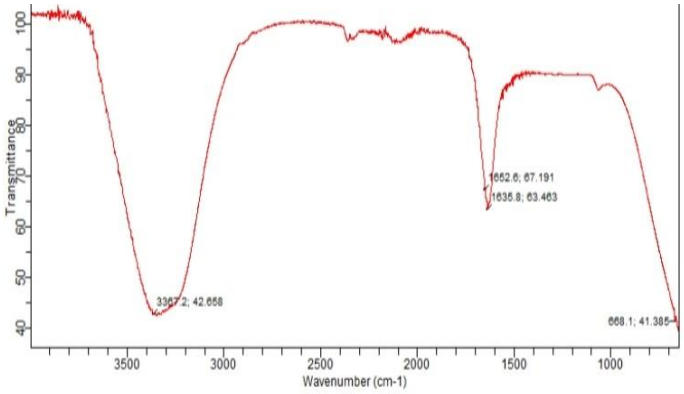
FTIR analysis is conducted to observe the binding of functional groups and to confirm the interaction between the Sorafenib drug, Folic Acid, and Silver Nanoparticles derived from potato peels. The vibrations that occur when Ag (Silver) bonds stretch are typically found within the range of 400-600 cm^{-1}, a key region for detecting the presence of silver nanoparticles in the sample. This spectral region can be used to confirm the synthesis of silver nanoparticles and their interactions with the drug and folic acid.

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

When the folic acid and sorafenib are combined with silver nanoparticles, the aromatic C=C bonds can be observed around 1600-1580 cm^{-1}, showing the interaction of these functional groups with the silver nanoparticles. Additionally, the presence of functional groups from potato peel extract may introduce additional peaks, reflecting its contribution to the nanoparticle synthesis process. The resulting FTIR spectrum provides



a



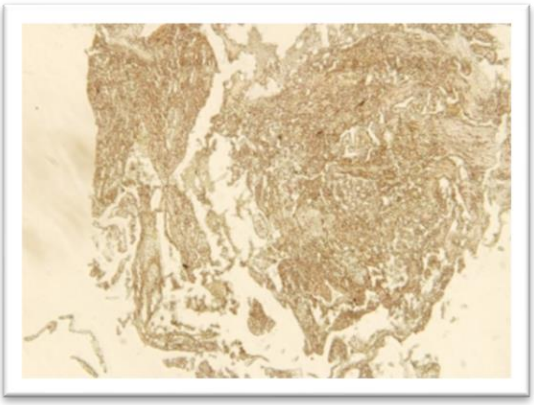
comprehensive view of the interactions between the silver nanoparticles, the drugs, and the bioactive components from the potato peels[Figure 02].

Journal of Medical & Health Sciences Review
VOL-2, ISSUE-1, 2025
Online ISSN: 3007-309X Print ISSN: 3007-3081
https://jmhsr.com/index.php/jmhsr

Figure 02(1-2): The representation of NPs conjugated with potato peel.

Immunochemistry

Immunochemistry is the method in biological techniques to detect the presence, localization, and abundance of specific proteins in cell or tissue samples, antibodies are used in this type of study to detect the protein in tissue samples allowing visualizing the distribution and localization of the target molecules. In this method, tissue samples of cancer cell lines are attached to the surface via formalin. Then this prepared nanocomposite is applied to this tissue sample, and parallel to this a control tissue sample



is also prepared. Nanoparticles are bound to the receptor on the cancer cells present in the tissue sample[Figure 03].

Figure 03: Nanoparticles binding to the receptor on the cancer cells present in the tissue sample.

DISCUSSION

This study investigated the efficacy of hepatocellular carcinoma (HCC) drug Sorafenib conjugated with silver nanoparticles. It demonstrates that these nanoparticles will target

the drug and enhance its efficacy as a chemotherapeutic agent for HCC while reducing off-target effects on normal cells. The use of folic acid as a ligand on the nanoparticle surface increases the specificity of the drug's targeted delivery to cancer cells, enhancing drug accumulation and binding to specific receptors on the cancer cells, which in turn reduces toxicity.

