ORIGINAL ARTICLE

Discovery Phytomedicine 2020, Volume 7, Number 2: 76-83

# Biosynthesis, Characterization and Biological Applications of Silver Nanoparticles using *Celosia trigyna* and *Solanum nigrum* Extracts: Neglected Vegetables in Nigeria

## ABSTRACT

Plant-mediated synthesis is gaining acceptance in many fields i.e. biology and pharmaceutical fields. This aim of this study is synthesizing Ag nanoparticles using air-dried leaves of two (2) neglected vegetables i.e. *Celosia trigyna* and *Solanum nigrum*. Ultraviolet–visible spectroscopy, fourier transform infrared spectroscopy (FT-IR) and scanning electron microscopy (SEM) were used to characterize the formation of silver nanoparticles (AgNPs). The anti-inflammatory properties of these AgNPs were evaluated using Cell Stabilization Membrane (CSM) and lipoxidase assays, their antioxidant activity were established on DPPH and ABTS+ assays. The positive control employed are indomethacin and ascorbic acid for these activities. Nanoparticles synthesized were labelled for *Celosia trigyna* (CT-AgNPs) and *Solanum nigrum* (SN-AgNPs) were noticed through visual color change. The UV–Vis spectra of the synthesized nanoparticles displayed absorption bands at around 360-440 nm, which is a characteristic band for Ag and FTIR displayed possible functional groups responsible for Ag nanoparticles synthesized by these plants. The SEM image of the AgNPs formed displayed were spherical in morphology. CT-AgNPs exhibited the most significant inhibitory activity against HRBC ($IC_{50}$: 32.2 µg/ml) while SN-AgNPs displayed the most significant inhibitory activity against lipoxygenases ($IC_{50}$: 32.8 µg/ml) when compared to the positive control used indomethacin ($IC_{50}$: 28.1 µg/ml). SN-AgNPs exhibited the most significant antioxidant effect against ABTS ($IC_{50}$: 11.4 µg/ml) while CT-AgNPs displayed the most significant antioxidant activity against DPPH ($IC_{50}$: 4.6 µg/ml) when compared to the positive control used ascorbic acid ($IC_{50}$: 4.7 µg/ml). This work showed that the synthesized AgNPs from non-cultivated vegetable can find relevance and application in health, drugs, food and environmental science.

**Keywords:** non-cultivated vegetables; nanoparticles; AgNPs; anti-inflammatory; antioxidant

## INTRODUCTION

Nanoparticles' synthesis comes with different dimensions and forms, coupled with the gained advantages is what Nanotechnology is. At present, an urgent pressure is evolving to acquire environmental friendly and green techniques for the manufacture of materials made-up of nanoparticles, these will eventually replace the toxic and harmful chemicals employed in the synthesis procedures hence evade their health dangers.[1,2] Silver nanoparticles (AgNPs) have been given more attention among the other nanoparticles due to their appealing physical and chemical properties.[3,4] Most nanomaterial industries use silver for production of over four hundred tonnes of silver nanoparticles each year. Different methods (both chemical and physical) are employed in preparation of silver nanoparticles i.e. biological methods, chemical reduction, chemical vapor deposition, electro-irradiation, hydrothermal method, laser-mediated synthesis, microware irradiation, microwave, photochemical reduction, reversemicelle method, sol–gel process and ultraviolet (UV) irradiation etc.[5,6,7] Biosynthesis of nanoparticles is mostly preferred because it is cost effective, environmental friendly and human friendly.[8,9] Biosynthesis of nanoparticles using plant extracts involves reduction of metal ions which has been discovered to be much faster compared to microorganisms and its stability is better.[10,11] Many studies have shown the biosynthesis of AgNPs employing various plants' extracts.[9,11,12,13,14,15]

*Celosia trigyna* occurs almost throughout tropical Africa, South Africa and southern Arabia and is regarded as a weed but is used as a leafy vegetable in Benin and southern Nigeria. It is found in forest clearings and grassland, along roadsides and rivers, and as a weed in fields. It grows on a wide range of soils, but prefers fertile well-drained loamy soils.[16] *C. trigyna* is employed in Africa to manage heart complaints, pustular skin eruptions and tapeworm related diseases. The leaves pulp is used to treat pains i.e. back, chest and costal, it is also use against stomach-ache and urethral disorders. The leaves and flowers are employed against diarrhea.[17] The plant is generally believed to be among the ingredients/preparations used against various women's disorders and diseases, including ovarian troubles and excessive menstruation.[18]

*Solanum nigrum* as a medicinal plant is use for food and medicine, studies have shown its anti-oxidant, anticonvulsant, anti-pyretic, antiulcerogenic, antimicrobial, anti-inflammatory and diuretic effects.[19,20,21,22,23] In China, its chemopreventive ability is held in high esteem and it is use to manage cancers related to the digestive system. It was a traditional European medicine for infirmities that needed cooling. It was considered good for cooling hot inflammations, ringworms, ulcers, testicular swellings, gout and ear pains.[24] It was also implored in the treatment of convulsions. The Arabs used its bruised fresh leaves to erase pain and reduce inflammation.[25]

Beside their nutritional benefits, leafy and non-cultivated vegetables have been known to possess therapeutic uses.[12,26,27,28] However, many of these cheap but diseases preventing plant species are yet to be sufficiently studied and exploited. Hence, this study aims at: investigate the phytochemical screening of these non-cultivated vegetables' leaves extract; experimentally carry out characterization and application of these medicinal plants species silver nanoparticles (AgNPs) as anti-inflammatory, antioxidant agents and acetylcholinesterase inhibitors.

