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Biological Synthesis, Characterization and Antimicrobial effect of Silver Nanoparticles (Ag-NPs) using Aqueous Extract of Mango Pulp (*Mangifera indica*)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SMY and YA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors TAM, BSS and MM managed the analyses of the study. Authors AKS and SAH managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The green synthesis of silver nanoparticles proceeds through the reduction of silver ions by the phytochemicals as an initial step in the formation of the nanoparticles. The phytochemicals also involved in the subsequent steps by stabilization and directing the shape and size of nanoparticles.

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In this study, a mango pulp extract was used for the biosynthesis of silver nanoparticles (Ag-NPs) using “One pot biological method of synthesis” under ambient temperature. The biosynthesized silver nanoparticles were characterized through visual development of color,UV-VIS spectroscopy and Fourier transform infrared ray. The antimicrobial activities of the synthesized mango pulp Ag-NPs were determined using agar well diffusion method, MIC and MBC methods. The biosynthesized Ag-NPs showed a yellowish-brown color. Broad bell-shaped range bend was gotten from UV–Vis examination with different metabolites of MPAgNPs**,** this makes the plasmon band wide. Surface plasmon reverberation (SPR) of silver happens at 350 - 375 nm for the 7Nps at 2Mm concentration and 13Nps at 1Mm. The FTIR shows absorbance at 3335 m^{-1}, 3324 m^{-1}, 326 8 m^{-1}, 3258 m^{-1}, and 1640 m^{-1} were obtained for mango pulp extract-mediated (Ag-NPs), which indicated that proteins were the capping and stabilizing molecules in the biogenic synthesis of (Ag-NPs). Silver nanoparticles at various concentration of $AgNO_3$ (2 mM, 1 mM, and 0.5 mM) have shown a profound effect by inhibiting the growth of *E. Coli* and *S. Aureus* with an inhibition zone of 12±0, 11.5±0.70, 11.33±1.5 and 12.5±2.12, 12±1.14, 12±4.24 using gentamycin as control (15.16±0.76. and 26.67±2.1) respectively, also MIC and MBC result of the MPAg-NPs extract have shown a –ve results confirming the potentiality of the extract against microbial forms. In conclusion, mango pulp silver nano particles demonstrated the feasibility of eco-friendly biogenic synthesis of Ag-NPs from a reliable, safe and available material (mango) that can be used for the green synthesis of Ag-NPs. And it also exhibits significant antimicrobial activity against gram –ve and gram +ve bacteria.

Keywords: Silver nanoparticles; mango pulp; antimicrobial; UV-VIS spectroscopy; FTIR.

1. INTRODUCTION

Nanoparticles can be defined as objects ranging in size from 1-100 nm, whose size may differ from the bulk material. Presently, different metallic nanomaterials are being produced using copper, zinc, titanium, magnesium, gold, alginate and silver. Nanoparticles are being used for diverse purposes, from medical treatments, using in various branches of industrial production such as solar and oxide fuel batteries for energy storage, to wide incorporation into diverse materials of everyday use such as cosmetics or clothes [1]. Silver nanoparticles have proved to be most effective because of their good antimicrobial efficacy against bacteria, viruses and other eukaryotic micro-organisms. Silver nanoparticles are the most widely applicable nanomaterials among all, being used as antimicrobial agents, in textile industries, for water treatment, sunscreen lotions etc [2]. Many studies have reported the successful biosynthesis of silver nanoparticles by plants such as *Azadirachta indica Capsicum annuum* and *Carica papaya* (Shankar 2004). Silver nanoparticles either chemically or biochemically synthesized have unequal properties and have gained prominence, because of their antimicrobial, anticancer, antibacterial, antioxidant, anti-parasitic, anticoagulant, thrombolytic and antifungal properties [3]. Ag-pNPs occupy a prime position because of their several application including optical, electronics, catalytic and electrochemical, that have greatly influenced their relevance in diverse areas such as food, healthcare, agriculture, biomedical, environmental, and textile application [4].

Silver is a non-toxic, safe inorganic antibacterial agent [5]. The bactericidal effect of silver is usually related to its small size and high surface-to-volume ratio, which gives them the ability to interact with microbial cell membranes [6]. Synthesis of silver nanoparticles was extensively studied which involved the use of chemical and physical methods, but the development of reliable technology to produce nanoparticles is an important aspect of nanotechnology [7]. However, chemical and physical methods have successfully produced well-defined silver nanoparticles, these processes are usually costly and involve the use of toxic chemicals. In addition, synthesis of silver nanoparticles using chemical methods could still lead to the presence of some toxic chemical species being adsorbed onto the surface of nanoparticles which may cause adverse effects in their applications. The plants or plant extracts, which act as reducing and capping agents for nanoparticles synthesis, are more advantageous over other processes [8], because they eliminate the elaborated process of culturing and maintaining of the cell, and can also be scaled up for large-scale nanoparticles synthesis [9]. Moreover, plant-mediated nanoparticle synthesis is preferred due to it cost-effective, environmentally friendly, a single-step method for biosynthesis process and safe for human therapeutic use [10].

