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Review Article

A Comprehensive Review on the Antioxidant Properties of Green Synthesized Nanoparticles: *in vitro* and *in vivo* Insights

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ABSTRACT

The use of green-synthesized nanoparticles has emerged as a promising avenue for enhancing antioxidant activity in various applications, including medicine, environmental protection and food preservation. This review provides a comprehensive overview of the role of nanotechnology in antioxidant activity, focusing on the green synthesis of nanoparticles using plant-based extracts. The paper begins by discussing the types of antioxidants, categorizing them into enzymatic, non-enzymatic and synthetic compounds and highlighting their mechanisms of action in scavenging free radicals. Various antioxidant assay methods, including DPPH, ABTS and FRAP, are examined for their effectiveness in evaluating antioxidant potential. The review also delves into the role of medicinal plants in the green synthesis of nanoparticles, detailing how bioactive compounds in plant extracts contribute to the reduction and stabilization of metal ions into nanoparticles. The types of green synthesized nanoparticles covered include silver, gold, titanium oxide, starch, iron oxide, zinc oxide, copper, cerium oxide, nickel oxide, selenium, platinum and palladium, each with unique properties that influence their antioxidant activity. The interaction between these nanoparticles and free radicals, as well as their potential synergistic effects with other antioxidants, is discussed. Finally, the review highlights the benefits of using green synthesis methods over conventional chemical synthesis, emphasizing sustainability, cost-effectiveness and the reduced environmental impact. This work underscores the growing potential of green-synthesized nanoparticles as powerful antioxidant agents, offering new insights into their applications and future directions in both scientific research and industrial innovation.

Keywords: Antioxidants, Bioactive compound, Free radical, Green synthesis, Medicinal, Nanoparticle.

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INTRODUCTION

Antioxidants are vital molecules that neutralize Reactive Oxygen Radicals (ROS), which are waste products of metabolism and shield cells from oxidative damage. These ROS have the potential to seriously harm proteins, lipids and DNA, which can then contribute to the onset of a number of illnesses, including cancer, heart problems and neurological conditions.[1,2] Exogenous antioxidants from the diet and endogenous enzymes like catalase and superoxide dismutase make up the body's antioxidant defense system.[3] When there is an imbalance between the body's antioxidant defenses and the production of Reactive Oxygen Species (ROS), oxidative stress occurs, increasing the risk of disease and leading to cellular dysfunction.[4] Dietary antioxidants potential to foster health and reduce the risk of illness has attracted a lot of attention due to the link between oxidative stress and disease.[5] Free radicals are extremely unstable molecules with an unpaired electron that play a significant role as intermediates in physiological processes like neurotransmission, cytotoxicity and vascular tone regulation. Numerous illnesses in humans, including cancer, Alzheimer's disease, irregularities in heart perfusion, kidney disease and fibrosis, are brought on by free radicals. When found in diet, antioxidants perform a variety of essential roles in cells and have numerous positive health impacts.[6,7]

When the body is under stress, it generates more Reactive Oxygen Species (ROS)-such as Hydrogen peroxide, hydroxyl radicals and superoxide anion radicals -than it can neutralize with its natural defense systems. These defenses include enzyme-based antioxidants like catalase, Superoxide Dismutase (SOD) and glutathione peroxidase, along with non-enzymatic antioxidants such as carotenoids, flavonoids, glutathione, vitamin E, vitamin

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C. This imbalance, where oxidative stress exceeds the body's antioxidant capacity, may result in cell damage and play a role in various health issues.[8-12]

A wide range of substances, including vitamins E and C, flavonoids, polyphenols and carotenoids, that are present in vegetables, fruits and whole grains are considered natural antioxidants. As an example, vitamin C is a strong water-soluble antioxidant that increases total antioxidant capacity by scavenging free radicals.[6] Rich in plant-based foods, polyphenols demonstrate a variety of biological functions, such as scavenging free radicals and modifying redox signalling pathways.[7] Apart from organic sources, artificial antioxidants such as Butylated Hydroxyanisole (BHA) and Butylated Hydroxytoluene (BHT) are frequently utilized in cosmetics and food preservation. But due to worries about possible health dangers, there's been more investigation and a hunt for natural, safer substitutes.[13,14]