## MATERIAL AND METHODS

### Collection of the Plants

*Celosia trigyna* and *Solanum nigrum* were collected in the month of November around Ilorin metropolis and also from Oshogbo, Osun State. The whole plants (leave, stem and stalk) were washed with distilled water then dried in open air for two weeks to completely remove the moisture content and to effectively prepare the leaves for the next stage of preparation. After air-drying, the plants (leave stem and stalk) were crushed into powder using pestle and mortar and kept in air tight plastic containers coded.

### Preparation of Extract

Extracts were prepared using solvent extraction (N-hexane and Methanol). 50 g of each of the prepared *Celosia trigyna* and *Solanum nigrum* were placed in jars and soaked in N-hexane, this lasted 4 days, then the N-hexane was concentrated using a rotary evaporator to give the crude N-hexane extract for each of the plants. The residues were exposed to air and soaked again, using methanol for 7 days after which the methanol extract was concentrated using a rotary evaporator to give crude methanol extracts for both plants.

### Phytochemical Screening

Phytochemical screening was done to detect the presence of alkaloids, flavonoids, phenols, saponins, steroids and triterpenes in both plants leaf extracts. Preparation for the test was done by pouring 3 mL of the leaf extracts into separate test tubes and diluting with 2-4 ml deionized water. Standard techniques of screening and detecting secondary metabolites in plants was used.[29,30]

### Synthesis of Silver Nanoparticles

The synthesis of nanoparticles using Silver was carried out following the procedure reported by Bello *et al.* (2019).[12] In a typical procedure, 10 mL of the methanol leaf extract was measured and poured into a clean 250 ml beaker and reacted with 90 ml of 0.01 M $AgNO_3$ from a burette (titration method) using $AgNO_3$ as the titrant and the aqueous extract as the analyte at room temperature. The synthesized mixture was left for 24 hours and then separated by centrifugation using centrifuging machine at 4000 rpm for 10 – 15 minutes the clear liquid was decanted and the settled layer (nanoparticles) was stored in a 5 ml plastic sample vial and labelled accordingly.

The following code-names were given to the synthesized nanoparticles: *Celosia trigyna* silver nanoparticles (CT-AgNPs) and *Solanum nigrum* silver nanoparticles (SN-AgNPs).

### Characterization of Silver Nanoparticles

CT-AgNPs and SN-AgNPs with the plants' extracts were characterized employing techniques such as: scanning electron microscopy (SEM), Fourier Transform Infrared (FTIR) and Ultra-violet/Visible (UV-vis).

#### *Ultra-Violet/Visible Spectroscopy*

The wavelength with the highest absorbance was determined by UV- visible spectroscopy using Biochrom Libra PCB 1500 UV-VIS spectrophotometer. The absorbance of silver nanoparticle dispersed in a quartz cuvette with a 1 cm optical path was measured by withdrawing small aliquot from the reaction mixture and wavelength scan was taken at every 60 mins interval, then 90 minutes and after 24 hours varying wavelength from 150 nm to 800 nm until a stable absorbance was obtained at maximum wavelength.

#### *Fourier Transform Infrared Analysis (FTIR)*

The FTIR analysis was done for the nanoparticles formed and the extracts of these plants were viewed employing the equipment and its software reported earlier by Bello *et al.,* (2019).[12]

### *Scanning Electron Microscopy (SEM)*

The nanoparticles of these plants' extracts were viewed employing the equipment and its software reported earlier by Bello *et al.,* (2019).[12]

## BIOLOGICAL ACTIVITIES

### Anti-inflammation

#### *Cell Stabilization Membrane (CSM)*

The method employed in carrying out the anti-inflammatory activity of these extracts have been reported by both Bello *et al.,* (2019)[12] and Oyedapo *et al.,* (1997; 2004).[31,32] All tests and analyses were run in triplicate and averaged

#### *Lipoxidase Assay*

The inhibitory activity against lipoxygenases was studied using linoleic acid as substrate and lipoxidase as enzyme, the detail procedure for this activity was previously employed by these authors.[12,33] All tests and analyses were run in triplicate and averaged

### Antioxidant Activity

#### *2, 2-diphenyl-1-picrylhydrazyl (DPPH) Activity*

The DPPH activity employed has been previously been reported by some authors though with little adjustment.[12,28,34] Mean ± standard error of the mean of two independent experiments run in duplicate was used to present the results.

#### *2, 2′-azino-bis-(3-ethyl) benzothiazoline-6-sulfonic acid (ABTS) radical cation scavenging Activity (ABTS)*

The $ABTS^{+}$ radicals' activity employed has been previously been reported by some authors though with little adjustment.[12,28,34] All analysis was determined in duplicate.

## RESULT AND DISCUSSION

### Phytochemical Screening

Phytochemical constituents of the extracts of *Celosia trigyna* and *Solanum nigrum* are shown in Table 2. On the whole, polyphenol, flavonoids, triterpenes and steroids were identified in all plants' extracts. Saponnins are absent in all the plants' extracts but alkaloids are only absent in the hexane part of all the plants' extracts as revealed in Table 2. The hexane extract of *C. trigyna* gave a poor result for most groups of secondary metabolites investigated as showed in Table 2.

