

Research Article

Preparation and Characterization of *Persea Americana* Silver Nanoparticles

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Abstract

The global impact of Peptic Ulcer Disease poses significant health challenges, with the costs and side effects of conventional medications often outweighing their benefits; this has led to failure in therapy or inefficacy of drug therapy. Phytomedicines are being investigated for their potential in the treatment of peptic ulcer disease. Silver nanoparticles (AgNPs) have unique properties that make them suitable for diverse therapies, and green synthesis of AgNPs is gaining popularity due to its cost-effectiveness and energy efficiency. In this study, Silver (Ag) nanoparticles (NPs) were effectively synthesized by a green synthesis method using *Persea americana* aqueous leaf extract. Characterization was performed using UV-visible spectroscopy and Zeta sizer. The colour change from light brown to dark brown confirmed AgNP formation, with maximum absorption peaks at 340 nm in UV-visible spectroscopy. The average particle size of optimized batch was 70.37 nm. The study highlights the potential of green synthesis via nanoparticle technology to improve the therapeutic effectiveness of natural remedies for peptic ulcer, presenting a promising avenue for the development of more efficient and safer medicines.

Keywords

Green Synthesis, Peptic Ulcer, Nanoparticles, *Persea americana*

1. Introduction

Peptic ulcers are fibrin-covered breaks in the stomach mucosa or proximal duodenum, caused by gastric acid injury [1]. Peptic ulcer disease (PUD) encompasses subtle lesions that usually occur in the stomach and duodenum, disturbing

the delicate balance of digestive processes [2]. They occur due to an imbalance between mucosal protective factors, (such as bicarbonate, mucin, prostaglandin, nitric oxide, and other peptides and growth factors) and damaging factors (Pepsin

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and Hydrochloric acid) in gastric juice [3-5]. The global prevalence of PUD is 5-10%, with an annual incidence of 0.1-0.3% [1]. PUD accounts for 10-15% of dyspepsia, a persistent or recurrent pain or discomfort in the upper abdomen. PUD can be caused by factors such as stress, smoking, alcohol consumption, nonsteroidal anti-inflammatory drugs (NSAIDs), *Helicobacter pylori* infection, and genetic factors [3, 6]. Other less common forms include Zollinger-Ellison syndrome and idiopathic peptic ulcer disease [3].

The global burden of peptic ulcer diseases poses a serious challenge to health care and quality of life of patients with conventional treatments having suboptimal target site delivery, low bioavailability, increased side effect, resistance, in addition to cost of production, and risk of pollution making the condition challenging to treat. In recent decades, polypharmacy regimens, including triple and quadruple therapies, have been extensively employed to combat *H. pylori*. Nonetheless, polyantibiotic treatments can disrupt the host's gastric and gut microbiota, resulting in antibiotic resistance [7]. This has made it of utmost necessity to develop alternative drug lines for treatment. In the post-antibiotic era, new antimicrobial treatments for *H. pylori* infection have used a new generation of antimicrobials, including antimicrobial peptides, antimicrobial photosensitizers, and nanomaterial-based antimicrobial agents (such as silver, gold, and zinc oxide nanoparticles) [8]. Advanced approaches such as Nano phytomedicine can be improve target site delivery, increase bioavailability, improve efficacy of therapy and reduce side effects.

Phytomedicines are also called herbal medicines and are derived from plant sources. Herbal medicines have been used for centuries in the management of diseases due to their potentially high therapeutic values and acceptability by patients with different health complications [9]. Alkaloids, flavonoids, terpenoids, and polyphenols are just a few examples of the myriad chemical constituents that contribute to the therapeutic potential of herbal medicines [9]. The bioactive components of herbal medicines are implicated in the management of diseases. Several plants have been studied for the presence of bioactive compounds with peptic ulcer treating abilities and more research is ongoing to discover more for use.

