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Comparison of Antioxidant Activities of Silver Nanoparticles and Methanol Extracts of Three Indigenous Nigeria Herbal Seeds

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Abstract

The antioxidant of seeds was carried out using extracts from methanol and Silver Nanoparticles from the spice. The SEM shows the shapes, dispersion and agglomeration of the sample, while the EDX confirms the SEM and the presence of some compounds. The FT-IR reveals the $AgNP_s$ capping and reducing the particular biomolecule from the functional group for identification. Compounds found in the FT-IR seeds of *Capsicum annum* are Ag L (Silver iodide), C K (Cyanogen chloride), P K (Phenol). *Monodora myristica* are Mo L (Molybdenum), Ag L (Silver iodide), C K (Cyanogen chloride), P K (Phenol), Mg K (Magnesium). *Piper guineense* are Ag L (Silver iodide), Ci K (Potassium chloride), C K (Cyanogen chloride), P K (Phenol). The seeds show that the $AgNP_S$ of CA and MM has a better antioxidant activity than the methanol of CA and MM, while the PG methanol has a better activity than the $AgNP_S$ PG. The control (Catechin and Galic acid) has a slight overall better DPPH activity than the $AgNP_S$. It is important to note that there is a concentration dependency in CA, MM $AgNP_S$, PG methanol respectively. Notably, at CA methanol, the conc. at 125 was higher than the conc. at 250. Hence, there is need to create a great part in using plant samples for making tabulated or capsulated drugs for treatment of diseases and using plant silver nanoparticles to develop a healthy food/drug preservative package material "smart packaging" that will enhance shelf-life.

Keywords

Piper guineense (PG) or Uziza, *Monodora myristica* (MM) or Ehuru and *Capsicum annum* (CA) or Cayenne Pepper, Scanning Electron Microscope/Energy Dispersive X-Ray (SEM/EDX), Silver Nanoparticles

(AgNP$_s$), Fourier-Transform Infrared (FT-IR),
2,2-Diphenyl-1-Picryl-Hydrazyl Radical Scavenging (DPPH),
Silver Nitrate ($AgNO_3$)

1. Introduction

Herbs are used to enhance the flavour, colour and taste of food as well as their antioxidant properties. Cayenne pepper (*Capsicum annum*), uziza (*Piper guineense*) and ehuru (*Monodora myristica*) are spices and herbs which are widely used as essential ingredients in preparation of different cuisines and medicinal treatments in Nigeria. [1] reported that herbs have antioxidants properties, especially polyphenols that are responsible for nutritional and medicinal properties.

Antioxidant activities have inhibitive effects against oxidative damage that has help in cancer and cardiovascular diseases preventions. Phytochemical substances found in phenolic compound like flavonoids and phenolic acids are the major group of natural compounds in plants like spices and herbs. Because of their free radical scavenging properties of these bioactive compounds, they also vary in their functional group. Over the last decade and in recent years, these bioactive compounds found in spices and herbs are being studied for prevention of human diseases examples: heart disease and cancer.

Cayenne pepper is a reliable source of beta-carotene and antioxidants including Vitamin C that strengthen the immune system. It fights off cold and flu and can treat associated symptoms such as nasal congestions and excessive mucus secretion. Cayenne raises the body temperature and causes sensation of sweat. Thermogenesis also enhances the activity of the immune system. *Capsaicin*, the hot principle of chilli, is found in cayenne pepper. *Capsaicin* is known to increase energy expenditure in the body, which has implications for its use in weight control. Epidemiological data reveal that the consumption of foods containing *capsaicin* is associated with a lower prevalence of obesity [2]. *Capsaicin* causes sustained fat oxidation during weight maintenance. However, *capsaicin* treatment had no limiting effect on 3-month weight regain after losing weight [3]. Another study conducted on anti-obesity suggested that *capsaicin* enhances the use of fats as a fuel source during rest and exercise and may increase weight loss during a controlled diet or exercise plan and the supplementation did not cause any adverse effects on cardiac function despite significantly improved lipolysis [4].

Both Ehuru and Uziza have reported in the treatment of cough, headache, fever, and skin diseases. They are added to food of lactating mothers during postpartum period, as it is claimed that it encourages or stimulates uterine contractions [5]. Therefore, aiding in the fast return of uterine muscle to the original shape, they are also believed to aid in weight loss. According to a report published in *British Journal of Nutrition*, Uziza contains cardiac glycosides in significant amounts and cardiac glycosides are useful in the management of disease associated with the heart [6].

Nanotechnology is becoming increasingly important for the food and health sectors. Promising result and applications have already been developed in theoretical nutrient and drug delivery system through bioactive nano encapsulation, biosensors to detect the quality pathogens, as well as moved resources for the evaluation and the development of safer product [7]. Plants are better options for nanoparticle synthesis because it is mostly non-toxic, provide natural applying agents and reduce the cost of micro-organism. Silver nanoparticles (AgNPs) have been applied as antibacterial, antifungal, antiviral, and anti-inflammatory and catalytic activity due to its distinguishable physical, chemical, biological and prevention of biofilm in food packaging [8]. The conventional chemical method is recognized as being dangerous, energy and wealth exhaustive removing the conventional techniques to be environmentally friendly. Chemical synthesis of silver nanoparticles mostly ended in aggregation as the storage time extends while biosynthesis of nanoparticles using plant extracts also known as synthesis is low-cost, environmentally kind and produce stable nanoparticles [9].

Silver nanoparticle may be added in nontoxic concentration of food as several studies executed the toxicity of silver nanoparticles [10] verified studies nanoparticles had no cytotoxicity to mammalian cells at 26.7 mg/l in another investigation recorded that AgNPs could not affect the mammalian cells morphology up to 6500 ng/Ml concentration [11]. Nanoparticles can discover food spoilage and food pathogens through Nano sensors. In addition, nanoparticles used in food packaging consisting of polymers in combination with Nano devices are known as smart packaging. Natural, edible nano laminates can also carry antioxidants and antimicrobials for extension of shelf-life [12].

Natural products, such as plant extract, either as pure compounds or as standardized extracts, provide unlimited opportunities for new drug discoveries because of the unmatched availability of chemical diversity [7]. According to the World Health Organization [13], more than 30% of the World's population relies on traditional medicine for their primary healthcare needs. The use of herbal medicines in Asia represents a long history of human interactions with the environment. Plant used for traditional medicine contains a wide range of substances that can be used to treat chronic as well as infectious diseases [14].