### Characterization

#### *UV-Visible spectroscopy study*

Physical examination (visual) revealed changes in colour. The colour changes that were witnessed indicate the formation of *Celosia trigyna* silver nanoparticles (CT-AgNPs) and *Solanum nigrum* silver nanoparticles (SN-AgNPs) as shown in Table 3. Several experiments showed that AgNPs exhibited such color vicissitudes in solution made-up of water due to AgNPs surface plasmon resonance excitation (SPR), this was the first validation test that silver nanoparticles were generated *48, 49*. The generated AgNPs were examined further using UV – Vis spectroscopy which is an essential and famous characterization tool. It was discovered that the aqueous extract of *S. nigrum* is able to reduce silver nitrate to silver nanoparticles at 420 nm being the surface plasmon absorbance peak. among others. Looking at Figure 3, the curve in each spectrum of synthesized silver nanoparticles that have been absorbed in the wavelength range 420-440 nm of silver nanoparticle but 440 nm for of *C. trigyna*. This peak falls within the range of specification for nanoparticles as reported by some authors.[11,35]

#### *FT-IR spectroscopy study*

FTIR spectroscopy measurements were used to identify and characterize the biological reduction functional group that will give an indication of the probable group of organic metabolites contained in these hegleted vegetables responsible for the reduction of the $Ag^{+}$ ions to elemental $Ag^{0}$ and the subsequent capping culminating in a successful stabilization of the AgNPs.[36] The FTIR spectra of the synthesized AgNPs of the two vegetables i.e. A= SN-AgNPs; B=CT-AgNPs are shown in Figure 2. The Infrared spectrum of SN–AgNPs showed the present of O-H functional group with a broadband at 3429.41 $cm^{-1}$, the IR spectrum of SN–AgNPs further revealed C=C structure with medium intensity at wavenumber of 1641.16 $cm^{-1}$ which is $sp^{2}$ carbon. The IR spectrum of CT-AgNPs shows a very broad band at 3400.74 $cm^{-1}$ which was assigned to -OH stretch. It shows a very sharp absorption band at 1631.64 $cm^{-1}$ which was assigned to C=O stretch, there is present of C=C functional group at wavenumber of 1600 $cm^{-1}$. Absorbance bands that are well-defined and broad were spotted at 3452.24 (-OH), 1631.41 (C=C, stretching), 1451.19-1384.70 (C-H, bending), 1141.42 (C-O) for the AgNPs synthesized (Figure 2). The OH stretching is the reason for the broad and penetrating bands spotted at around 3400 $cm^{-1}$ for both AgNPs, which suggests that there is like hood of flavonoids and polyphenols present in the nanoparticles formed. The –C=C– stretching give rise to the medium band seen at around 1640 $cm^{-1}$ in both SN-AgNPs and CT-AgNPs. The C–H stretching belonging to compounds containing aromatic rings gives peaks at 1450 $cm^{-1}$ (Figure 2). This give a hint about the

presence of alkaloids, flavonoids and others in this plant extract. As shown in Figure 2, most of these spectra proved distinctive functional groups of compounds i.e. Alkaloids, coumarins, flavonoids, phytosterols, tannins and phenolic acids, all these secondary metabolites may be responsible for the capping and reduction of the AgNPs that were synthesized.[12]

**Table 1 Phytochemical Screening Result**

| | *Solanum nigrum* | | *Celosia trigyna* | |
|---|---|---|---|---|
| | MeOH | Hexane | MeOH | Hexane |
| Polyphenol | +++ | + | +++ | - |
| Flavonoids | +++ | + | +++ | - |
| Triterpenes | ++ | ++ | ++ | ++ |
| Saponnins | - | - | - | - |
| Alkaloids | +++ | - | ++ | - |
| Steroids | ++ | ++ | +++ | - |
| Phenols | ++ | ++ | +++ | ++ |

*+++= Very Good, ++=Good, +=Fair, - =Not present, MeOH= Methanol*

**Table 2 AgNPs Colour Changes observed**

| | | Colour Change | |
|---|---|---|---|
| | Plant Name | Initial | Final |
| 1 | *Solanum nigrum* | Black | brown |
| 2 | *Celosia trigyna* | Blackgreenish | Yellow |

### *Scanning Electron Microscope (SEM)*

SEM identifies the physiognomies of the AgNPs' surface, its morphology and the distribution of the SN-AgNPs and CT-AgNPs described on the SEM micrograph (Figure 1)., to determine the concentration of the silver formed in the nanoparticles. Nanoparticles formed due to Silver usually display a distinctive absorption characteristic peak at approximately 3 keV due to the surface plasma resonance phenomenon.[37] The cracked lines in the SEM micrographs (Figure 1 A-D) would enhance a lamina flow indicating the potential of the AgNPs for toxicant removal.[9,38] The nanoparticles synthesized by these non-cultivated vegetables were highly agglomerated for CT-AgNP and ST-AgNPs displayed a brief scattered morphology (Figure 1). MubarakAli *et al.* (2011) ascribes this cluster showed by CT-AgNPs to a dehydration-induced combination of Ag nanoparticle. Though, these two synthesized nanoparticles showed a trend in term of differences in the dimension and magnitude of the synthesized nanoparticles. The study can be credited to the fact that the bigger and bulkier nanoparticles are possible to hold more Ag.[39]

## Biological Activities

### *Antioxidant Activity*

The antioxidant activity of the methanol extracts of the two wild vegetables with their corresponding synthesized nanoparticles were evaluated and

**Table 3 Antioxidant Activity of the Synthesized AgNPs and Extracts of the Plant Species**

| | *Solanum nigrum* | | | | *Celosia trigyna* | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ABTS | | DPPH | | ABTS | | DPPH | | |
| µg/ml | SN-AgNPs | Me-SN | SN-AgNPs | Me-SN | CT-AgNPs | Me-CT | CT-AgNPs | Me-CT | *Ascorbic Acid* |
| 100 | 11.4±2.1 | 13.4±1.5 | 15.4±3.1 | 13.6±1.5 | 12.4±0.1 | 14.7±1.6 | 9.4±0.1 | 13.3±1.6 | 4.7±0.6 |
| 200 | 13.9±0.2 | 24.2±1.8 | 18.9±0.2 | 24.2±0.2 | 13.4±0.1 | 17.2±2.1 | 10.4±0.1 | 13.9±2.1 | 5.6±0.5 |
| 300 | 16.8±0.2 | 34.3±1.3 | 21.2±0.2 | 34.3±1.3 | 16.4±1.1 | 35.3±1.3 | 11.4±1.1 | 14.1±1.3 | 7.1±6.1 |
| 400 | 15.3±1.7 | 38.3±0.4 | 21.8±1.7 | 38.3±1.4 | 15.4±0.00 | 34.8±1.1 | 11.5±0.0 | 15.1±2.2 | 8.3±4.9 |
| 500 | 14.9±1.8 | 38.5±0.6 | 20.5±0.6 | 38.5±0.6 | 17.4±0.01 | 35.2±2.6 | 16.4±0.1 | 17.2±3.1 | 13.6±0.2 |