Nanotechnology involves the manipulation of matter at the nanoscale, typically between 1 to 100 nanometers, to create materials with unique properties and functionalities [10, 11]. By means of their biopharmaceutical properties, pharmacokinetic profiles, and target specificity, nanosized formulations offer unmatched performance in drug delivery systems when compared to conventional formulations, therefore strengthening the clinical efficacy of therapeutic medicines [12]. Nanomedicine presents a promising approach by employing nanoparticles for targeted drug delivery, addressing antibiotic resistance and delivery challenges. Nanocarriers, including liposomes and nanoparticles, improve drug stability and circulation by targeting infection sites via the properties of the gastric mucosa [13]. Formulations using nanocarriers facili-

tate efficient drug delivery to targeted sites with the intended release profile. Moreover, these nanoformulations enable drug administration via multiple routes. By incorporating appropriate ligands into nanocarrier designs, targeting can be improved, which enhances the systemic bioavailability and stability of the medications. Furthermore, the usage of nanocarriers can minimize the necessary pharmaceutical dosage and decrease the administration frequency. Ultimately, these tailored nanoformulations can reduce the likelihood of hazardous side effects [14].

Noble metal nanoparticles and nanocomposites are popular due to their unique properties and versatility. They can be synthesized using extracts from bark, leaves, stems, and roots, and reduced and stabilized using biomolecules like phenols, alkaloids, proteins, and sugars [15]. Metal nanoparticles like Ag, Au, Pt, and Pd have unique biological and physico-chemical characteristics, while AgNPs are widely used in scientific and technological fields [15].

Green chemistry methods for the biological synthesis of nanoparticles (NPs) provide a sustainable alternative to traditional chemical techniques. These nanoparticles, particularly metallic NPs and metal oxides synthesized from plant extracts, has been found to achieve better therapeutic output in the management of ulcer than native crude products [16].

Phyto-nanotherapy delivers superior biopharmaceutical qualities and is demonstrated to be clinically equal to various currently available antidiabetic medicines. In addition, plant metal nanoparticles can reach unique therapeutic benefits via a synergistic effect. Green synthesis of gold, silver, and zinc oxide nanoformulations of herbal medications has attracted substantial attention via enhancing the stability, pharmacokinetic features, and biopharmaceutical properties of containing phytochemicals to obtain higher therapeutic efficacy in the management of ulcer [12]. In addition to being ecologically sustainable, this process extends the life of nanoparticles, surpassing the restrictions of current chemical and physical procedures for NP synthesis [17].

In this study, we developed and characterised silver nanoparticles using aqueous extract of *Persea americana* for the treatment of diabetes.

2. Materials and Methods

2.1. Materials

Leaves of *Persea americana*, Distilled water, Silver nitrate (Sigma Aldrich, USA), measuring cylinders, weighing balance (OHAUS, New Jersey, United States), Aluminum foil, cotton wool, beakers, glass jars, Differential Scanning Calorimeter (Perkin-Elmer, Philadelphia USA), Fourier Transform Infrared Spectrophotometer (DSC-Shimadzu 50), Scanning Electron Microscope (SEM, Hitachi X650, Tokyo, Japan), ZetasizerVer: 7.01 (Nano Zs 90, Malvern Instruments).

2.2. Collection and Identification of Plants

Fresh leaves of *Persea americana* was collected in the Department of Pharmacognosy medicinal plant farm, Faculty of Pharmacy, University of Uyo, Akwa Ibom State, Nigeria. Dr. Imoh Imeh Johnny of the University of Uyo's Department of Pharmacognosy and Natural Medicine in Uyo, Akwa Ibom State, identified and verified the leaves, and a voucher number was allocated. They were washed with running tap water, rinsed with distilled water, cut into tiny pieces and dried under a shade at room temperature. The dried samples were stored in an air-tight container till further use.

2.3. Preparation of Plants Extract

Plant powders were weighed using an electronic weighing balance (Denver instrument, Model XL-31000). The powders were then transferred into a glass jar and distilled water poured into the glass jar to submerge the containing powder and stirred. The mixture was allowed to stand for 24 hours after which it was decanted and filtered using cotton wool. The resulting filtrate was concentrated to dryness on a water-bath at 400 °C and the extract preserved in the refrigerator until required for the work.

2.4. Preparation of Silver Nitrate Solution

0.25% Silver nitrate solution was prepared by dissolving 0.25 g of silver nitrate in aliquot quantity of distilled water and the volume made up to 100 mL.

