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SYNTHESIS OF SILVER NANOPARTICLES USING *CARICA PAPAYA* LEAF EXTRACT AND EVALUATION OF ITS ANTIMICROBIAL POTENTIAL – A REVIEW

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ABSTRACT:
For green synthesis of silver nanoparticles *Carica papaya* leaf extract is used to potentiate extent of their antimicrobial activity against range of microorganisms. Silver nanoparticles display characteristics like size and distribution has remarkable use in numerous scientific fields. *Carica papaya* leaves are known for their benefits as they possess antimicrobial, anti-inflammatory, anti-proliferative, antioxidant activities, anti-dengue effects and bioremediation as well. The small size of nanoparticles is gaining importance in research for their use as potential therapeutics. Silver nanoparticles are very important especially due to their physiochemical and antimicrobial properties which are less pronounced in case of other nanoparticle. The present study assessed the characterization of silver nanoparticles using UV–Visible spectroscopy, scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR). The synthesized nanoparticles have larger surface area compared to bulk molecule which enhances their interaction with micro-organisms and increases their antimicrobial activity. These are more soluble than bulk molecule making them easier to transport and distribute in various applications. The green synthesis of nanoparticles is simple, safe, easy, fast, economical and environment-friendly technique which adds to its advantages.

Keywords: - *Carica papaya*, Antimicrobial, Silver Nanoparticles, UV–Visible Spectrophotometry, Electron Scanning Microscopy, FTIR Spectrophotometry, Green synthesis.

INTRODUCTION :

Carica papaya is herbaceous succulent plant commonly known as Papaya, Paw Paw, Kates and Papaw (Bere *et al.*, 2021) belongs to the family *Caricaceae* is one of the important medicinal plants (Banala *et al.*, 2015). Papaya, a tropical fruit is often seen in orange-red, yellow green and yellow orange hues with a rich orange pulp (Anbarasu *et al.*, 2018). Different parts of the papaya plant such as the fruit, seed, and leaves are used in treating various human and veterinary diseases around the world. The extract from *C. papaya* leaves is particularly known for its medicinal properties, as a result of several bioactive compounds that exhibit antimicrobial, anti-inflammatory and antioxidant effects. Research has shown that papaya leaf extract contains important compounds such as the enzyme papain, alkaloids, flavonoids, saponins and tannins (Bere *et al.*, 2021). The fruit, bark and leaves of the papaya plant are used in traditional medicine to treat a wide range of ailments, including constipation, skin lesions, high blood pressure, indigestion, cancer cell growth, diabetes, malaria, reproductive health problems, dengue fever and sickle cell anemia (Banala *et al.*, 2015).

Silver is a safe, non-toxic inorganic agent known for its antibacterial properties, capable of eliminating around 650 types of disease-causing microorganisms (Reenal, M., and Santhi, V. 2017). Since ancient times, as early as 1000 B.C., silver has been incorporated into traditional medicine for its health benefits (Kale, R. *et al.*, 2018). Nanoparticles typically range in size from 1 to 100 nm (VB, K., Saranya *et al.*, 2018) and they possess unique characteristics compared to bulk molecules. Their larger surface area allows for enhanced interactions and greater effectiveness (Konjari, R. S. *et al.*, 2015). The reduction of metal compounds into nanoparticles often facilitated by microbial enzymes or plant

phytochemicals with antioxidant or reducing properties converts metal ions into metal atoms (Patel, N., and Singh, S. 2020). Green synthesis methods such as using plant extracts are preferred over chemical processes as they produce more stable and economical nanoparticles (Arsene *et al.*, 2023).

The characterization of silver nanoparticles synthesized using *C. papaya* leaf extract was confirmed through various techniques such as UV-VIS, FTIR, SEM, etc. The synthesis of silver nanoparticles using CPL extract was highly efficient and provided additional bactericidal properties. This method presents a promising alternative to traditional antibiotics, offering a potential solution to antibiotic resistance. The phytochemicals in the extract act as catalysts, inhibiting enzymes required by bacteria, viruses and fungi for oxygen intake. Importantly, these nanoparticles do not harm human enzymes or tissues leading to the destruction of harmful microorganisms while leaving surrounding human cells unharmed (VB, K., Saranya *et al.*, 2018).