Bioactive, like coenzyme, vitamins, iron, calcium, curcumin, etc., have been widely tested in nano delivery systems [15]. Different nano delivery vehicles have been developed such as association colloids, lipid-based nanoencapsulations/nanocarriers, nano emulsions, biopolymeric nanoparticles, nanolaminates, nanofibers, etc. These nano delivery systems can increase the bioavailability of bioactive by different pathways. Nanoencapsulation can enhance bioavailability of bioactive compounds after oral administration through targeted delivery systems. Such nanoencapsulation enables to control the release of flavors at the desired time and also to protect the degradation of these flavors during processing and storage [16].

Nowadays, people are requiring more nutritional supplements because many nutrients in food are being destroyed in the digestive tract. Each part presents a

completely different environment, from oral cavity to the colon. In other words, there are several factors which decide the absorption of food in the body for infants, children, adults, old people, and those who are suffering from any type of gastrointestinal diseases. A nutrition delivery system is a system or nanocarrier that delivers nutrition to specific places [17]. Although a delivery system has numerous functions, one of them is to transport a functional ingredient to its desired site. Just like taste, texture, and shelf-life, major functions of a delivery system for a food product are that it should protect an ingredient from chemical or biological degradation, such as oxidation, and controlling the rate of release of functional ingredient under specific environmental conditions. Nano dispersions and nano capsules are ideal mechanisms for delivery of functional ingredients because they can effectively perform all these tasks.

2. Materials and Methods

2.1. Material Collection

The seeds (*Capsicum annum*, *Piper guineense* and *Monodora myristica*) were purchased at Garki market Abuja. These spices were identified by a taxonomist from the Herbarium Unit of National Institute for Pharmaceutical Research and Development (NIPRD), Abuja; Department of Medicinal plant, National Institute for Pharmaceutical Research and Development Garki Abuja Nigeria and African University of Science and Technology, Abuja, Nigeria, were the institute's used for the research work.

2.2. Methods

Raw Materials Preparation

The sample was subjected to post-harvest treatment before experimental use. The modified method described by [18] was used accordingly. The particle size of the sample was determined manually by sieve analysis [19]. The sample was sorted in an airtight container for experimental analysis.

The flow diagram for the preparation of samples for maceration/hydro-distillation (**Figure 1**).

2.3. Extractions

Maceration of Methanol Extract

Cold maceration was the method of extractions for the methanol extract. The solvent used was methanol (64.7˚C). The volume of the solvent was twice the physical size of the extract, the sample was crushed put in a big conical flask, the solvent added, covered and kept at a room temperature (20˚C - 25˚C) of 24 hours, shaken at intervals. After maceration, the plant sample was filtered using muslin, the extract was put in a rotary-evaporator to reduce the volume in the extractant after which it was transferred into a stainless plate and put in a water bath (100˚C) for complete drying and methanol evaporation. The dried extract was collected (using a spatula) and put in an air-tight bottle container, kept in a cool dry place for laboratory analysis (**Table 1**, **Figure 2**).

Fresh seeds
↓
Cleaning and Sorting
↓
De-pulping (manual) optional
↓
De-pulped seeds
↓
Washing
↓
Air drying (2 days)
↓
Dried seed
↓
Coarsely milled (warring blender)
↓
Maceration/Hydro-distillation

Figure 1. Flow diagram for processing of plant sample for Maceration/Hydro-distillation.

Table 1. Maceration of methanol extraction.

Sample	Quantity used (g)	Quantity of solvent (ml)	Drying Period
Capsicum annum	300 g	1500 ml	3 days
Monodora myristica	250 g	750 ml	3 days
Piper guineense	250 g	750 ml	3 days

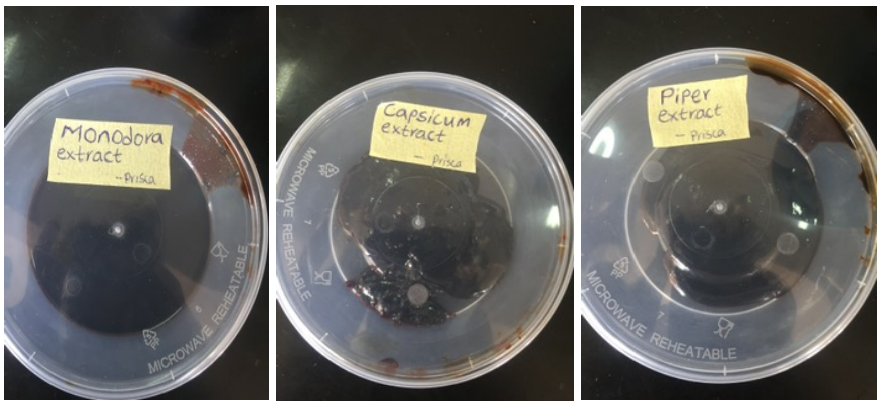


Figure 2. Methanol extracts of seeds samples: *Monodora myristica* (MM), *Capsicum annum* (CA), and *Piper guineense* (PG).

2.4. Silver Nanoparticle Characterization

Synthesis of Silver Nanoparticles

Seeds AgNPs extract was synthesized by adopting the method described by [20]. A 20 g of the sample was weighed into conical flask of 250 ml and 100 ml of water was added at 60˚C in a water bath for 10 minutes, respectively. Each extract was cooled, filtered using watchman filter paper. Fifteen (15) ml of the extract was added into 45 ml aqueous silver nitrate ($AgNO_3$) (0.1 M solution) at room temperature and stirred continuously with a magnetic stirrer for 15 minutes so as to get a solution of extract and $AgNO_3$ in the ratio of 1:3. Each conical flask containing the respective extract was wrapped in aluminum foil and kept in the dark to prevent auto-oxidation of silver. After 24 hours, each extract containing silver Nanoparticle ($AgNP_s$) was centrifuged at 3000 rpm for 10 minutes and the resulting pellets were dried in an oven at 100˚C for 24 hours.

After 24 h, the solution containing AgNPs was centrifuged at 3000 rpm for 10 min and temperature of 38˚C, the resulting pellets was dried in an oven at 100˚C for 24 h. The purified AgNPs was characterized using the following techniques. The formation of AgNPs was monitored by visual assessment of the colour changes of the solutions. The reduction of silver was measured periodically at a wavelength range of 300 - 700 nm using a UV-Vis spectrophotometer (UV-3000 PC, UK). The UV-Vis spectra of AgNPs produced was plotted and recorded as a function of bio reduction time (15 min intervals) at room temperature at a resolution of 0.5 nm. Size, shape, and morphology of the nanoparticles were determined by scanning electron microscopy (SEM) (ZEISS product, Evo/LS10), the samples for SEM assays were sonicated for 5 min to make a suspension of AgNPs in distilled water. A drop of the suspension was then placed on double-sided-coated carbon stubs, allowed to dry, and observed using SEM at a voltage of 15 - 20 kV at different magnifications. Fourier Transform Infrared (FTIR) (Nicolet iS5, Thermo-scientific Berlin Germany). Analysis was used to determine the possible biomolecules responsible for the reduction of silver ions to AgNPs. The samples were analysed using a spectrometer. Spectra were collected from fifty scans at a resolution of 4 cm^{-1} in the range of 500 - 4000. The remaining pallet was used for AgNPs Antioxidant and compared with Methanol extract (**Picture 1**).