2.5. Preparation of Herbal Drug Nanoparticle

1 mL of *Persea americana* aqueous extract was added to 5 mL of 0.25% silver nitrate solution in a beaker and stirred on a magnetic beaker stirrer assembly till uniform mixing occurred and visible colour change was observed.

2.6. Characterisation of Silver Nanoparticles

2.6.1. Determination of Particle Diameter and Index of Polydispersity (PDI)

The mean diameter (Z-average) and PDI of the nanoparticles was determined by dynamic light scattering method on a Zetasizer Ver: 7.01 (Nano Zs 90, Malvern Instruments).

2.6.2. Determination of Surface Plasmon Resonance of the Silver Nanoparticles Using Ultraviolet-Visible Light Spectroscopy

UV scanning was done (using Shimadzu UV visible, Model uv1800) at a wavelength of 300 nm to 450 nm to determine the surface Plasmon Resonance for the nanoparticles.

3. Results and Discussion

The nanoparticles were synthesized using 1 ml of plant extract combined with 5 ml of silver nitrate (AgNO_3) solution. Upon the addition of the extract to the AgNO_3 mixture, a noticeable color change occurred, shifting from light brown to deep brown indicating the successful formation of silver nanoparticles.

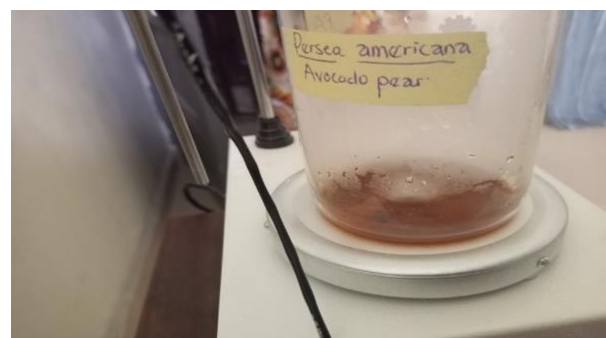


Figure 1. Synthesis of PA-AgNPs.

Table 1. Size Distribution results for *Persea Americana*.

Peak	Size (d.nm)	Percentage Volume	Standard Deviation
Peak 1	9.231	7.9	1.774
Peak 2	20.8	40.5	4.927
Peak 3	52.06	50.6	41.37

Z-average d.nm = 70.37

Pdi = 0.382

Intercept: 0.944

Result Quality = Good.

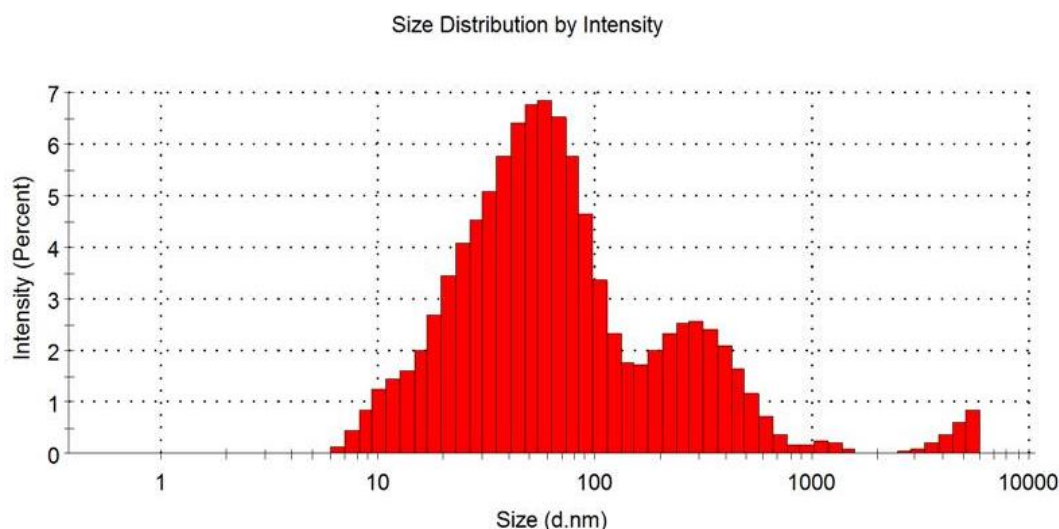


Figure 2. Size distribution graph for *Persea americana*.