Our results indicate that silver nanoparticle-based Sorafenib drug delivery enhances the therapeutic index of Sorafenib for treating HCC. The drug is conjugated using glutamate and folic acid methods. FTIR results confirm the conjugation of the drug with silver nanoparticles. The nanoparticle-based drug was then tested on a mouse model. HCC was induced in the mice, and nanoparticle-based drug treatment was implemented. Microscopic results demonstrate that the drug concentration in the HCC cells is higher than in normal or local cells, showing that the drug is specifically targeted and binds to the HCC cells via the folic acid receptors on these cells. A limitation of this study is the use of a mouse model, which may yield different results in humans due to physiological differences between species. However, the use of nanoparticles allows for more precise targeting of cancer cells, which leads to better clinical outcomes, such as improved patient survival and higher remission rates. Additionally, reducing toxicity through nanoparticle-based drug delivery improves the quality of life for patients undergoing chemotherapy. Numerous studies have shown significant positive results in treating cancer cells with nanoparticles for targeted drug delivery. Future research should focus on clinical trials to evaluate the efficacy and safety of nanoparticle-based systems in human patients with HCC. Investigating the long-term biocompatibility and potential side effects of nanoparticles will be critical for their successful translation into clinical practices.

References

1. Ahmad M, Khan AU. Global economic impact of antibiotic resistance: a review. J Glob Antimicrob Resist. 2019; 19:313–316.

2. Tacconelli E, Carrara E, Savoldi A, et al. Discovery, research, and development of new antibiotics: the WHO priority list of antibiotic-resistant bacteria and tuberculosis. Lancet Infect Dis. 2018 Mar;18(3):318–327.

3. Tabah A, Koulenti D, Laupland K, et al... Characteristics and determinants of outcome of hospital-acquired bloodstream infections in intensive care units: the EUROBACT International cohort study. Intensive Care Med. 2012;38(12):1930–1945.

4. Laxminarayan R, Matsoso P, Pant S, et al. Access to effective antimicrobials: a worldwide challenge. Lancet. 2016 Jan 9;387(10014):168–175. -

5. Allegranzi B, Bagheri Nejad S, Combescure C, et al. Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. Lancet. 2011 Jan 15;377(9761):228–241.

6. Barendregt JJ, Doi SA, Lee YY, et al. Meta-analysis of prevalence. J Epidemiol Community Health. 2013;67(11):974.

7. van Houwelingen HC, Arends LR, Stijnen T. Advanced methods in meta-analysis: multivariate approach and meta-regression. Stat Med. 2002 Feb 28;21(4):589–624.

8. Team RC. R: a language and environment for statistical computing. Vienna: R Foundation for Statistical Computing; 2021 [cited 2021 August 24]. Available from: http://www.R-project.org.

9. Guido Schwarzer JRC, Rücker G.. Meta-analysis with R. Springer International Publishing. Basel; 2015.

10. Viechtbauer W. Conducting meta-analyses in R with the metafor package. J Stat Softw. 2010;36(3):1–48.

11. Ahoyo TA, Bankole HS, Adeoti FM, et al. . Prevalence of nosocomial infections and anti-infective therapy in Benin: results of the first nationwide survey in 2012. Antimicrob Resist Infect Control. 2014;3. 10.1186/2047-2994-3-17.

12. Labi AK, Obeng-Nkrumah N, Owusu E, et al. . Multi-centre point-prevalence survey of hospital-acquired infections in Ghana. J Hosp Infect. 2019;101(1):60–68.

13. Appelgren P, Björnhagen V, Bragderyd K. A prospective study of infections in burn patients. *Burns* 2002; 28:39-46.

14. Brusselaers N, Monstrey S, Soneji T. Burn injury morbidity and mortality of blood stream infections in patients with severe burn injury. *American Journal of Critical Care* 2010;19: e81-7.

15. Cakir B, Yegan BC. Systemic responses to burn injury. *Turkish Journal of Medical Sciences* 2004; 34:215-26.

16. Church D, Elsayed S, Reid O, Winston B, Lindsay R. Burn wound infections. *Clinical Microbiology Reviews* 2006;19(2):403-34.

17. Conil JM, Georges B, Breden A, Segonds C, Lavit M, Seguin T. Increased amikacin dosage requirements in burn patients receiving a once-daily regimen. *International Journal of Antimicrobial Agents* 2006; 28:226-30.

18. D'Avignon LC, Saffle JR, Chung KK, Cancio LC. Prevention and management of infections associated with burns in the combat casualty. *Journal of Trauma* 2008;64(Suppl 3): S277-86.