Mangifera indica L. is one of the delicious tropical fruit of the world. It belongs to genus *Mangifera* and family *Anacardiaceae*. It is considered as king of fruits. Mango is consumed all over the world. The production of this fruit is very high. After consumption of the pulp and Seeds are thrown away into the environment causing pollution; their disposal is also problematic but seeds show many pharmacological activities like antimicrobial, antioxidant, antidiabetic, anti-inflammatory, anti-ulcer, etc. [11] because of various phytoconstituents present in them.

The chemical components of mango have always piqued my interest. Polyphenolics, flavonoids, and triterpenoids are some of the plant's chemical constituents. Isomangiferin, tannins and gallic acid derivatives are all significant bio-active constituents of *mangiferin*, a xanthone glycoside. Procatechic acid, catechin, mangiferin alanine, glycine, -aminobutyric acid and kinetin are all stated to be present in the bark [12]

This component are used for the treatment of diarrhea, dysentery, anemia, asthma, bronchitis, cough, hypertension, insomnia, rheumatism, toothache, leucorrhoea, haemorrhage, and piles, various parts of the plant are used as a dentifrice, antiseptic, astringent, diaphoretic, stomachic, vermifuge, tonic, laxative, and diuretic. Abscesses, torn horns, rabid dog or jackal bites, tumors, snakebite, stings and datu are all treated with all pieces.

At a dose of 250 mg/kg, a 50 percent ethanolic extract of MI leaves developed a major hypoglycemic effect in both normal and streptozotocin-induced diabetic animals. Part of the mechanism of action was thought to be the activation of -cells to release insulin [13]. The effect of an aqueous extract of MI leaves on blood glucose levels in normoglycemic and glucose-induced hyperglycemic patients and Streptozotocin (STZ)-induced diabetic rats has been assessed. The results indicate that the aqueous extract of the leaves of MI possesses a significant hypoglycaemic effect. This may be due to a reduction of the absorption of glucose [14].

Mangiferin's effect on Herpes simplex virus type 2 was studied in vitro; mangiferin does not specifically inactivate HSV-2, but it does inhibit the late event in HSV-2 replication [15]. *In vitro*, mangiferin blocked HSV-1 virus replication in cells [16] and counteracted the cytopathic effects of HIV [17]. *Mangiferin* demonstrated activity against seven bacterial species, including *Bacillus pumilus, Bacillus cereus, Staphylococcus aureus, Staphylococcus citreus*, *Escherichia coli, Salmonella agona*, and *Klebsiella pneumoniae*, as well as one yeast (Saccharomyces cerevisiae) and four fungi, in an in vitro agar diffusion technique (*Thermoascus aurantiacus, Trichoderma reesei, Aspergillus flavus and A. fumigatus)* [18].

The antimicrobial properties of P. guajava and *Mangifera indica* methanolic extracts were investigated. *P. guajava* and *Mangifera indica* extracts had antimicrobial activity at a concentration of 20 mg/ml, according to the findings. Overall, *P. guajava* extract outperforms MI extract in terms of antimicrobial activity against the species studied [19].

The effects of mangiferin, a naturally occurring glucosyl xanthone from MI (Anacardiaceae), on gastric injury induced by ethanol and indomethacin in mice were investigated. Changes in mean gastric lesion area or ulcer score in mice, as well as gastric secretory volume and total acidity in 4-h pylorus-ligatted rats, were used to assess the effects of *mangiferin* on gastric mucosal damage. These findings show that *mangiferin* protects the stomach from ethanol and indomethacin-induced gastric injury, most likely through antisecretory and antioxidant mechanisms [20].

The inhibitory effect of the mango core nanoparticles after fluconazole on the majority of clinical and standard strains of Candida had a direct relationship with the increasing concentrations of this substance [21]. There are a few applications of this pulp [22]. This is the first time in which the silver nanoparticles are synthesized using the pulp to ascertain it pharmacological activities compared to another part of the plant like leaves, seeds, stem bark etc. this study hypothesized that the pulp could be applied in the synthesis of silver nanoparticles. This paper is aimed at Synthesis, Characterized and determined the antimicrobial effect of silver nanoparticles (Ag-NPs) from mango pulp extract (*Mangifera indica*.).