In recent years, the use of nanoparticles in medicine has significantly increased with applications spanning molecular imaging, drug delivery, diagnosis and treatment of cardiovascular diseases, wound healing, development of antimicrobial materials and medical devices (Anbarasu *et al.*, 2018). Green synthesis of nanoparticles has been found to be highly effective in combating a range of harmful, MDR pathogens (VB, K., Saranya *et al.*, 2018). Silver nanoparticles synthesized from *C. papaya* leaves have demonstrated anticancer properties by disrupting the cell cycle and inducing prostate cancer cellular apoptosis (Devanesan *et al.*, 2021).

THE REVIEW :

Banala, R. R., Nagati, V. B., & Karnati, P. R. 2015 studied on "Green synthesis and characterization of *Carica papaya* leaf extract coated silver nanoparticles through X-ray diffraction, electron microscopy and evaluation of bactericidal properties" and the silver nanoparticles synthesized using *Carica papaya* leaf extract were characterized using techniques such as UV-visible spectrophotometry, FTIR, TEM and XRD. The study concluded that the green synthesis of silver nanoparticles mediated by papaya leaf extract was highly effective, exhibiting bactericidal properties. This approach could offer a promising alternative and potential solution to the growing issue of antibiotic resistance.

Jain, A., Ahmad, F., Gola, D., Malik, A., Chauhan, N., Dey, P., & Tyagi, P. K. 2020 studied on "Multi dye degradation and antibacterial potential of Papaya leaf derived silver nanoparticles" that the metabolites present in papaya leaf extract play a crucial role in the formation and stabilization of silver nanoparticles in a colloidal solution. The properties of these synthesized AgNPs were thoroughly analyzed and confirmed using techniques such as UV-visible spectroscopy, Zeta potential-DLS, EDX and TEM. The AgNPs exhibited strong antibacterial effects as demonstrated by their zones of inhibition (ZOI) against both *E. coli* and *S. aureus*. Furthermore, the papaya leaf-derived AgNPs showcased an additional capability to degrade dyes, effectively breaking down Blue CP and Yellow 3RS dyes individually. The study highlighted the significant medicinal potential of *C. papaya* leaves and emphasized their suitability for producing eco-friendly AgNPs with versatile applications.

Syafiuddin, A., Salmiati, Hadibarata, T., Salim, M. R., Kueh, A. B. H., & Sari, A. A. 2017 studied on "A purely green synthesis of silver nanoparticles using *Carica papaya*, *Manihot esculenta*, and *Morinda citrifolia*: Synthesis and antibacterial evaluations" that silver nanoparticles were successfully synthesized through a green synthesis approach using leaf extracts from *Carica papaya, Manihot esculenta* and *Morinda citrifolia*. These extracts functioned

as both reducing and stabilizing agents during the synthesis process. Among the three AgNPs synthesized from *C. papaya* displayed the highest absorbance and a peak at 336 nm. Additionally, *C. papaya* leaf extract demonstrated superior antibacterial activity against *E. coli*, producing the largest inhibition zone compared to the other plant extracts. In contrast, *M. esculenta* leaf extract showed the highest effectiveness against *B. cereus*. The study concluded that AgNPs hold significant promise for future medical applications, particularly as natural antibacterial agents and highlighted the potential of plant-based methods for sustainable AgNP synthesis.

Yoro, M., Samson, J. D., Joshua, J., Bello, P. D., & Jonah, J. W. K. 2022 studied on "Physicochemical parameters and antibacterial activity of biosynthesized silver nanoparticles from *Carica papaya* leaf extract" that silver nanoparticles synthesized through green methods were identified by a noticeable color change from light to dark brown, along with confirmation through UV-Visible and SEM analysis. Antibacterial studies demonstrated that the inhibition zone generally expanded with increasing concentrations of AgNPs across all tested bacteria. While the inhibition zone for the control (Augmentin) was larger than that of AgNPs for most pathogens, an exception was observed with *Pseudomonas aeruginosa*, where the inhibition zones were nearly identical. This finding highlights the strong antibacterial activity of AgNPs against *P. aeruginosa*. The study concluded that silver nanoparticles have significant potential as effective antibacterial agents.