19. Ekrami A, Kalantar E. Bacterial infections in burn patients at a burn hospital in Iran. *The Indian Journal of Medical Research* 2007;126(6):541-4.

20. Fitzwater J, Purdue GF, Hunt JL, O'Keefe GE. The risk factors and time course of sepsis and organ dysfunction after burn trauma. *Journal of Trauma* 2003;54(5):959-66.

21. Baghbani-Arani F, Movagharnia R, Sharifian A, Salehi S, Shandiz SAS. Photocatalytic, anti-bacterial, and anti-cancer properties of Phyto-mediated synthesis of silver nanoparticles from Artemisia tournefortiana Rchb extract. J Photochem Photobiol B. 2017; 173:640-9

22. Bala Shanmugam P, Kalaichelvan PT. Biosynthesis characterization of silver nanoparticles using Cassia Roxburghe DC. aqueous extract, and coated on cotton cloth for effective antibacterial activity. Int J Nanomedicine. 2015;10 Suppl 1(Suppl 1):87-97.

23. Beg M, Maji A, Mandal AK, Das S, Aktara MN, Jha PK, et al. Green synthesis of silver nanoparticles using Pongamia pinnata seed: Characterization, antibacterial property, and spectroscopic investigation of interaction with human serum albumin. J Mol Recognit. 2017;30(1).

24. Choi JS, Jung HC, Baek YJ, Kim BY, Lee MW, Kim HD, et al. Antibacterial Activity of Green-Synthesized Silver Nanoparticles Using Areca Catechu Extract against Antibiotic-Resistant Bacteria. Nanomaterials (Basel). 2021;11(1).

25. Choi JS, Lee JW, Shin UC, Lee MW, Kim DJ, Kim SW. Inhibitory Activity of Silver Nanoparticles Synthesized Using Lycopersicon Esculentum against Biofilm Formation in Candida Species. Nanomaterials (Basel). 2019;9(11).

26. Kumar D, Kumar G, Agrawal V. Green synthesis of silver nanoparticles using Holarrhena antidysenterica (L.) Wall.bark extract and their larvicidal activity against dengue and filariasis vectors. Parasitol Res. 2018;117(2):377-89.

27. Kumar SSD, Houreld NN, Kroukamp EM, Abrahamse H. Cellularimaging and bactericidal mechanism of green-synthesized silver nanoparticles against human pathogenic bacteria. J Photochem Photobiol B. 2018; 178:259-69.

28. Küp F, Çoşkunçay S, Duman F. Biosynthesis of silver nanoparticles using leaf extract of Aesculus hippocastanum (horse chestnut): Evaluation of their antibacterial, antioxidant and drug release system activities. Mater Sci Eng C Mater Biol Appl. 2020; 107:110207.

29. M KR, K SM, Nair SS, K BK, T MS, K PS, et al. Facile coconut inflorescence sap mediated synthesis of silver nanoparticles and its diverse antimicrobial and cytotoxic properties. Mater Sci Eng C Mater Biol Appl. 2020; 111:110834.

30. Otunola GA, Afolayan AJ, Ajayi EO, Odeyemi SW. Characterization, Antibacterial and Antioxidant Properties of Silver Nanoparticles Synthesized from Aqueous Extracts of Allium sativum, Zingiber officinale, and Capsicum frutescens. Pharmacogn Mag. 2017;13(Suppl 2): S201-s8.

31. Patil MP, Singh RD, Koli PB, Patil KT, Jagdale BS, Tipare AR, et al. Antibacterial potential of silver nanoparticles synthesized using Madhuca longifolia flower extract as a green resource. Microb Pathog. 2018; 121:184-9.

32. Patra JK, Baek KH. Antibacterial Activity and Synergistic Antibacterial Potential of Biosynthesized Silver Nanoparticles against Foodborne Pathogenic Bacteria along with its Anticandidal and Antioxidant Effects. Front Microbial. 2017; 8:167.
33. Patra JK, Das G, Baek KH. Phyto-mediated biosynthesis of silver nanoparticles using the rind extract of watermelon (Citrullus lanatus) under photo-catalyzed condition and investigation of its antibacterial, anticandidal and antioxidant efficacy. J Photochem Photobiol B. 2016; 161:200-10.