2. MATERIALS AND METHODS

2.1 Collecting of Samples, Processing and Identification *Mangifera indica* Fruits

A fresh mango (*Magnifera indica*.) fruit was collected from Kofar Nasarawa Market Kano

State, Nigeria, then proceeded to Bayero University Kano for identification and an Herbarium Accession Number was given as BUKHAN 348, identified as *Magnifera indica*. Then, washed with fresh water and the layer of the mango was removed carefully to expose the pulp which further washed and cleaned in the crucible for manual grinding to an aqueous form.

2.2 Preparation of *Mangifera indica* (Pulp) Extract

The *Magnifera indica* pulp extract was prepared as described by Lateef et al. [23], 5 g of the pulp was dissolved in 100 ml distilled water and stir for 1 hour, then the solution was filtered using Whatman No.1 filter paper and centrifuged at 2000 rpm for 20 mins before the collection of the final clear extract, which was stored in refrigerator at 4°C for further analysis.

2.3 Biosynthesis of *Mangifera indica* Ag-NPs (MPAg-NPs)

The *Mangifera indica* pulp extract was used to synthesize silver nanoparticles using different concentrations of silver nitrate ($AgNo_3$) such as 2 mM, 1 mM, 0.5 mM of $AgNo_3$. Each of the three $AgNo_3$ concentration, seven different volume (20, 20, 20, 20, 20, 10 and 10 ml) were pick and mixed with seven different volume of the *Mangifera indica* pulp aqueous extract at room temperature**.** The reaction mixture was transferred to the Water bath at 60 °C for 15minutes. A color changes of the reaction mixture from pale yellow to reddish brown was observed after 2 hours which confirmed the formation of AgNPs [24]. The mixture obtained was then centrifuged at 25000 g for 15 min and the pellet was washed to obtain Ag-NPs. The obtained sample was dried at room temperature for further studies.

2.4 Characterisation of *Mangifera indica* Ag-NPs

2.4.1 UV-VIS spectroscopy MPAg-NPs

The colloidal nanoparticles solution was analyzed to monitor the bioreduction of silver ($Ag^{+}\rightarrow Ag^{0}$) using a UV-Visible spectrophotometer (Agilent Technologies, Cary 300) in the wave length range of 300-800 nm at a resolution of 1 nm. Due to the elevated optical density (OD) of the colloidal suspension, a 1 ml aliquot of the solution was diluted with 3 ml of distilled water. The absorbance spectrum of the silver nanoparticles was monitored periodically for 24 hours. Distilled water was used as a blank.

2.4.2 FTIR spectroscopy of MPAg-NPs

FTIR studies of the powder AgNPs and crude extracts of *Mangifera indica* were performed using the Bruker spectrophotometer. FTIR measurements were carried out using a wave length range of 4000-400 cm^{-1} with a resolution of 4 cm^{-1} at an average of 32 scans per sample. The FTIR measurements were carried out in the Attenuated Total Reflectance mode.

2.5 Antimicrobial Activities of *Mangifera indica* Ag-NPs (MPAg-NPs)

The antibacterial efficacy of the synthesized Ag-NPs was examined using agar well diffusion method [25]. The antimicrobial activity test was done on Bacteria using gram-negative and gram positive (*Escherichia Coli* and *Staphylococcus Aureus*). The plates were prepared by pouring Mueller Hinton agar media into sterile petri plates and allowed to set. Each organism (culture) was inoculated on three (3) plates (replicate) using swab stick. A 4 mm cork borer was used to bore holes on the medium and four holes were made on each petri plate. About 0.2 drops of the different concentrations (2 mM, 1 mM,0.5 mM) were introduced into the well. The petri plates were incubated at 37°C for 24 h, after which the zones of inhibition were measured using a meter rule. A standard antibiotic, Gentamycin was used as a positive control [26].

2.5.1 Minimum Inhibitory Concentration (MIC)

The MIC of the extracts was determined by the broth dilution method. Test tubes were labeled as 7NP, 14NP, 21NP and 5 ml of nutrient broth was introduced into each test tube, 0.5 ml of bacteria suspension was inoculated. This was followed by the addition of different concentrations (2 mM, 1 Mm, 0.5 mM) of the extract to the sterile nutrient broth test tubes and incubated at 37 ^{o}C for 24 hours. In the control tubes, only extracts were not added (contains nutrient broth + bacteria), the other control contains (nutrient broth + nanoparticles). By comparing the three sets of tubes. The uninoculated test tubes were used to check the sterility of the medium and as negative control while the positive control tubes were used to check the suitability of the medium for growth of the microorganisms. The MIC was determined by the lowest concentration of the extract that prevented visible growth [27].