Picture 1. Synthesis of silver nanoparticles.

2.5. Antioxidant Assay

The antioxidant activities of the seeds methanol extract and AgNPs was evaluated using 2, 2-diphenyl-1-picryl-hydrazyl radical scavenging (DPPH) and Reducing power [21].

2.6. Free Radical Scavenging Assays

2, 2-diphenyl-1-picryl-hydrazyl radical scavenging (DPPH) Assay. The DPPH is a stable free radical and widely used to assess the radical scavenging activity of antioxidant compounds. This method is based on the reduction of DPPH in methanol solution in the presence of a hydrogen-donating antioxidant due to the formation of the non-radical form DPPH. This transformation results in a colour change from purple to yellow, which is measured by a spectrophotometer at (517 nm). The disappearance of the purple colour is monitored at 517 nm. The free radical scavenging activity was measured by using 2, 2-diphenyl-1-picryl-hydrazyl. The reaction mixture consisted of 0.1 ml of DPPH in methanol (0.3 mM), 1.0 ml of the extract and 1.0 ml of methanol. It is incubated for 10min in dark, and then the absorbance is measured at 517 nm. In this assay, the positive controls were ascorbic acid. The percentage of inhibition was calculated using the formula:

$$\text{Inhibition } \% = \frac{A\bigcup - A1}{AO} \times 100$$

where AO is the absorbance of control and $A1$ is the absorbance of test.

2.7. Reducing Power Assay (RP)

Reducing power is associated with antioxidant activity and may serve as a significant reflection of the antioxidant activity. Compounds with reducing power indicate that they are electron donors and can reduce the oxidized intermediates of liquid per oxidation processes, so that they can act as primary and secondary antioxidants.

The reducing power was determined by taking 1.0 ml of extract with 2.5 ml of Phosphate buffer (200 Mm, pH 6.6) and 2.5 ml of Potassium ferricyanide (30 mM) and incubated at 50˚C for 20 min. Thereafter, 2.5 ml of Trichloroacetic acid (600 mM) is added to the reaction mixture, centrifuged for 10 min at 3000 rpm. The upper layer of solution (2.5 ml) is mixed with 2.5 ml of distilled water and 0.5 ml of $FeCl_3$ (6 mM) and absorbance is measured at 700 nm. Ascorbic acid was used as positive control (**Picture 2**).

3. Results

3.1. Methanol Extraction; Cold Maceration Method

Table 2 shows the name of samples, yield, colour and appearance of the extract after extraction. *Capsicum annum* yield was 10.3 g, as the extract dries, the colour became thicker in deep red and gummier, the more the drying in a water bath takes place the more the extract forms. The appearance looks shinny and

bright. The aroma was that of *C. annum*, after total drying, the appearance and aroma like a melted chocolate and gummy.

Monodora myristica the yield was 10.76 g, as the extract dries up the appearance looks like that of palm oil puree and coarse. The colour was deep brown like that of raw *Piper guineense* and the aroma was soothing.

Piper guineense yield was 6.36 g. The colour of the extract did not change much. It slightly changed to deep brown that looked burnt. The aroma was the same. The appearance was not light, but coarse as it dries up it stains slightly.

3.2. Scanning Electron Microscope/Energy Dispersive X-Ray

Figure 3 shows the SEM/EDX of *Capsicum annum* $AgNP_S$. The SEM show the shapes, dispersion and agglomeration of the sample, while the EDX confirms the SEM and the presence of some compounds; Ag L (Silver iodide), C K (Cyanogen chloride), P K (Phenol).

Figure 4 shows the SEM/EDX of *Monodora myristica* $AgNP_S$. The SEM show the shapes, dispersion, and agglomeration of the sample, while the EDX confirms the SEM and the presence of some compounds; Mo L (Molybdenum), Ag L (Silver iodide), C K (Cyanogen chloride), P K (Phenol), Mg K (Magnesium).

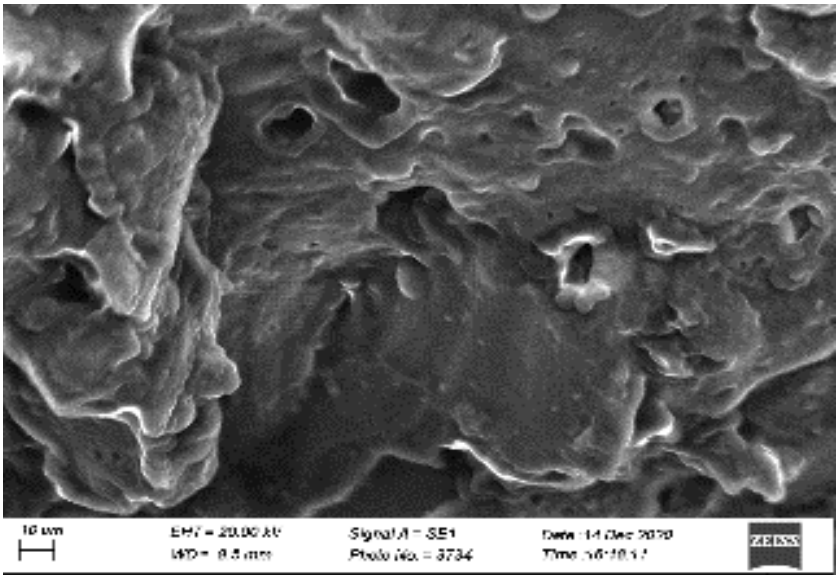
Figure 5 shows the SEM/EDX of *Piper guineense* $AgNP_S$. The SEM show the shapes, dispersion and agglomeration of the sample, while the EDX confirms the SEM and the presence of some compounds; Ag L (Silver iodide), Ci K (Potassium chloride), C K (Cyanogen chloride), P K (Phenol).

Table 2. Observation during methanol extraction.