34. Rahman AU, Khan AU, Yuan Q, Wei Y, Ahmad A, Ullah S, et al. Tuber extract of Arisaema flavum eco-benignly and effectively synthesize silver nanoparticles: Photocatalytic and antibacterial response against multidrug resistant engineered E. coli QH4. J Photochem Photobiol B. 2019; 193:31.

35. Ramesh PS, Kokila T, Geetha D. Plant mediated green synthesis and antibacterial activity of silver nanoparticles using Emblica officinalis fruit extract. Spectrochim Acta A Mol Biomol Spectrosc. 2015; 142:339-43.

36. Rashid S, Azeem M, Khan SA, Shah MM, Ahmad R. Characterization and synergistic antibacterial potential of green synthesized silver nanoparticles using aqueous root extracts of important medicinal plants of Pakistan. Colloids Surf B Bio interfaces. 2019; 179:317-25.

37. Ravichandran A, Subramanian P, Manoharan V, Muthu T, Periyannan R, Thangapandi M, et al. Phyto-mediated synthesis of silver nanoparticles using fucoidan isolated from Spatoglossum asperum and assessment of antibacterial activities. J Photochem Photobiol B. 2018; 185:117-25.

38. Rezk N, Abdelsattar AS, Makky S, Hussein AH, Kamel AG, El-Shibiny A. New formula of the green synthesised Au@Ag core@shell nanoparticles using propolis extract

presented high antibacterial and anticancer activity. AMB Express. 2022;12(1):108.

39. Rigopoulos N, Thomou E, Kouloumpis A, Lamprou ER, Petropoulea V, Gournis D, et al. Optimization of Silver Nanoparticle Synthesis by Banana Peel Extract Using Statistical Experimental Design, and Testing of their Antibacterial and Antioxidant Properties. Curr Pharm Biotechnol. 2019;20(10):858-73.

40. Gosain A, Gamelli RL. Role of the gastrointestinal tract in burn sepsis. *Journal of Burn Care & Rehabilitation* 2005;26(1):85-91

41. Branski LK, Al-Mousawi A, Rivero H, Jeschke MG, Sanford AP, Herndon DN. Emerging Infections in Burns. *Surg Infect (Larchmt)* 10(5), 389–97 (2009).

42. Church D, Elsayed S, Reid O, Winston B, Lindsay R. Burn wound infections. *Clin Microbiol Rev* 19, 403–34 (2006).**Has a thorough discussion of options for infection surveillance and prevention, the different types of infections in burn patients, and treatment strategies.

43. Barrow RE, Spies M, Barrow LN, Herndon DN. Influence of demographics and inhalation injury on burn mortality in children. *Burns* 30, 72–7 (2004).

44. Fitzwater J, Purdue GF, Hunt JL, O'Keefe GE. The risk factors and time course of sepsis and organ dysfunction after burn trauma. *J Trauma* 54, 959–66 (2003).

45. Neely AN, Fowler LA, Kagan RJ, Warden GD. Procalcitonin in pediatric burn patients: An early indicator of sepsis? *J Burn Care Rehabil* 25, 76–80 (2004).

46. Heredia-Rodríguez M, Bustamante-Munguira J, Lorenzo M, Gómez-Sánchez E, Álvarez FJ, Fierro I et al. Procalcitonin and white blood cells, combined predictors of infection in cardiac surgery patients. *J Surg Res* 212, 187–94 (2017).

47. Stanojcic M, Vinaik R, Jeschke MG. Status and Challenges of Predicting and Diagnosing Sepsis in Burn Patients. *Surg Infec* 19(2), 168–75 (2018). *Discusses diagnostic tools for predicting sepsis as well as treatment options for burn infections.

48. Mann-Salinas EA, Baun MM, Meininger JC, Murray CK, Aden JK, Wolf SE et al. Novel predictors of sepsis outperform the American Burn Association sepsis criteria in the burn intensive care unit patient. *J Burn Care Res* 34(1), 31–43 (2013).

49. Norbury W, Herndon DN, Tanksley J, Jeschke MG, Finnerty CC. Infection in Burns. *Surg Infect (Larchmt)* 17(2), 250–55 (2016).

50. Powers JH. Development of drugs for antimicrobial-resistant pathogens. *Curr Opinion Infec Dis* 16(6), 547–51 (2003).