2.5.2 Minimum Bactericidal Concentration (MBC)

The MBC of the extract(s) was determined by sub culturing the contents of the tubes that showed inhibition of growth due to the presence of extract (nanoparticles). The tube(s) were plated out on nutrient agar plates which had neither antibiotics nor extract and incubated for 24 hours to determine whether there is growth of microorganisms or not, to confirm the effect of the extract (nanoparticles) on the Bacteria [28].

2.5.3 Statistical analysis

Graph Pad Prism version 6 software was used for statistical analysis of all the data obtained. Values were expressed as mean ± standard deviation. P values of <0.05 was considered significant.

3. RESULTS AND DISCUSSION

3.1 Biosynthesis of *Mangifera indica* Ag-NPs (MPAg-NPs)

The AgNPs were characterized with typical yellowish brown color produced from the bio-reduction of silver ions to silver nanoparticles. The change in color from colorless to yellowish brown, suggests the presence of different biomolecules in the extract, that play catalytic and stabilization roles in the formation of the particles. The intensity of color increased as the bioreduction of silver ions progressed and stabilized when the reaction was completed. Typical AgNPs coloration, previously reported from bacterial exopolysaccharides and mushroom culture extracts and mycelia, was yellowish brown for *Lactobacillus rhamnosus* [29].

3.2 Characterization of Synthesized *Mangifera indica* pulp Ag-NPs (MPAg-NPs)

3.2.1 FTIR spectroscopy MPAg-NPs

FTIR result of MPAg-NPs showed the characteristic properties of biomolecules and their functional groups that stabilized and capped the synthesized AgNPs of 2 mM, 1 mM and 0.5 mM respectively. FTIR result (Table 1) (Figs. 1-4) showed a strong peaks at 3335, 3324, 3268, 3258, 2124, 2121, 2109 and 1640 cm^{-1} which showed that the biological synthesized silver nanoparticles were capped and stabilized by proteins. The bands 3335, 3324 $cm^{-1}$are associated with the N-H bond of primary and secondary amines since it is nearly within the range of 3360-3310 cm^{-1}, it also indicated the presence of OH for alcohol OH and hydroxyl compound –OH witha peak band from 3570-3200 cm^{-1} [30]. The peaks at 2109, 2121, 2124 cm^{-1} indicate terminal alkyne stretch peaks which are within 2260-2100 cm^{-1}. While the peak at 1640 cm^{-1}suggested the presence of C=C bond of alkene nitrogen oxy-compound or C=O carbonyl of amide or C=N bond of amide group since it within 1680-1620 cm^{-1}. This proved that proteinous molecules present in the pulp extracts of *Magnifera indica* were involved in the bio-reduction of silver nitrate/silver metal ion to silver nanoparticles and hence these biomolecules are responsible for capping and efficient stabilization of the AgNPs. It has been reported that proteins can bind to nanoparticles either through free amine groups or cysteine residues in the proteins [30].

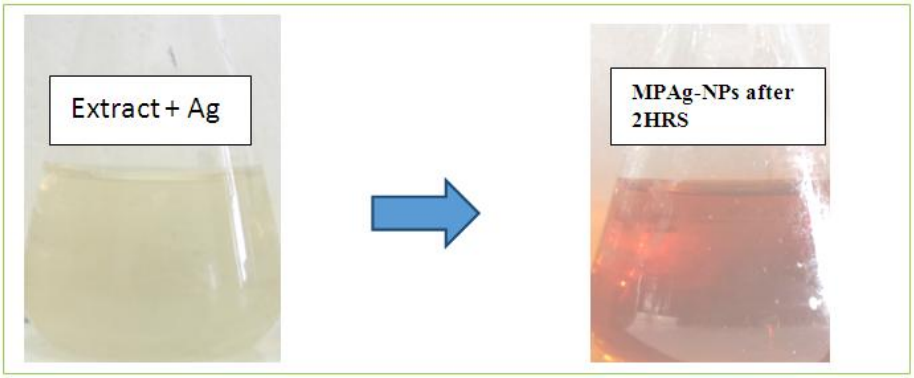


Fig. 1. Color changes observed 2 hours after adding AgNO3 in the aqueous extract of *Mangifera indica*

Table 1. FTIR of synthesized *Mangifera indica* silver nano particles (MPAg-Nps)