*Me-SN= Methanol Extract of S. nigrum; Me-CS=Methanol Extract of C. trigyna;: The $IC_{50}$ are means of three replicates (N=3 ± SD).*

**Table 4 Anti-inflammatory Activity of the Synthesized AgNPs and Extracts of the Plant Species**

| | *Solanum nigrum* | | | | *Celosia trigyna* | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | HRBC | | LIP | | HRBC | | LIP | | |
| µg/ml | SN-AgNPs | Me- SN | SN-AgNPs | Me-SN | CT-AgNPs | Me-CT | CT-AgNPs | Me-CT | *Indomethacin* |
| 100 | 32.2±0.1 | 39.1±0.1 | 57.6±0.1 | 63.1±0.1 | 38.5±0.1 | 62.9±1.1 | 32.8±0.1 | 51.9±1.1 | 28.1±0.0 |
| 200 | 32.5±0.1 | 39.9±1.1 | 55.5±0.1 | 59.9±1.1 | 43.2±1.1 | 58.3±2.1 | 33.8±2.1 | 58.3±2.1 | 34.4±0.0 |
| 300 | 33.1±0.1 | 38.4±2.1 | 49.1±0.1 | 58.4±2.1 | 44.2±1.2 | 61.1±1.2 | 34.5±1.2 | 61.1±1.2 | 34.8±0.0 |
| 400 | 34.4±0.1 | 43.3±1.0 | 49.4±0.1 | 63.3±1.0 | 46.6±0.2 | 64.5±0.1 | 34.7±0.1 | 64.5±0.1 | 37.3±0.0 |
| 500 | 35.9±0.1 | 45.4±1.3 | 45.9±0.1 | 61.4±1.3 | 51.2±1.3 | 63.6±0.1 | 35.1±1.1 | 63.6±0.1 | 36.3±0.0 |

*Me-SN= Methanol Extract of S. nigrum; Me-CS=Methanol Extract of C. trigyna; The $IC_{50}$ are means of three replicates (N=3 ± SD).*