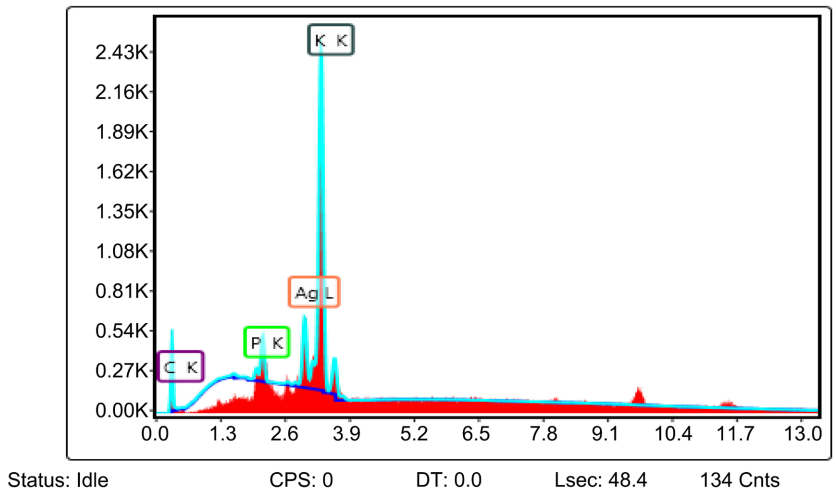
Samples	Yield	Color	Appearance
Capsicum annum	10.3 g	thicker in deep red and gummier	Consistency
Monodora myristica	10.76 g	deep brown	Consistency
Piper guineense	6.36 g	deep yellow	Consistency

(a) (b)

Picture 2. (a) Methanol sample extract solution (b) Silver nanoparticle extract solution.

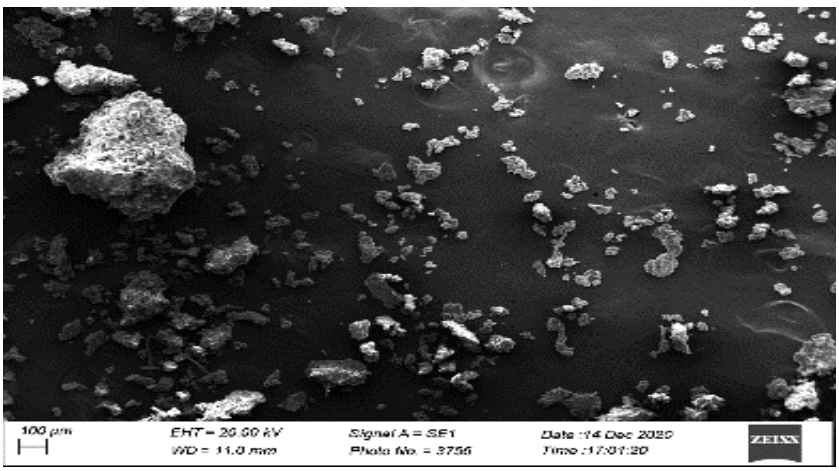


(a)

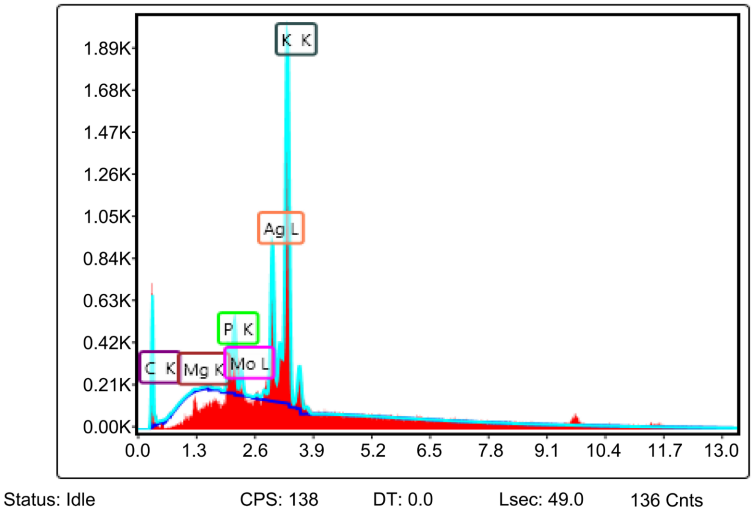


(b)

Figure 3. (a) SEM CA = *Capsicum Annum*; (b) EDX CA = *Capsicum Annum*.

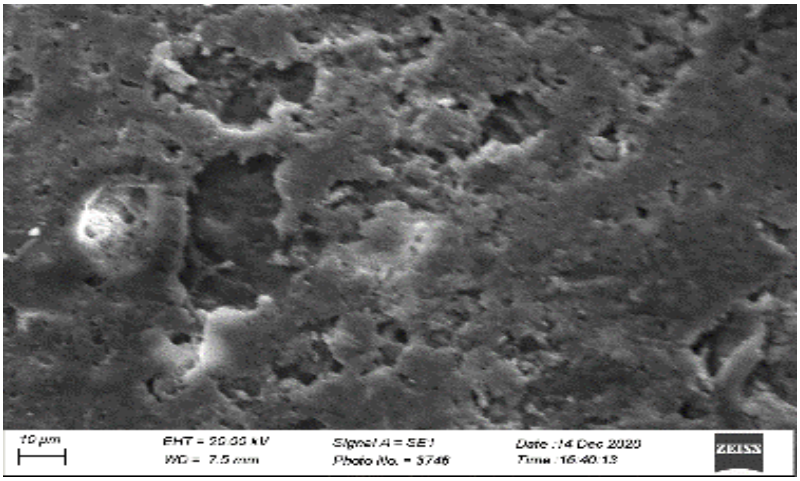


(a)

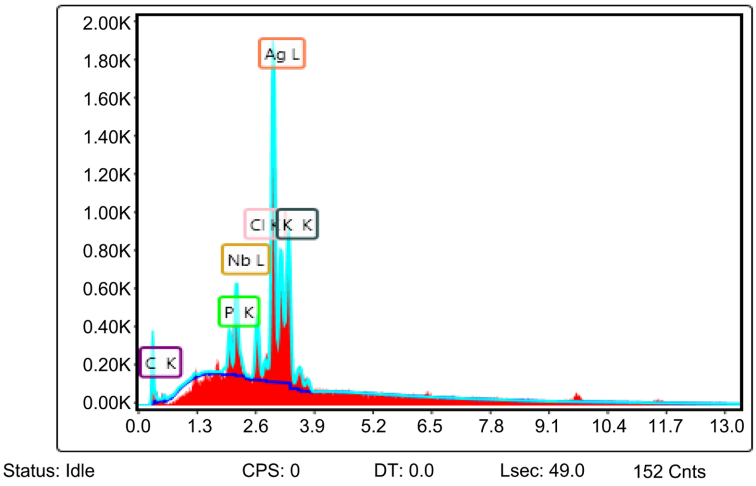


(b)

Figure 4. (a) SEM MM = *Monodora Myristica*; (b) EDX MM = *Monodora Myristica*.