Jackson, T. C., Uwah, T. O. O., Agboke, A. A., Udo, B. E., & Udofa, E. M. 2018 studied on "Eco-friendly synthesis of silver nano particles using *Carica papaya* leaf extract" and silver nanoparticles were successfully produced through an eco-friendly green synthesis method utilizing papaya leaf extract. The formation of AgNPs was confirmed by a noticeable color shift from colorless to reddish-brown and further analyzed using UV-Visible spectroscopy. The antimicrobial potential of the synthesized nanoparticles was evaluated against four bacterial strains: *Pseudomonas aeruginosa, Escherichia coli, Bacillus subtilis* and *Staphylococcus aureus*. The results revealed effective inhibitory activity against all tested microorganisms, with *Pseudomonas aeruginosa* displaying the highest sensitivity to the nanoparticles.

Anbarasu, A., Karnan, P., Deepa, N., & Usha, R. 2018 studied on "*Carica papaya* mediated green synthesized silver nanoparticles" concluded that silver nanoparticles were synthesized using fresh aqueous papaya leaf extract which contains functional groups such as amine, alkene, and alkyl halides. These groups played a dual role acting as both reducing and stabilizing agents, facilitating the formation of shape-controlled nanoparticles. The synthesized AgNPs were thoroughly characterized using UV-Visible spectroscopy, HR-TEM, FE-SEM, EDX and XRD techniques. Additionally, phytochemical screening of the papaya leaf extract revealed the presence of various bioactive compounds including carbohydrates, tannins, saponins, phenols, flavonoids, alkaloids, and triterpenoids.

VB, K., Saranya, C. V., Tamil, A. E., Anitha, A., & Soruba, R. 2018 studied on "Biosynthesis of silver nanoparticles using carica papaya l. Leaf extract and screening its antimicrobial activity" and concluded silver nanoparticles were synthesized through the bio-reduction of aqueous Ag^{+} ions using papaya leaf extract in a simple, economical with potential pharmaceutical applications. The nanoparticles were analyzed and characterized using UV-Visible spectroscopy, FTIR, SEM, TEM, and XRD techniques. In antibacterial studies, the papaya leaf extract-mediated AgNPs exhibited significant effectiveness against human pathogenic bacteria,

particularly *Staphylococcus aureus* and *Pseudomonas aeruginosa*.

Offor, S. J., Anah, V. U., Umoh, R., Iseh, U. P., Ebong, I. I., & Mbagwu, H. O. 2021 studied on "Antimicrobial activities of biosynthesized silver nano particles from leaves extract of some medicinal plants" in this silver nanoparticles were produced using leaf extracts from *Carica papaya, Garcinia kola, Moringa oleifera* and *Mangifera indica*. The synthesis was confirmed by a visible color transformation from golden yellow to dark brown and further analyzed using UV-Visible spectroscopy. AgNPs derived from all four plants demonstrated broad-spectrum antibacterial activity against both gram-negative and gram-positive bacteria. It was observed that at a higher Ag^+ ion ratio (1:2) all the biogenic AgNPs exhibited notable antimicrobial effectiveness.