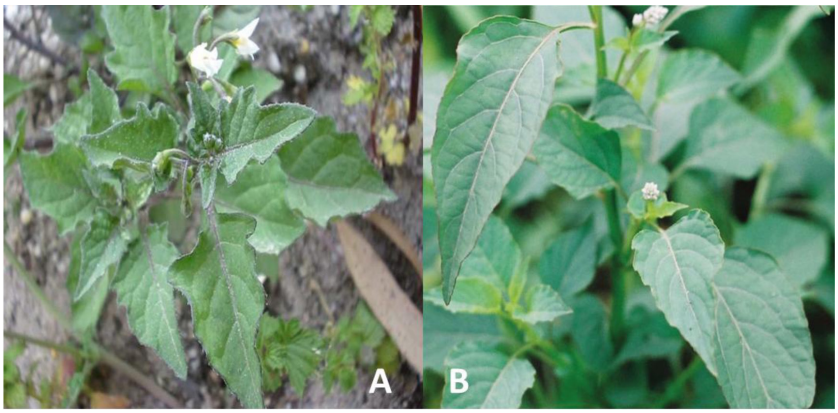


**Figure 1** The leaves of A= *Solanum nigrum*, B= *Celosia trigyna*

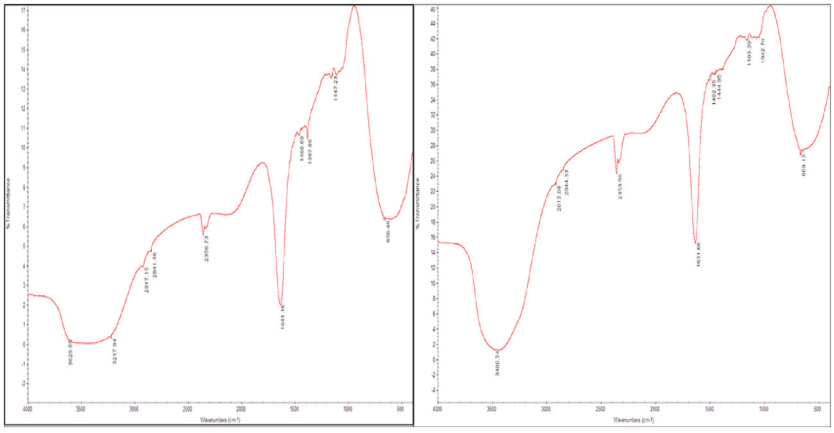

**Figure 2** FTIR spectrum of A= *SN-AgNPs*; B= *CT-AgNPs*

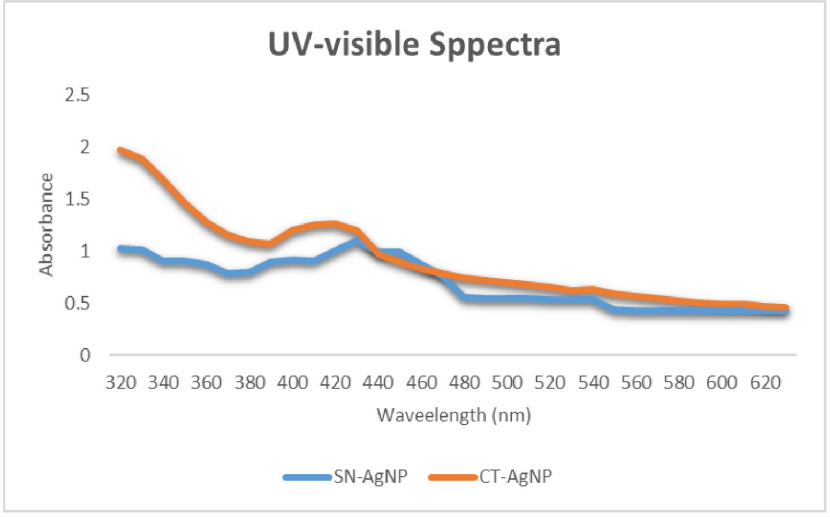


**Figure 3** UV-visible spectra of the Synthesized AgNPs

compared employing two different antioxidant assays as presented in Table 4. The AgNPs and the methanol extract for each of these plants were evaluated for *in-vitro* activity employing DPPH and ABTS assays. The results are expressed in terms of $IC_{50}$ (the concentration that caused a 50 % inhibition) and presented in Table 4. These were carried out with *in-vitro* method at various concentrations (100, 200, 300….500 µg/mL) of the extracts and AgNPs formed. The synthesized AgNPs of these wild but eaten plant species and the extracts tends to display a significant antioxidant activity at the dose 100 µg/mL concentration, this was noticed with the positive control too. The higher the concentration the less the antioxidant effect that was noticed though there was a climax at 400 µg/mL as shown in Table 4. From Table 4, it is observed that there is an obvious trend, the synthesized AgNPs displayed a better activity when compared to the extracts of these plants i.e. AgNPs from *Celosia trigyna* and *Solanum nigrum* displayed a better *in-vitro* antioxidant activity ($IC_{50}$: 11.4 and 12.4 µg/mL) with ABTS assay and ($IC_{50}$: 15.4 and 9.4 µg/mL) using DPPH assay but the methanol extracts of these plants displayed a lower value to the former. SN-AgNPs showed the most significant antioxidant activity against ABTS ($IC_{50}$: 11.4 µg/mL) while CT-AgNPs displayed the most significant antioxidant activity against DPPH ($IC_{50}$: 9.4 µg/mL) when compared to the positive control used ascorbic acid ($IC_{50}$: 4.7 µg/mL). Most of the AgNPs formed showed the most significant result at 100 µg/mL though the positive control gave the best result at this dose also (Table 4). Higher plants always contain constituents and substances with antioxidant effect. Flavonoids and polypenols are one of naturally occurring substances that are widely renowned to exert scavenging ability against superoxide, free and hydroxyl radicals.[40] In this study, we assess the antioxidant of the AgNPs of these wild vegetables and their methanol extracts because of the multifaceted and complex nature of compounds in plants, the antioxidant nature of these AgNPs and their extracts cannot be studied by only a single assay (method). As a result of this, the generally accepted assays i.e. DPPH and ABTS methods were used in this study. Though, CT-AgNPs display a significant antioxidant effect in both assays employed but SN-AgNPs only showed a good antioxidant activity in DPPH assay only. The DPPH and ABTS antioxidant assays proves that these neglected vegetables with their synthesized AgNPs portend a good antioxidant activity. Bello *et al.,* (2019A) reported the health benefits of non-cultivated plants species beyond dietary uses. Their antioxidant activity via ABTS assay is well acknowledged in this study as compared with DPPH.[41] Some secondary metabolites have been reportedly isolated from *C. trigyna,* these compounds include chondrillasterol, chondrillasterol acetate, Pheophytin A and lutein.[42] These molecules and others reportedly identified in this plant exhibit antiulcer, antioxidant, antidiuretic, against heart diseases.[42,43,44] *Celosia trigyna*

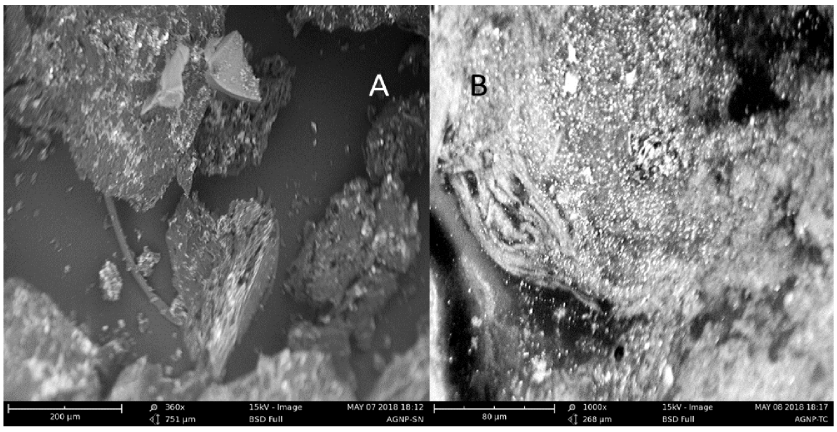


**Figure 4** Scanning electron microscope picture A= SN-AgNPs; B= CT-AgNPs

extract could be a promising nutraceutical for preventing and managing some radicals causing diseases.