(a)



(b)

Figure 5. (a) SEM PG = *Piper guineense*; (b) EDX PG *Piper guineense*.

3.3. The Fourier-Transfer Infrared Spectroscopy (FT-IR) of the Seeds Samples

The FT-IR of *Capsicum annum* shows the wave number, compounds and its functional group as shown in figure and Table 3.

The FT-IR of Monodora Myristica shows the wave number, compounds and its functional group as shown in Table 4.

The FT-IR of *Piper guineense* shows the wave number, compounds and its functional group as shown in figure and Table 5.

Free radical scavenging assays of 2, 2-diphenyl-1-picryl-hydrazyl radical scavenging (dpph) (Table 6).

4. Discussion

One of important part of the food industry is extracting nutrition from raw materials. Conventional methods for food processing are being replaced by newer techniques like nanotechnology, which play a major role here. These techniques may improve food processing yields and decrease waste or spoilage of nutrition. Nutrition delivery systems must be prepared with biodegradable materials to prevent adverse effects on health of consumers.

Table 3. Vibrational frequencies and wave number of *Capsicum annum*.

Wave number (cm^{-1})	functional group	compounds
3007.92	O-H stretching	alcohol (weak)
2922.94	C-H stretching	alkane (medium)
2852.69	C-H stretching	alkane (medium)
1742.97	C-H bending	aromatic compound (weak)
1587.83	N-H/C=C stretching	cyclic alkane (medium)
1457.42	N-O stretching	nitro compound (strong)
1376.82	O-H bending	alcohol (medium)
1234.56	C-O stretching	alkyl aryl ether (strong)
1039.53	C-N stretching	amine (medium)
824.04	C=C bending	alkene (medium)

Table 4. Vibrational frequencies and wave number of *Monodora myristica*.

Wave number (cm^{-1})	functional group	compounds
3209.67	O-H stretching	alcohol (strong)
2925.16	C-H stretching	alkene (medium)
2854.12	C-H stretching	alkene (medium)
2241.42	C≡C stretching	alkyne (weak)
1712.34	C=O stretching	carboxylic acid (strong)
1379.90	O-H stretching	carboxylic acid (strong)
1241.04	C-O stretching	alkyl aryl ether (strong)
721.17	C=C bending	alkene (strong)

Table 5. Vibrational frequencies and wave number of *Piper guineense*.

Wave number (cm^{-1})	functional group	compounds
3385.73	O-H stretching	alcohol (strong)
2925.11	C-H stretching	alkene (medium)
1629.02	C=C stretching	α,*β*-unsaturated ketone (strong)
1365.69	O-H bending	alcohol (medium)
1243.06	C-O stretching	alkyne aryl ether (strong)
1023.13	C-O stretching	vinyl ether (strong)
576.26	C-Cl stretching	halo compound (strong)

Table 6. Inhibitory concentration at 50 (ic50) of dpph of seeds sample.

Samples	IC50
Capsicum annum AgNPs	43.11
Capsicum annum methanol	23.46
Monodora myristica AgNPs	89
Monodora myristica methanol	170.1
Piper guineense AgNPs	9.82^{e}-05
Piper guineense methanol	93.71

Figure 1 was the process applied on seeds before maceration is carried out. After maceration the yield was kept in an airtight container. **Figure 2** shows the extracts from the 3 sample seeds *Capsicum annum* (10.3 g), *Monodora myristica* (10.76 g), and *Piper guineense* (6.36 g).

SEM/EDX of each sample AgNPs (*Capsicum annum, Monodora myristica,* and *Piper guineense*) were crystalline and well dispersed with no agglomeration, as shown in the **Figure 3(a)**, **Figure 4(a)** and **Figure 5(a)**. EDX further confirms the presence and formation of AgNPs as shown in **Figure 3(b)**, **Figure 4(b)** and **Figure 5(b)**. FTIR shows some functional groups formular and absorbance at different wavelength shown in **Figures 6-8** and represented in **Tables 3-5**.

Silver nitrate used for the synthesis of AgNPs [22] which also play a role in the colour change, that changes from light yellow to deep brown. Colour change is a crucial factor for the synthesis of AgNPs. AgNPs appear brown in aqueous medium as a result of surface Plasmon vibrations [23].

SEM analysis reveals the size, shape, morphology, and organization, because AgNPs have ability to agglomerate as a result of high surface tension and high surface energy in the extreme fine particles of AgNPs, [24]. The EDX measures the distribution of X-ray signal generated by an electron beam on a specimen which was confirmed by the AgNPs synthesis of the extract conducted [25] and stated that the weak peaks from the EDX was a result of biomolecules bounded to the surface. Finally, the EDX of each sample shows the presence of some compounds that can be used in different SET-applications.

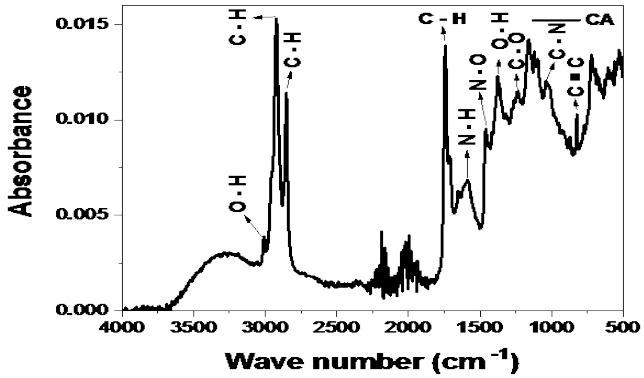


Figure 6. FT-IR spectra of *Capsicum annum*.

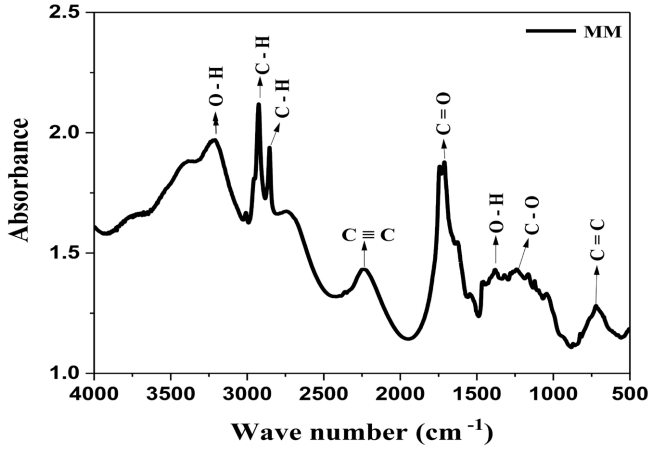


Figure 7. FT-IR spectra of *Monodora myristica*.