3.1. Visual Observation

The addition of silver nitrate solution to *Persea americana* aqueous extract gave a visible color change from light brown to dark brown. Figure 1 above shows the visual observation of the synthesis of AgNPs using *Persea americana* aqueous extract, due to the reduction of silver ions to AgNPs. The changing color of the reaction mixture (visual observation) during the reaction time is the major sign of nanoparticles synthesis. This color change occurs owing to the excitation of the surface plasmon on metal nanoparticles [18].

3.2. UV-Visible Spectroscopy Analysis

UV-Vis spectrometer is spectral techniques are widely used to confirm the formation and structural characterization of silver nanoparticles in colloidal solution. Metal nanoparticles have free electrons which give Surface Plasmon Resonance absorption band due to the combined vibration of electrons of metal nanoparticles in resonance with a light wave [19]. Silver nanoparticles have an absorption band in the visible region. PA showed the formation of an SPR band at 340 nm with broadband confirming the formation of varied size and shape nanoparticles and silver colloid.

3.3. Particle Size Analysis of Silver Nanoparticles

One of the key determiners in epithelial and mucosal tissue uptake of NPs, coupled with their intracellular bargaining, thereby having an effect on the therapeutic efficacy is the particle size [20].

The Z-average diameter and particle size distribution (PSD) of the biosynthesized silver nanoparticles (AgNPs) were analyzed using the Zetasizer technique. As illustrated in Figure 2,

the average size of the PA-AgNPs was approximately 70.37 nm. The PSD profile revealed three prominent peaks with intensities of 7.9%, 40.5% and 50.6%. The size variability of NPs is equally as essential as their average particle size (nm). A dimensionless and scaled indicator developed from the cumulants analysis, the PDI (polydispersity index), commonly referred to as the heterogeneity index, characterizes the relative disagreement of the particle size distribution. [20].

The PA-AgNPs exhibited a PDI of 0.382, indicating a high level of homogeneity and a uniform size distribution among the nanoparticles.

The PDI is employed in size distribution range of the particles with values spanning between 0 and 1. The number 0 indicates the presence of highly homogenous NPs, while and 1 indicates the presence of highly heterogeneous NPs population [21].

4. Conclusion

The synthesis of silver nanoparticles by the chemical reduction technique was effectively achieved. The formation of silver nanoparticles was readily evidenced by a brownish discoloration. The creation of a brownish tint in the sample shows that the synthesis process is largely controlled by silver nanoparticles. The optical characteristics of produced silver nanoparticles were investigated by UV-vis spectroscopy and Zeta sizer. Zeta sizer technology was applied to confirm the production and structural characterisation of silver nanoparticles in colloidal solution. Optical absorption spectra of silver nanoparticles are dominated by surface plasmon which displayed a shift towards the red end or blue end depending on particle size, shape, state of aggregation, and the surrounding dielectric medium. An absorption band was detected in the visible area which was indicative of silver nanoparticles. Building upon this successful synthesis, future research should focus on leveraging these silver nanoparticles, partic-

ularly in the realm of nanophytomedicine for antiulcer applications. Investigating the synthesis of silver nanoparticles using extracts from *Persea americana* holds significant promise. Further studies are warranted to optimize the synthesis process for these specific plant extracts and to thoroughly evaluate the in vitro and in vivo antiulcer efficacy of the resulting silver nanoparticles. Understanding the precise mechanisms of action and exploring potential drug formulations of these nano-phytomedicines represent crucial next steps towards developing novel and potentially more effective treatments for peptic ulcer disease.

Abbreviations

AgNPs	Silver Nanoparticles
PUD	Peptic Ulcer Disease
NSAIDs	Nonsteroidal Anti-inflammatory Drugs
NPs	Nanoparticles
AgNO ₃	Silver Nitrate
PSD	Particle Size Distribution
PDI	Polydispersity Index

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Conflict of Interest

The authors declare no conflicts of interest.

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