### *Anti-inflammatory Activity*

The methanol extracts of the two non-cultivated vegetables with their corresponding synthesized nanoparticles were evaluated and compared using cell-based assays for their anti-inflammatory activity as shown in Table 5. The AgNPs and the methanol extract for *Celosia trigyna* and *Solanum nigrum* were evaluated for *in-vitro* activity employing the Human Red Blood Cell Membrane Stabilization (HRBC) method and lipoxidase Assay. The results are expressed in terms of $IC_{50}$ (the concentration that caused a 50 % inhibition) and presented in Table 5. These were carried out with *in-vitro* method at various concentrations (100, 200, 300….500 µg/mL) of the extract. The extract tends to display a significant anti-inflammatory activity at 100 µg/mL concentration, this was noticed with the positive control too. The higher the concentration the less the anti-inflammatory effect that was noticed though there was a climax at 400 µg/mL as shown in Table 5. From Table 5, it is observed that there is an obvious trend, the synthesized AgNPs displayed a better activity when compared to the extracts of these plants i.e. AgNPs from *S. nigrum* and *C. trigyna* displayed a better *in-vitro* anti-inflammatory activity ($IC_{50}$: 32.2 and 38.5 µg/mL) against Human Red Blood Cell Membrane (HRBC) and ($IC_{50}$: 57.6 and 32.8 µg/mL) against lipoxygenases but the methanol extracts of these plants generally exhibited a lower value to the former. SN-AgNPs showed the most significant inhibitory activity against HRBC ($IC_{50}$: 32.2 µg/ml) while CT-AgNPs showed the most significant inhibitory activity against lipoxygenases ($IC_{50}$: 32.8 µg/ml) when compared to the positive control used indomethacin ($IC_{50}$: 28.1 µg/mL). Most of the AgNPs formed showed the most significant result at 100 µg/ml though the positive control gave the best result at this dose too. CT-AgNPs displayed good activity against LOX assay employed, they could serve well as LOX inhibitors. It is so surprising to note that they display a moderate activity in the other assay used. Some authors have reported the anti-inflammatory activity of *C. trigyna* through LOX assay. Some secondary metabolites have been reportedly isolated from *C. trigyna,* these compounds include chondrillasterol, chondrillasterol acetate, Pheophytin A and lutein.[42] Eboh *et al.,* (2019) reported that ethanol extract of *C. trigyna* has a high content of flavonoids (4.72 ± 0. 97 mgQE/g extract) and phenolic acid (2.51 ± 0.21 mgGAE/g extract).[44] *Celosia trigyna* extract could be a promising nutraceutical for preventing and managing some radicals causing diseases. Flavonoids, polyphenols, bioactive phytosterols and triterpenoids are widely broadly distributed in the plants species globally, these have been documented as important contributing to nutrients for human health.[45] These compounds are considered to have chelating properties, scavenging free radicals by donating hydrogen, antioxidants and agents preventing low-density lipoproteins oxidation. These are excellent Lipoxygenase (LOX) inhibitors, hence this plant could have some advantages for the treatment of psoriasis, osteoporosis arthritis, cancer, allergic rhinitis, asthma and atherosclerosis.[46,47]

### *Future Consideration and Conclusion*

The CT-AgNPs, SN-AgNPs, extracts of *C. trigyna* and *S. nigrum* exhibited some lipoxygenase activity and are therefore possess a significant inhibition towards inflammation but these conclusions should be carefully seen because *in-vitro* assays were only applied. In this study only HBRC and 5-LOX inhibitory activities were studied. These results were produced from *in-vitro* assays using artificial radicals ABTS and DPPH for the antioxidant activity while HBRC and LOX are also artificial *in-vitro* assays for anti-inflammatory. Therefore, the extracts from these wild vegetables and their corresponding nanoparticles need further *in-vivo* activity to be employed in order to fully validate their antioxidant and anti-inflammatory activities.

## CONFLICT OF INTEREST

No conflict of interest among the authors based.

## FUNDING

No funding was received for this study.