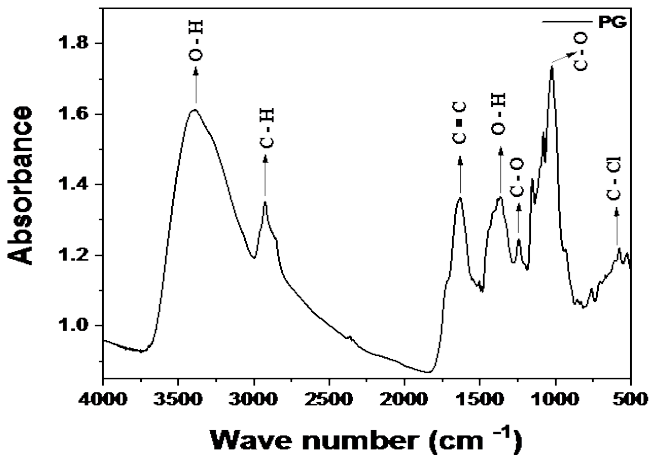


Figure 8. FT-IR spectra of *Piper guineense*.

Antioxidants control oxidative reactions by inhibiting, delaying, or hindering the oxidation of the biomolecules [26]. Non enzymatic antioxidants also neutralize radicals for example water soluble substances such as Vitamin C, glutathione, or fat-soluble substances such as Vitamin E, β-carotene [27]. In recent years there has been an increased in the search for effective, non-toxic, natural

compounds with antioxidative activity. Some nanomaterials have been seen to exhibit strong antioxidant property. In this study, antioxidant activity of the synthesized silver nanoparticles and corresponding methanol extract of the plants were studied by analysing antioxidant capacities which are indicative of the antioxidant potential of the synthesized AgNPs. [28] also reported DPPH as a stable organic free radical that has been used for investigating the free radical activities and thus antioxidant activity of various natural products [29]. The DPPH was a model of lipophilic radical. A chain reaction in lipophilic radicals was initiated by lipid auto-oxidation. Being a stable free radical, DPPH is extensively used to determine radical scavenging activity of natural compounds. In its radical form, DPPH absorbs at 517 nm and its absorbance decreases upon reduction with an antioxidant [30].

The IC_{50} (Inhibitory Concentration at 50 percent) values for DPPH scavenging activity of synthesized AgNPs and methanol extract were presented in **Table 6**. The lower the concentration the higher the potency of the extract, which means the lower the value, the better the effect of the scavenging activity of the DPPH. Therefore, both CA methanol (22.46) and CA AgNPs (43.11) has the highest potency followed by MM AgNPs (89).

Figure 8 shows the dose response for the DPPH scavenging activity of the synthesized AgNPs and methanolic extract of the extract. The AgNPs synthesized from water extract are potential free radical's scavengers with effective inhibition activity in a dose dependent manner. The varying concentration of the AgNPs (62.5, 125, 250 and 500 µg/ml) significantly scavenged DPPH, however, these activities are less than that of catechin and gallic acid. (The standard reference used) but does not have a dose dependent manner. Notably, at CA methanol, the conc. at 125 was higher than the conc. at 250.

The Reducing power of *C.annum* of AgNPs has a higher antioxidant activity than the *C.annum* of methanol. *M.myristica* of AgNPs has a better antioxidant activity than the *M.myristica* of methanol. The *P.guineense* of AgNPs has a higher antioxidant activity than the *P.guineense* of methanol. The seeds used in this work shows that the AgNPs synthesized seeds extracts has a higher antioxidant activity than the Methanol extracts.

The Reducing Power of a compound is related to its electron transfer ability and therefore may serve as a significant indicator of its potential antioxidant activity [31]. The reductive capabilities of the biosynthesized AgNPs and methanolic extracts are shown in **Figure 9**. The reducing power of the samples increased with increasing number of concentrations. The reducing property of the extracts implies that it is capable of donating hydrogen atom in a dose dependent manner.

In general, the samples have a better antioxidant activity than the control. This can create a great part in using plant samples in making tabulated or capsulated drugs for treatment of diseases and developing a healthy food/drug preservative package material that will enhance shelf-life (**Figure 10**).

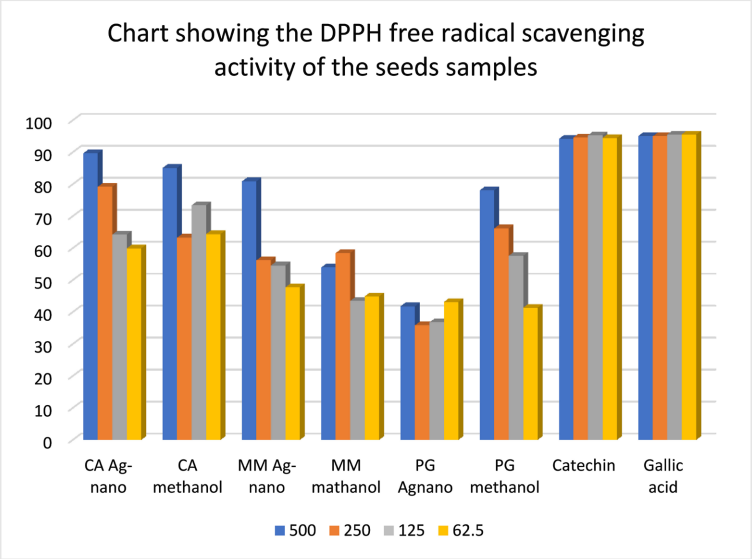


Figure 9. DPPH chart of the AgNPs and methanol seeds samples extract (CA, MM, PG). **Keywords:** CA Ag-nano = *Capsicum annum* AgNPs, CA methanol = *Capsicum annum* methanol, MM Ag-nano = *Monodora myristica* AgNPs, MM methanol = *Monodora myristica* methanol, PG Ag-nano = *Piper guineense* AgNPs, PG methanol = *Piper guineense* methanol.