RESULTS :

Qualitative phytochemical analysis of *Carica papaya* aqueous leaf extract revealed the presence of various bioactive compounds including carbohydrates, saponins, flavonoids, alkaloids, phenols, glycosides, tannins, terpenoids, acids and proteins (Anbarasu *et al.*, 2018). Silver nanoparticles were synthesized using the papaya leaf extract and characterized through UV-Vis spectrophotometry showing absorbance peaks at 470 nm (Banala *et al.*, 2015), 400 nm (Yoro *et al.*, 2022), 435 nm (Jackson *et al.*, 2018), 445.7 nm (Anbarasu *et al.*, 2018), and 438 nm (Offor *et al.*, 2021), with an overall range of 300–700 nm (Jain *et al.*, 2020). SEM analysis revealed an average nanoparticle size of 50 nm (Yoro *et al.*, 2022) with SEM-EDX spectra indicating 94.69% silver content (Syafiuddin *et al.*, 2017). FE-SEM coupled with EDX images confirmed the spherical crystalline structure of the nanoparticles (Anbarasu *et al.*, 2018). TEM analysis demonstrated particle sizes ranging from 5–40 nm with spherical morphology (Banala *et al.*, 2015), 10–50 nm (Jain *et al.*, 2020) and 10 nm (Anbarasu *et al.*, 2018). EDX analysis confirmed a silver content of 41%, with trace amounts of oxygen (Banala et al., 2015), while EDS micrographs indicated the presence of copper and carbon alongside silver with a zeta potential value of -12.1 mV in water and a hydrodynamic radius measured via DLS (Jain *et al.*, 2020). FTIR analysis showed spectra in ranges of 500–4000 cm^{-1} (Banala *et al.*, 2015), 1000–3000 cm^{-1} (Syafiuddin *et al.*, 2017), and absorbance bands between 500–2000 cm^{-1} (VB, K. *et al.*, 2018). The mean particle size was recorded at 250 nm with a polydispersity index of 0.22 (Jackson *et al.*, 2018). XRD analysis confirmed the crystalline nature of silver ions (Anbarasu *et al.*, 2018), with patterns showing three prominent peaks in the 2θ range of 10–80° (VB, K. *et al.*, 2018). The synthesized AgNPs exhibited strong antibacterial activity assessed through methods like disc diffusion, MIC and MBC (Banala *et al.*, 2015). The nanoparticles also showed effectiveness in dye degradation (Jain *et al.*, 2020). MIC values varied between 100–500 µg/L (Yoro *et al.*, 2022), 25–100 µg/L (Jackson *et al.*, 2018) and 3.125–12.5 µg/mL against both gram-positive and gram-negative bacteria (Offor *et al.*, 2021). Growth inhibition values exceeded 25 µg/mL for both bacterial groups (VB, K. *et al.*, 2018).

DISCUSSION :

The synthesis of silver nanoparticles using *Carica papaya* aqueous leaf extract was successfully performed with nanoparticle formation and confirmed through visual inspection, UV-Vis spectroscopy, SEM and FTIR analysis. The visual color change from light yellow to dark brown indicated nanoparticle formation. UV-Vis spectroscopy demonstrated the growth and stability of AgNPs, with maximum absorption peaks observed within the 400–500 nm range. FTIR analysis identified functional biomolecules including carboxylic (-C=O) peaks at 1680–1640 cm^{-1}, hydroxyl (-OH) peaks at 3200–3400 cm^{-1}, amine (-N-H) peaks at 1351–1441 cm^{-1} and sulfonate (S=O) peaks at 1708 cm^{-1}. These biomolecules facilitated the reduction and stabilization of silver ions into nanoparticles. SEM analysis revealed spherical to ovoid nanoparticles, with sizes below 100 nm. The MIC studies showed the lowest effective concentration of AgNPs required to inhibit microbial growth, ranging from 25–100 mg/mL. Overall, the utilization of *Carica papaya* leaf extract for green synthesis provides a sustainable and eco-friendly alternative to conventional chemical approaches contributing to advancements in nanotechnology with promising antimicrobial applications.

CONCLUSION :

Based on the literature, the quick and efficient synthesis of silver nanoparticles using *Carica papaya* leaf extract offers a simple, safe and environmentally friendly approach that is both economical and easy to perform. The nanoparticles wide surface area improves their solubility and enhances their interaction leading to increased activity. These silver nanoparticles have demonstrated strong antibacterial effects against both Gram-positive and Gram-negative bacteria making them useful as antibacterial agents with potential pharmaceutical applications.

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