## REFERENCE


1. Gopinath, V., Mubarak, A.D., Priyadarshini, S., Prishadharsshini, N.M., Thajuddin, N., Velusamy, P., Biosynthesis of silver nanoparticles from *Tribulus terrestris* and its antimicrobial activity: a novel biological approach. *Colloids and Surfaces. B, Biointerfaces* 2012, 96, 69–74.
2. Sharma, V.K., Yngard, R.A., Lin, Y. Silver nanoparticles: green synthesis and their antimicrobial activities. *Advances in Colloid and Interface Science* 2009, 145, 83–96.
3. Elechiguerra, J.L., Burt, J.L., Morones, J.R., Camacho-Bragado, A., Gao, X., Lara, H.H., Yocaman, M., Interaction of silver nanoparticles with HIV-1. *Journal of Nanobiotechnology* 2005, 3, 6.
4. Kannan R.R.R., Stirk W.A., Van Staden J. Synthesis of silver nanoparticles using the seaweed *Codium capitatum* P.C. Silva (Chlorophyceae). *South African Journal of Botany* 2013, 86: 1–4 doi.org/10.1016/j.sajb.2013.01.003.
5. Murthy, Y., Kondala Rao, T., Singh, R. Synthesis and characterization of nano-silver ferrite composite. *Journal of Magnetism and Magnetic Materials* 2010, 322, 2071–2074.
6. Shankar, S. S., Ahmad, A., Sastry, M. Geranium leaf assisted biosynthesis of silver nanoparticles. *Biotechnology Progress* 2003, 19, 1627–1631.
7. Venkatpurwar, V., Pokharkar, V. Green synthesis of silver nanoparticles using marine polysaccharide: study of in-vitro antibacterial activity. *Materials Letters* 2011, 65, 999–1002.
8. Bello, O. M., Zaki, A.A., Khan, I.S., Fasinu, P.S., Ali, Z., Khan, I.A., Usman, L.A. & Oguntoye, O.S. Assessment of selected medicinal plants indigenous to West Africa for antiprotozoal activity. *South Africa Journal of Botany* 2017 https: //doi.org/10.1016/jsajb.2017.08.002.
9. Dada Adewumi O., Adejumoke A. Inyinbor, Ebiega I. Idu, Oluwasesan M. Bello, Abimbola P. Oluyori, Tabitha A. Adelani-Akande, Abiodun A. Okunola and Olarenwaju Dada. Effect of operational parameters, characterization and antibacterial studies of green synthesis of silver nanoparticles using *Tithonia diversifolia*. *PeerJ* 2018, 30 (6): e5865. doi: 10.7717/peerj.5865.
10. Zayed, W.H., Eisa, W.H., Shabaka, A.A. *Malva parviflora* extract assisted green synthesis of silver nanoparticles. *Spectrochimica Acta. Part A, Molecular and Biomolecular Spectroscopy* 2012, 98, 423–428.
11. Fafal T., Taştan P., Tüzüna B.S., M. Ozyazici, Bijen Kivcak. (2017). Synthesis, characterization and studies on antioxidant activity of silver nanoparticles using *Asphodelus aestivus* Brot. aerial part extract. *South African Journal of Botany* 2017, 112: 346–353.
12. Bello Oluwasesan M., Olubunmi Stephen Oguntoye, Adewumi Oluwasogo Dada, Oluwatoyin E. Bello, Tijjani Ali, Ahmad Abdullahi Alhaji, Oluwatosin Adeniyi. Phytobiological Facilitated Production of Silver Nanoparticles from Selected Non-Cultivated Vegetables in Nigeria and Their Biological Potential. *Turkish Journal of Pharmaceutical Science* 2019, DOI: 10.4274/tjps.10846.
13. Amkamwar, B., Damle, C., Ahmad, A., Sastry, M. Biosynthesis of gold and silver nanoparticles using *Emblica officinalis* fruit extract, their phase transfer and transmetallation in an organic solution. *Journal of Nanoscience and Nanotechnology* 2005, 5, 1666–1671.
14. Chandran, P.S., Chaudhary, M., Pasricha, R., Ahmad, A., Sastry, M. Synthesis of gold nanotriangles and silver nanoparticles using Aloe vera plant extract. *Biotechnology Progress* 2006, 22, 577–583.
15. Li, S., Shen, Y., Xie, A., Yu, X., Qui, L., Zhang, L., Zhang, Q., (2007). Green synthesis of silver nanoparticles using *Capsicum annuum* L. extract. *Green Chemistry* 2007, 9, 852–858.
16. Christenhusz, M. J., Byng, J. W. The number of known plants species in the world and its annual increase. *Phytotaxa*, 2016, 261(3), 201-217.
17. Williamson, E. M., Okpako, D. T., Evans, F. J. Selection, preparation and pharmacological evaluation of plant material (Vol. 1). *John Wiley & Sons*. 1996.
18. Müller, K. and Borsch, T. Phylogenetics of Amaranthaceae based on matK/trnK sequence data: evidence from parsimony, likelihood, and Bayesian analyses. *Annals of the Missouri Botanical Garden* 2005, 66-102.
19. Adesina, S.K. Studies on some plants used as anticonvulsants in Amerindian and African traditional medicine. *Fitoterapia* 1982, 53, 147-162.
20. Akhtar, M.S. and Munir, M. Evaluation of the gastric antiulcerogenic effects of *Solanum nigrum*, *Brassica oleracea* and *Ocimum basilicum* in rats. *Journal of Ethnopharmacology* 1989, 27, 163-176.
21. Dornberger, K. and Lich, H. Screening for antimicrobial and presumed cancerostatic plant metabolites. *Pharmazie* 1982, 37, 215-221.
22. Dhar, S.K., Gupta, S. and Chandhoke, N. Antifertility studies of some indigenous plants. *Proceedings of the XI Annual Conference of the Indian Pharmacological Society, New Delhi,* 1978.
23. Wang, K. R., Zhao, Y.L., Wang, D.S. and Zhad, M.L. Effect of traditional chinese herbs, toad tincture and adenosine 3 ‘,5 ‘AMP on Ehrlich aseites tumor cells in mice. *Chinese Medical Journal* 1982, 95, 527-532.
24. Watt, J. M. and Breyer-Brandwijk, M. G. Medicinal and Poisonous Plants of Southern and Eastern Africa, 2nd Edn., E. *Livingstone Ltd., Edinburgh, London* 1962.
25. Saha, J.C., Savini, E.C. and Kasinathan, S. Ecbolic properties of Indian medicinal plants. Part 1. *Indian Journal of Medical Research* 1961, 49, 130-151.
26. Bello Oluwasesan M., Abiodun B. Ogbesejana and Uduma A. Uduma. *Launaea taraxacifolia*; a Neglected Vegetable from Nigeria, its Anti-inflammatory and Antioxidant Activities. *ChemSearch Journal* 2018b, 9(1): 9 – 12.
27. Bello, O. M., Ogbesejana, A. B. and Tijjani, A. (2018c). Lipoxygenase (Lox) Inhibitory Activity of Leaves of *Ceiba Pentandra* (L.) Gaertn: A Neglected Vegetable from Nigeria. *FUDMA Journal of Sciences* 2018c, 2(2); 79-82.
28. Oguntoye S. Olubunmi, Bello Oluwasesan M., Emmanuel Opeyemi, Dada Adewumi Oluwasogo, Abdulmeen Hamid (2018). Acetylcholinesterase inhibition and antioxidant evaluation of polyphenolic fractions and oil from four melon seeds used as condiments in Nigeria. *Carpathian Journal of Food* Science *and Technology* 2018, 10 (1); 82-94.
29. Sofowora, E. A. Medicinal Plants and Traditional Medicine in Africa. 2nd ed. *Spectrum Books limited Ibadan, Nigeria* 1993, 9 (25): 289.
30. Trease, G. E. & Evans, W. C. A Textbook of Pharmacognosy, 13th ed. *Bailliere Tindall Ltd, London*, 1989, 134 pp.
31. Oyedapo O. O., Akindele V. R., Okunfolami K. O. Effects of the extracts of *Olax subcorpiodes* and *Aspilia Africana* on bovine red blood cells. *Phytotherapy Res.* 1997, 11: 305-306.
32. Oyedapo O. O, Akinpelu B. A., Orefuwa S. O. Anti-inflammatory effects of *Theobroma cacao*, L. root extract. *J. of Tropical Med. Plants* (Malaysia) 2004, 5(2): 161-166.
33. Shinde, U.A., Kulkarni K.R., Phadke A.S.; Nair A.M., Dikshit V.J., Saraf M. N. Mastcell stabilizing and lipoxygenase inhibitory activity of *Cedrus deodara* (Roxb.) Loud wood Oil. *Indian J. Exp. Biol,* 1999, 37(3): 258-261.
34. Atolani, O., Omere, J., Otuechere, C. A., Adewuyi, A. Antioxidant and cytotoxicity effects of seed oils from edible fruits. *Journal of Acute Disease* 2012, 1, pp 130–134.
35. Sigamoney M., Shaik, S., Govender, P., Krishna, S. B.N., Sershen. African leafy vegetables as bio-factories for silver nanoparticles: A case study on *Amaranthus dubius* C Mart. Ex Thell. *South African Journal of Botany* 2016, 103: 230–240.
36. Kumar, D.A., Palanichamy, V., Roopan, S.M., (2014). Green synthesis of silver nanoparticles using *Alternanthera dentata* leaf extract at room temperature and their antimicrobial activity. *Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy* 2014, 127, 168–171.