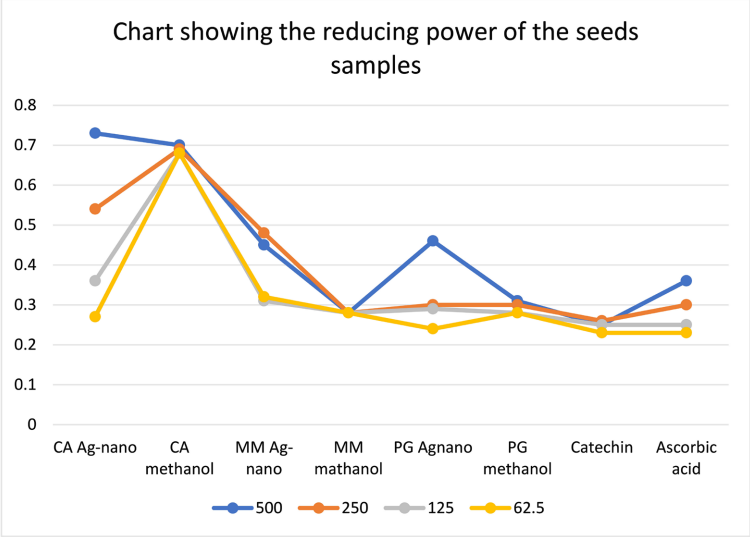


Figure 10. Reducing power chart of the AgNPs and methanol seeds samples extract (CA, MM, PG). **Keywords:** CA Ag-nano = *Capsicum annum* AgNPs, CA methanol = *Capsicum annum* methanol, MM Ag-nano = *Monodora myristica* AgNPs, MM methanol = *Monodora myristica* methanol, Pg Ag-nano = *Piper guineense* AgNPs, PG methanol = *Piper guineense* methanol.

5. Conclusions

Both the DPPH and Reducing power have shown that the spices have antioxidant properties and should be used in drug and therapeutic development. AgNPs was successfully synthesized, characterized from $AgNP_3$ and aqueous extract of spices, the size and shape were a controlled process. The FT-IR shows that the

extract can be further used in different application, especially in food packaging and drug delivery. The FT-IR compounds like alcohol have strong presence in all the samples followed by alkene and vinyl ether while carboxylic acid has presence in few samples.

The Antioxidant assay of methanol, Inhibitory Concentration at 50 of DPPH shows that *C. annum* $AgNP_s$ and *M. myristica* $AgNP_s$ have the higher potency than the *C. annum* methanol and *M. myristica* methanol extract, while *P. guineense* methanol has higher potency than *P. guineense* $AgNP_s$. The DPPH of the Silver nanoparticles has a better concentration dependency than the methanol extract. The Reducing power of silver nanoparticle extract (*C. annum* $AgNP_s$, *M. myristica* $AgNP_s$ and *P. guineense* $AgNP_s$) has better concentration dependency and antioxidant activities than the methanol extract and the control.

Recommendation

There is need to create a great part in using plant samples for making tabulated or capsulated drugs for treatment of diseases and using plant silver nanoparticles to develop a healthy food/drug preservative package material "smart packaging" that will enhance shelf-life.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Wijekoon, M.J.O., Bhat, R. and Karim, A.A. (2011) Effect of Extraction Solvents on the Phenolic Compounds and Antioxidant Activities of bunga kantan (*Etlingera elatior* Jack.) Inflorescence. *Journal of Food Composition and Analysis*, **24**, 615-619. https://doi.org/10.1016/j.jfca.2010.09.018

[2] Joseph, E., Pizzorno, N.D. and Joiner-Bey, N.D. (2016) The Clinician's Handbook of Natural Medicine. 3rd Edition, Churchill Livingstone, London.

[3] Lejeune, M.P., Kovacs, E.M. and Westerterp-Plantenga, M.S. (2003) Effect of Capsaicin on Substrate Oxidation and Weight Maintenance after Modest Body-Weight Loss in Human Subjects. *British. Journal of Nutrition,* **90**, 651-659. https://doi.org/10.1079/BJN2003938

[4] Tallon, M.J. (2008) Spicing up Health with Capsaicin. *Natural Foods Merchandiser*, **28**, 38-40.

[5] Achinewhu, S.C., Ogbonna, C.C. and Hart, A.D. (1995) Chemical Composition of Indigenous Wild Herbs, Spices, Fruits, Nuts, and Leafy Vegetables Used as Foods. *Plant Foods for Human Nutrition*, **48**, 341-348. https://doi.org/10.1007/BF01088493

[6] Dada, A.A., Ifesan, B.O.T. and Fashakin, J.F. (2013) Antimicrobial and Antioxidant Properties of Selected Local Spices used in "Kunun" Beverage in Nigeria. *Acta scientiarum polonorum. Technologia alimentaria*, **12**, 373-378.

[7] Alsammarraie, F.K., Wang, W., Zhou, P., Mustapha, A. and Lin, M. (2018) Green Synthesis of Silver Nanoparticles Using Turmeric Extracts and Investigation of their Antibacterial Activities. *Colloids and Surfaces B: Biointerfaces*, **171**, 398-405.

https://doi.org/10.1016/j.colsurfb.2018.07.059

[8] Gurunathan, S., Han, J.W., Kwon, D.N. and Kim, J.H. (2014) Enhanced Antibacterial and Anti-Biofilm Activities of Silver Nanoparticles against Gram-Negative and Gram-Positive Bacteria. *Nanoscale Research Letters*, **9**, Article No. 373. https://doi.org/10.1186/1556-276X-9-373

[9] Sharma, V.K., Siskova, K.M., Zboril, R. and Gardea-Torresdey, J.L. (2014) Organic-Coated Silver Nanoparticles in Biological and Environmental Conditions: Fate, Stability, and Toxicity. *Advances in Colloid and Interface Science*, **204**, 15-34. https://doi.org/10.1016/j.cis.2013.12.002

[10] Ivask, A., Kurvet, I., Kasemets, K., Blinova, I. and Aruojaaa, V. (2014) Size-Dependent Toxicity of Silver Nanoparticles to Bacteria, Yeast, Algae, Crustaceans and Mammalian Cells *in Vitro*. *PLOS ONE*, **9**, Article ID: e102108. https://doi.org/10.1371/journal.pone.0102108

[11] Arora, S., Jain, J., Rajwade, J.M. and Paknikar, K.M. (2008) Cellular Responses Induced by Silver Nanoparticles: *In Vitro* Studies. *Toxicology Letter*, **179**, 93-100. https://doi.org/10.1016/j.toxlet.2008.04.009

[12] Ramachandraiah, K., Han, S.G. and Chin, K.B. (2015) Nanotechnology in Meat Processing and Packaging: Potential Applications—A Review. *Asian Australasian Journal of Animal Sciences*, **28**, 290-302. https://doi.org/10.5713/ajas.14.0607