S/N	Concentration	Frequency	Functional groups	Assignment
	2 Mm			
1		1680–1620	C=C	Alkenylstretch
2		1650–1550	N-H	bend Primary amine
3		1680–1630	C=O	Amide
4		600–500	C–I	Aliphatic iodo compound
5		620–600	S–S	Disulfide
6		2140–2100	C=C	Terminal alkyne
7		3130–3070	C–C	Aromatic ring stretch
	1 mM			
8		1690–1590	–C=N–	Open-chain Imino group
9		2200–2000	CN–	Cyanide ion, thiocynide.
10		1640–1620		Organic nitrate
11		3570–3200	OH	Hydroxyl group
12		500–430	S–S	Aryl disulfide
	0.5 mM			
13		500–470	S-S	Polysulfide
14		3345–3324	N–H	Stretch Aliphatic primary amine
15		3350–3320	=N–H	Immino compound
16		720–590	OH	Alcohol, OH out of plane band

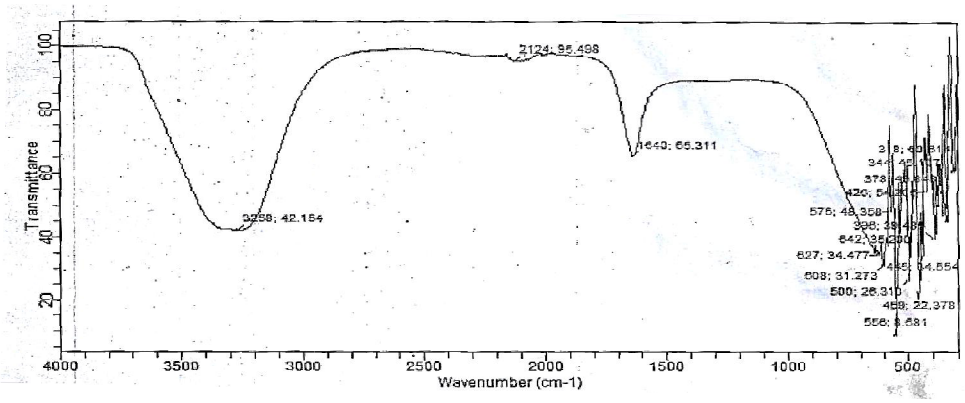


Fig. 2. FTIR spectra at 2 mM $AgNO_3$ of Synthesized MPAgNPs

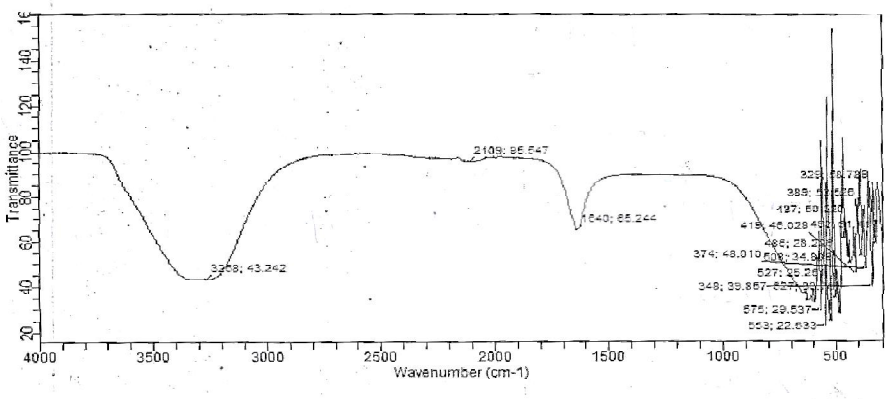


Fig. 3. FTIR spectra at 1 mM $AgNO_3$ of Synthesized MPAgNPs

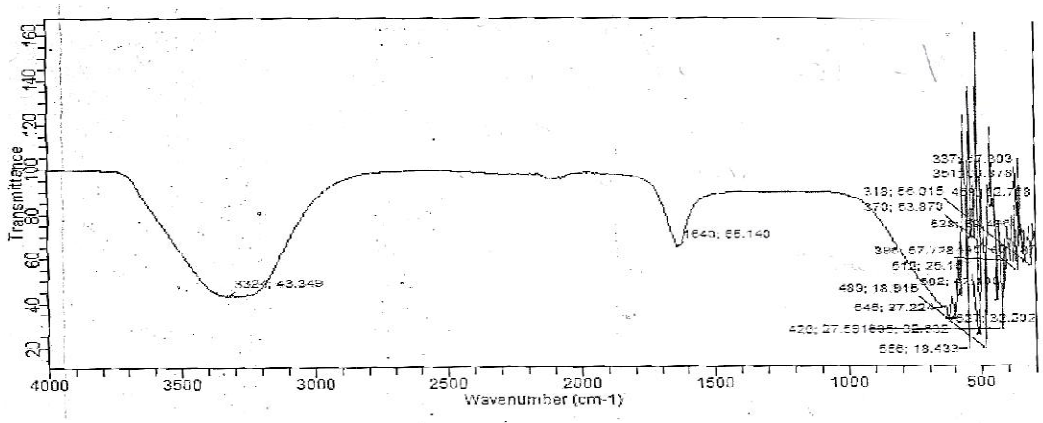


Fig. 4. FTIR spectra at 0.5 mM $AgNO_3$ of Synthesized MPAgNPs.

3.2.2 UV-VIS Spectroscopy of MPAg-NPs

UV–Vis retention range of Ag-NPs shows in Table 2 and Fig. 5. Broad bell-shaped range bend was gotten from UV–Vis examination. Different metabolites of MPAgNPs make the plasmon band wide. Surface plasmon reverberation (SPR) of silver happens at 350 - 375 nm for the 7Nps at 2 mM concentration and 13Nps at 1 mM while there is no absorbance of 20NPs at 0.05 mM this may be due to low concentration of the MPAgNPs. This top expanded with time up to 360 min. Concurring to Mie hypothesis, round nanoparticles appear as it were a single SPR band. suggesting