37. Prasad, T.N.V.K.V., Kambala, V.S.R., Naidu, R. Phyconanotechnology: synthesis of silver nanoparticles using brown marine algae *Cystophora moniliformis* and their characterization. *Journal of Applied Phycology* 2012, doi.org/10.1007/s10811-012-9851-z.
38. Dada Adewumi Oluwasogo, Folahan Amoo Adekola, Fehintoluwa Elizabeth Dada, Adunola Tabitha Adelani-Akande, Micheal Oluwasesan Bello, Chidiogo Rita Okonkwo Adejumoke Abosede Inyinbor, Abimbola Peter Oluyori, Adeniyi Olayanju, Kolawole Oluseyi Ajanaku, Charles Oluwaseun Adetunji. Silver Nanoparticle Synthesis by *Acalypha wilkesiana* Extract: Phytochemical Screening, Characterization, Influence of Operational Parameters and Preliminary Antibacterial Testing. *Heliyon* 2019, 5: e02517. doi.org/10.1016/j.heliyon.2019.e02517.
39. MubarakAli, D., Thajuddin, N., Jeganathan, K., Gunasekaran, M. Plant extract mediated synthesis of silver and gold nanoparticles and its antibacterial activity against clinically isolated pathogens. *Colloids Surf. B: Biointerfaces* 2011, 85, 360–365.
40. Chang W. Choi, Sei C. Kim, Soon S. Hwang, Bong K. Choi, Hye J. Ahn, Min Y. Lee, Sang H. Park, Soo K. Kim. Antioxidant activity and free radical scavenging capacity between Korean medicinal plants and flavonoids by assay-guided comparison. *Plant Science* 2002, 163; 1161-1168.
41. Bello Oluwasesan M., Safiya Muhammad Jagaba, Oluwatoyin Eunice Bello, Abiodun Busuyi Ogbesejana, Oluwasogo A. Dada, Charles Oluwaseun Adetunji, Saudat Muhammad Abubakar. Phytochemistry, Pharmacology and Perceived Health Uses of Non- Cultivated Vegetable Cyphostemma adenocaule (Steud. ex A. Rich.) Desc. ex Wild & R.B. Drumm: A Review. *Scientific Afric*. 2019A, 2: e00053 https: //doi.org/10.1016/j.sciaf.2019.e00053
42. Adebimpe Esther Ofusori, Roshila Moodley, Sreekantha B. Jonnalagadda. Antiulcerogenic effects of *Celosia trigyna* plant extracts on ethanol-induced gastric ulcer in adult Wistar rats. *J. Trad. and Comp. Med.*, 2019, doi.org/10.1016/j.jtcme.2019.11.004.
43. Vanitha Varadharaj and Jayalakshmi Muniyappan. Phytochemical and Phytotherapeutic Properties of Celosia species- A Review. *Int J Pharm Phytochem Res.* 2017 9, 820-825
44. Eboh A. S., Arhoghro E. M., Frank-Oputu A., Wodu E, Adah O. G. and Uwuma B. A. Phytochemicals and chelating properties in extract of *Celosia trigyna* inhibits xanthine oxidase *in vitro*. *GSC Biological and Pharmaceutical Sciences* 2019, 08(02), 053–058.
45. Merken, H. M. and Beecher, G. R. Analysis of flavonoids in botanical: a review. In Quality Washington, DC, 2002, 21-41.
46. Fukuishi N, Takada T, Fukuyama Y, Akagi M. Antiallergic effect of ardisiaquinone A, a potent 5-lipoxygenase inhibitor. *Phytomedicine* 2001, 8: 460–464.
47. Dana A., Ilse Z, Dingermann T., Müller W. E., Steinhilber D., Werz O. Hyperforin is a dual inhibitor of cyclooxygenase-1 and 5-lipoxygenase. *Biochem Pharmacol* 2002, 64: 1767–1775.
48. Kotakadi, V.S., Gaddam, S.A., Subba Rao, Y., Prasad, T.N.V.K.V., Varada Reddy, A., Sai Gopal, D.V.R. Biofabrication of silver nanoparticles using *Andrographis paniculata*. *European Journal of Medicinal Chemistry* 2014, 73. https: //doi.org/10.1016/j.ejmech.2013.12.004.