[13] World Health Organization (2019) WHO Global Report on Traditional and Complementary Medicine 2019. World Health Organization, Geneva. https://creativecommons.org/licenses/by-nc-sa/3.0/igo

[14] Duraipandiyan, V., Ayyanar, M. and Ignacimuthu, S. (2002) Antimicrobial Activity of Some Ethnomedicinal Plants Used by Paliyar Tribe from Tamil Nadu, India. *BMC Complementary and Alternative Medicine*, **6**, Article No. 35. https://doi.org/10.1186/1472-6882-6-35

[15] He, X. and Hwang, H.M. (2016) Nanotechnology in Food Science: Functionality, Applicability, and Safety Assessment. *Journal of Food and Drug Analysis*, **24**, 671-681. https://doi.org/10.1016/j.jfda.2016.06.001

[16] Yu, H., Park, J.Y., Kwon, C.W., Hong, S.C., Park, K.M. and Chang, P.S. (2018) An Overview of Nanotechnology in Food Science: Preparative Methods, Practical Applications, and Safety. *Journal of Chemistry*, **2018**, Article ID 5427978. https://doi.org/10.1155/2018/5427978

[17] Francesca, M., Garcia-Fuentes, M., Mura, P. and Alonso, M.J. (2006) A New Drug Nanocarrier Consisting of Chitosan and Hydoxyprophylcyclodextrin. *European Journal of Pharmaceutics and Biopharmaceutics*, **63**, 76-86. https://doi.org/10.1016/j.ejpb.2005.12.006

[18] Adewole, E., Ajiboye, B.O., Idris, O.O., Ojo, O.A., Onikanm A., Ogunmodedem O.T. and Adewumi, D.F. (2013) Phytochemical, Antimicrobial and GC-MS of African nutmeg (*Monodora myristica). International Journal of Pharmaceutical Science Invention*, **2**, 25-32.

[19] Jillavenkatesa, A., Dapkunas, S.J. and Lin-Sien, L. (2001) NIST Recommended Practice Guide: Particle Size Characterization. NIST Special Publication, Technology Administration US, Department of Commerce, 960-961.

[20] Aderonke Otunola, G., Jide Afolayan, A., Olusegun Ajayi, E. and Samuel Odeyemi, W. (2017) Characterization, Antibacterial and Antioxidant Properties of Silver Nanoparticles Synthesized from Aqueous Extracts *of Allium Sativum*, *Zingiber officinale* and *Capsicum frutescens*. *Pharmacognosy Magazine*, **13**, 201-208. https://doi.org/10.4103/pm.pm_430_16

[21] Cheng, Z. and Li, Y. (2004) Reducing Power: The Measure of Antioxidant Activities of Reductant Compounds? *Redox Report*, **9**, 213-217. https://doi.org/10.1179/135100004225005994

[22] Hyllested, J., Espina Palanco, M., Hagen, N., Mogensen, K.B. and Kneipp, K. (2015) Green Preparation and Spectroscopic Characterization of Plasmonic Silver Nanoparticles Using Fruits as Reducing Agents. *Beilstein Journal of Nanotechnology*, **6**, 293-299. https://doi.org/10.3762/bjnano.6.27

[23] Priya, B., Satapathy, M., Mukhopahayay, A. and Das, P. (2014) Leaf Extract Mediated Green Synthesis of Silver Nanoparticles from Widely Available Indian Plants: Synthesis, Characterization, Antimicrobial Property and Toxicity Analysis. *Bioresources and Bioprocessing*, **1**, Article No. 3. https://doi.org/10.1186/s40643-014-0003-y

[24] Theivasanthi, T. and Alagar, M. (2011) An Insight Analysis of Nano Sized Powder of Jackfruit Seed. *Nano Biomedicine and Engineering*, **3**, 163-168. https://doi.org/10.5101/nbe.v3i3.p163-168

[25] Song, E.K., Cho, H., Kim, J.S., Kim, N.Y., An, N.H. and Kimm, J.A. (2001) Diarylkeptanoids with Free Radical Scavenging and Hepatoprotective Activity *in Vitro* from *Curcuma longa*. *Planta Medica*, **67**, 876-877. https://doi.org/10.1055/s-2001-18860

[26] Kumar, S., Vasudeva, N. and Sharma, S. (2012) GC-MS Analysis and Screening of Antidiabetic, Antioxidant and Hypolipidemic Potential of *Cinnamomum tamala* Oil in Streptozotocin Induced Diabetes Mellitus in Rats. *Cardiovascular Diabetology*, **11**, Article No. 95. https://doi.org/10.1186/1475-2840-11-95

[27] Sonia, T., Serini, S., Di Dicuolo, F., *et al*. (2004) Atioxidant Effect of Ferulic Acid in Isolated Membranes and Intact Cells. Synergistic Interactions with—Tocopherol, Carotene and Ascorbic Acid. *Journal of Agriculture and Food Chemistry*, **52**, 241-220. https://doi.org/10.1021/jf0303924

[28] Singaravelu, V., Christensen, L., Misra, M. and Kumar Mohanty, A. (2012) Green Process for Impregnation of Silver Nanoparticles into Microcrystalline Cellulose and Their Antimicrobial Bio Nanocomposite Films. *Journal of Biomaterials and Nanobiotechnology*, **3**, Article ID: 20556, 6 p.

[29] Rusherder Rajan, C., Madhavieerike, N., Madhusudhanan and Venugoalaraokonda (2012) *In Vitro* Antioxidant and Free Radical Scavenging Activity of *Nympha eapubescens*. *Journal of Pharmacy Research*, **5**, 3804-3806.

[30] Lateef, A., Azeez, M.A., Asafa, T.B., Yekeen, T.A., Akinboro, A., Oladipo, I.C., Ajetomobi, F.E., Gueguim-Kana, E.B. and Beukes, L.S. (2015) *Cola nitida*-Mediated Biogenic Synthesis of Silver Nanoparticles Using Seed and Seed Shell Extracts and Evaluation of Antibacterial Activities. *BioNanoScience*, **5**, 196-205. https://doi.org/10.1007/s12668-015-0181-x

[31] İlhami, G., Oktay, M., Kirecci, E. and Irfan Kufrevioglu, O. (2003) Screening of Antioxidant and Antimicrobial Activities of Anise (*Pimpinella anisum* L.) Seed Extracts. *Food Chemistry*, **83**, 371-382. https://doi.org/10.1016/S0308-8146(03)00098-0