the reduction of silver nitrate into silver nanoparticles. Since the SPR absorbance depends intensely on the shape, and environment by which the nanoparticles are shaped, the plasmon groups are wide with an retention tail within the longer wavelengths by expanding the concentration of AgNO3, demonstrating an upgrade in molecule estimate conveyance of the synthesized nanoparticles. The number of crests increments by expanding differing qualities of particle shapes [31,32]. This proved that biosynthesized Ag NPs are collectively round in nature.

From the Table 2, the sample 7NPs at 2 mM concentration has the highest peak with 375.00nm,10.93A and 350.04nm, compared to the other samples because of high concentration of $AgN0_3$ in the sample.

3.3 Antimicrobial Activities of *Mangifera indica* Ag-NPs (MPAg-NPs)

3.3.1 Zone of inhibition

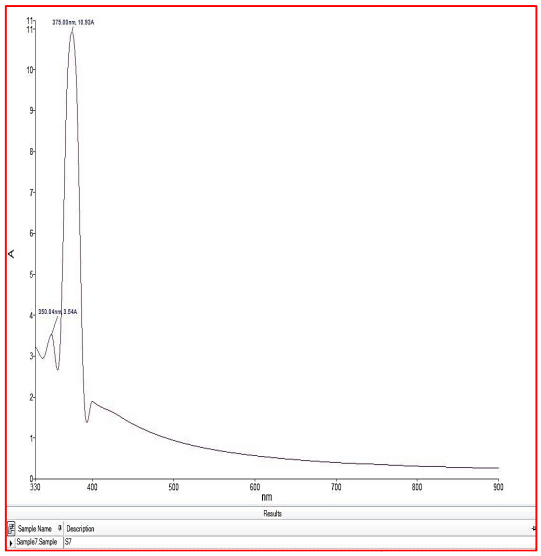
The antimicrobial activity of the synthesized mango pulp silver nanoparticles (MPAg-NPs) was carried out using gram-ve and gram+ve bacteria such as *Escherichia coli* and *Staphylococcus aureus* respectively. Measurement of zone of inhibition was carried out using Gentamycin as a control to determine antimicrobial efficacy of AgNPs mango pulp extract (Table 3).

The mango pulps Ag-NPs (MPAg-NPs) exhibited antibacterial efficacy against the two forms of bacterial *E. Coli (gram -ve) and S. Aureus (gram +ve)*. The zones of inhibition show the relative antimicrobial effect of gentamycin (control) and that of mean molar concentration of the synthesized AgNPs. (Table 3).

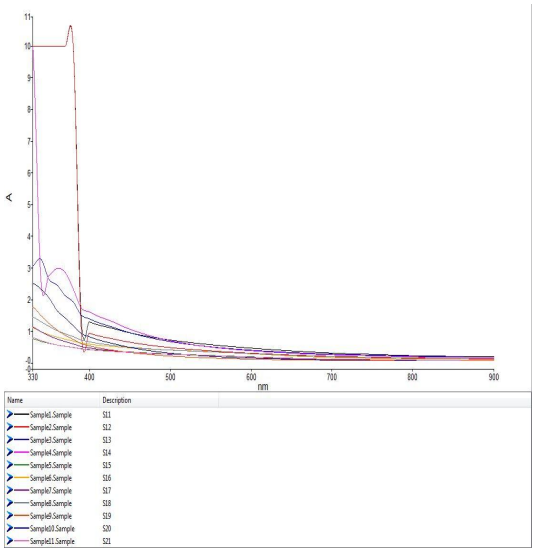
The AgNPs at 2 mM, 1 mM and 0.5 mM concentrations of $AgNO_3$ inhibited the growth of *E. Coli* with zones of inhibition of 12±0.00, 11.5±0.70, 11.33±1.5mm respectively. With regard to antibiotic gentamycin which was used as a control revealed the zone of inhibition at 15.16±0.76mm.

Table 2. UV-Vis spectrum absorbance peak of different sample

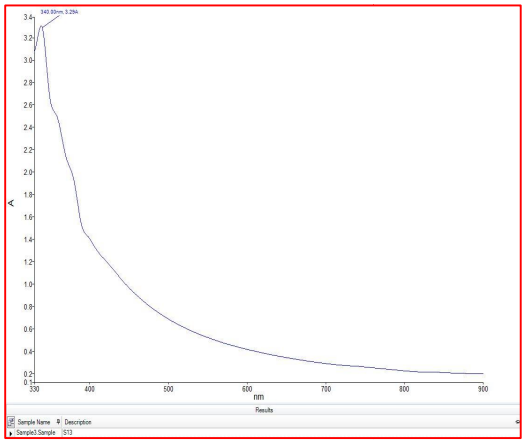
Samples	7NPs (2 mM conc.)	13NPs (1 mM conc.)	20NPs (0.5 mM conc.)
Absorbance	375.00nm, 10.93A 350.04nm, 3.54A	340.00nm, 3.29A	No absorbance



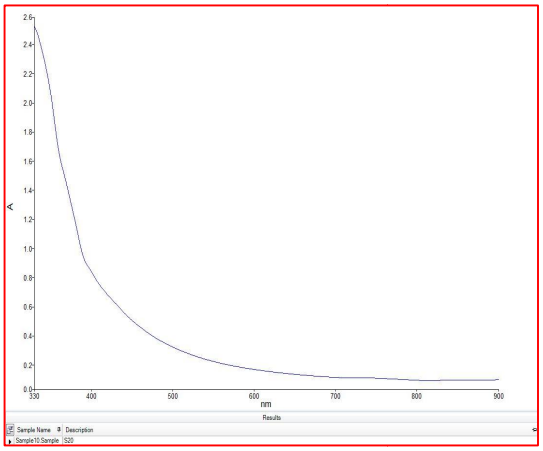
The UV-Vis absorption spectrum of the biosynthesized AgNPs of sample 7 of 2 mM concentration of silver nitrate showing an absorbance peak of 375nm.



The UV-Vis absorption spectrum of the biosynthesized AgNPs of sample 7 of 2 mM concentration of silver nitrate showing an absorbance peak of 350nm.



The UV-Vis absorption spectrum of the biosynthesized AgNPs of sample 13 of 1 mM concentration of silver nitrate showing an absorbance peak of 340 nm.



The UV-Vis absorption Spectrum of the biosynthesized AgNPs of Sample 20 of 0.5 mM concentration of silver nitrate with no absorbance peak.

Table 3. Mean zone of inhibition

Bacterial specie [mm]	Control (Gentamycin)	2 mM NPs	1 mM NPs	0.5 mM NPs
E. Coli	15.16±0.76*	12.00±0.00[a]	11.50±0.70[b]	11.33±1.50[c]
S. Aureus	21.67±2.11*	12.50±2.12[a]	12.0± 1.41[b]	12.00 ±4.24[d]

The result are presented in triplicate as mean ± standard deviation, values with asterisk as superscript are statistically different and values with similar alphabet as superscript are statistically (p≤0.05) the same

While in *S. Aureus* the zone of inhibition at 2 Mm, 1 mM and 0.5 mM and control (Gentamycin) were 12.5±2.12, 12±1.14,12±4.24 and 26.67±2.1mm respectively, *S. Aureus* was found to have a better zone of inhibition than in *E. Coli*. This confirmed the susceptibility of gram + ve than a gram – ve bacteria to the synthesized MPAgNPs and their therapeutic efficacy, a

similar result is reported by Perez et al. [25]. The result is also shown that the increase in inhibition depends on the concentration of $AgNO_3$ in the MPAgNPs.

3.3.2 Minimum Inhibitory Concentration (MIC) and Minimum Bacterial Concentration (MBC)

The MIC of *E. Coli* and *S. aureus* using AgNPs of mango pulp extract aws carried out to ensure the presence or absence of inhibition caused by the synthesized silver nanoparticles against bacteria (table 4). Its also used for the cultivation and determination of susceptibility to an antimicrobial agent. The MIC results were found to be all negative (-ve) at all the three concentration of the synthesized MPAg-NPs , this proved to be no any growth of bacteria at three concentrations of $AgNO_3$ (Table 4). While the MBC is an emergence and confirmatory analysis which was carried out to ensure the significance of the AgNPs mango pulp extract against microbial activities of *E. Coli* and *S. Aureus* (Table 5). The MBC for *E. Coli* at the three concentrations of $AgNO_3$ showed no any growth while *S. Aureus* was also no growth at 2 Mm and 1 Mm but at 0.5 Mm concentration of $AgNO_3$ a growth of *S. Aureus* was observed. Similarly, the MIC and MBC values of AgNPs synthesized using *Eucalyptus globulus* against *E. coli* were found to be 36 and 42 *µ*g/ml [33]. Moreover, Ansari and Alzohairy have reported that the MIC and MBC values of AgNPs prepared using seed extracts of *Phoenix dactylifera* as 10.67 and 17.33 *µ*g/ml, respectively, against methicillin-resistant *S. aureus* [34]. These variations might be due to the different intrinsic tolerance levels of test strains used in the assays, size and nature of nanoparticles, and methods adopted for the determination of the MIC and MBC.

This activity of MPAg-NPs may be attributed to small size of the nanoparticles and increased surface area which provides opportunities for interactions with bacterial cells because it leads to increased membrane permeability and cell destruction to bacteria and fungi. Silver nanoparticles synthesized from mango pulp may cause cell breaking and changes in the cell membrane permeability. In addition, silver nanoparticles attach to the surface of the cell membrane, penetrating in bacteria and disturb the cell function, interactions of silver nanoparticles with amino acids and enzymes: Bonding with amino acids (especially to –SH group), these may be related to antibacterial activities demonstrated by mango pulp AgNPs in this study. It is also attributed to the fact that cells are made up of sulfur and phosphorus which are soft bases and DNA has sulfur and phosphorus as its major components; silver nanoparticles can act on these soft bases and destroy the DNA which would definitely lead to cell death. The mango pulp silver nanoparticles synthesized in this study show significant anti-microbial activities against Gram-positive and Gram negative bacteria. It is reported that green silver nanoparticles showed more efficient anti-microbial activity than the plant extract alone as revealed by the Mango pulp Ag-NPs. This is similar to that of *Azadirachta indica* [35], *Calatropis procera* [36], *Fagonia cretica* [37], *Tinospora cordifolia* [38]. While, antimicrobial activity of synthesized silver nanoparticles from *Phyllanthus amarus* was reported to be higher than that of the standard drug used [38] as shown by MPAg-NPs when compared the gentamicin used as control in this study. Silver nanoparticles from *Lawsonia inermis* gel in combination with antibiotics showed a synergistic anti-microbial effect [39]. Whereas Marslin et al. [24] stated that a cream incorporated with silver nanoparticles biosynthesized from *Withania somnifera* possessed a significantly higher antimicrobial activity.

Table 4. Minimum inhibitory concentrations

	2 mM NPs	1 mM NPs	0.5 mM NPs
E. Coli	-	_	-
S. Aureus	_	_	_

Key : -ve means presence of inhibition, + ve means absence of inhibition

Table 5. Minimum Bacterial Concentration (MBC)

Bacterial specie	2 mM NPs	1 mM NPs	0.5 mM NPs
E. Coli	_	_	_
S. Aureus	_	_	+

Key:-ve means absence of growth and + ve means presence of growth

4. CONCLUSION

The silver nanoparticles from a low cost material mango pulp extract (*Mangifera indica*) using a reliable, safe and ecological friendly green approach was synthesized for the first time. The synthesized MPAgNPs were characterized using UV-VIS and FTIR which indicated an absorbance peak range from 350-370nm and the presence of many functional group related to phytoconstituent such as phenol, flavonoids respectively.the phytochemicals are responsible for their reducing ability of silver ions. The biological MPAgNPs have shown excellent antimicrobial activity against *E. Coli* and *S. Aureus* forms of bacteria.

CONSENT

It's not applicable.

ETHICAL APPROVAL

As per international standard written ethical permission has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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