Throughout ancient times, Indian complementary and alternative medicine systems have effectively employed herbal antioxidants as rejuvenators. Numerous studies have shown that the chemicals found in different herbal treatments are diverse, with many of them possessing antibacterial and radical scavenging properties that can shield the human body from infections and cellular oxidation processes.[15]

Nanotechnology plays a critical role by increasing antioxidant component stability, bioavailability and targeted distribution thus enhancing antioxidant function. Antioxidants can be encapsulated in nanoparticles to prevent deterioration and to boost their potency. With the use of this technology, antioxidant effects can be maximized where they are most required by targeting distribution to particular areas inside the body. Studies have demonstrated, that the antioxidant qualities of natural substances such as flavonoids and vitamins can be improved by the application of silver, gold and other metal oxide nanoparticles. By increasing the solubility and absorption of antioxidants, these nanocarriers can reduce oxidative stress and neutralize free radicals more effectively.[16] Figure 1 illustrates different role of Antioxidants.

Types of antioxidants

Antioxidants are mainly of 2 types which are as follows

- Non enzymatic
- Enzymatic

Non enzymatic

Non-enzymatic antioxidants are substances that help shield cells from oxidative damage without necessitating enzymatic activity. They include vitamins (like C and E), carotenoids, flavonoids

Figure 1: Role of Antioxidants.

and glutathione.[17] Glutathione (GSH), a tripeptide consisting of cysteine, glutamate and glycine is often referred to as the "master antioxidant." It features a unique gamma peptide bond between carboxyl group of glutamate and the amine group of cysteine, which is then linked to glycine by a standard peptide bond. Found in every cell of the body, GSH plays a crucial role in optimizing the function of other antioxidants, supporting overall cellular health and protection.[18] Vitamin C (Ascorbic Acid) is a water-soluble antioxidant that scavenges free radicals, especially in aqueous environments like the cytoplasm, preventing damage to proteins, lipids and DNA. Vitamin E (Tocopherols) is a fat-soluble antioxidant that helps protect cell membranes from oxidative damage by neutralizing lipid peroxyl radicals. Carotenoids (e.g., Beta-carotene, Lutein) are plant-derived pigments that combat Reactive Oxygen Species (ROS), particularly in the eyes and skin, offering protection against UV and light-induced damage. Flavonoids (e.g., Quercetin, Catechins) are polyphenolic compounds that neutralize free radicals and support the body's overall antioxidant defence system.[19-22]

Enzymatic

Enzymatic antioxidants function by dissolving and eliminating free radicals. In general, antioxidant enzymes neutralize harmful oxidative byproducts by converting them into hydrogen peroxide, which is then further broken down into water. This multi-step process requires the assistance of various trace metal cofactors, including copper, zinc, manganese and iron, to function effectively. Glutathione peroxidase, catalase and Superoxide Dismutase (SOD) are important enzymes involved in the neutralization of Reactive Oxygen Species (ROS) that protect cells from oxidative damage. Together, these enzymes preserve redox balance and guard against cellular damage linked to a no of diseases, such as neurodegenerative disorders and cancer.[23] The activity of these enzymes is regulated by a person's diet, genetics and environment, underscoring their significance for the longevity and health of cells.[24]

Various types of Antioxidants have been described in Figure 2.

Antioxidants Assay Methods

Some of the main methods are as Follows Different antioxidant assay methods have been depicted in Figure 3.

In vitro assay methods Includes

DPPH free radical scavenging assay

A common method for assessing the radical scavengers in natural foods is the DPPH, which is 1 of the most stable free radicals.[25] The DPPH test method is a rapid and easy way to manually analyse the levels of antioxidants. The DPPH test relies on the stable 2, 2-diphenyl-1 picrylhydrazyl free radical's capacity to react with hydrogen donors.[26,27] The process includes measuring the absorbance of DPPH at its 516 nm absorption maxima, which

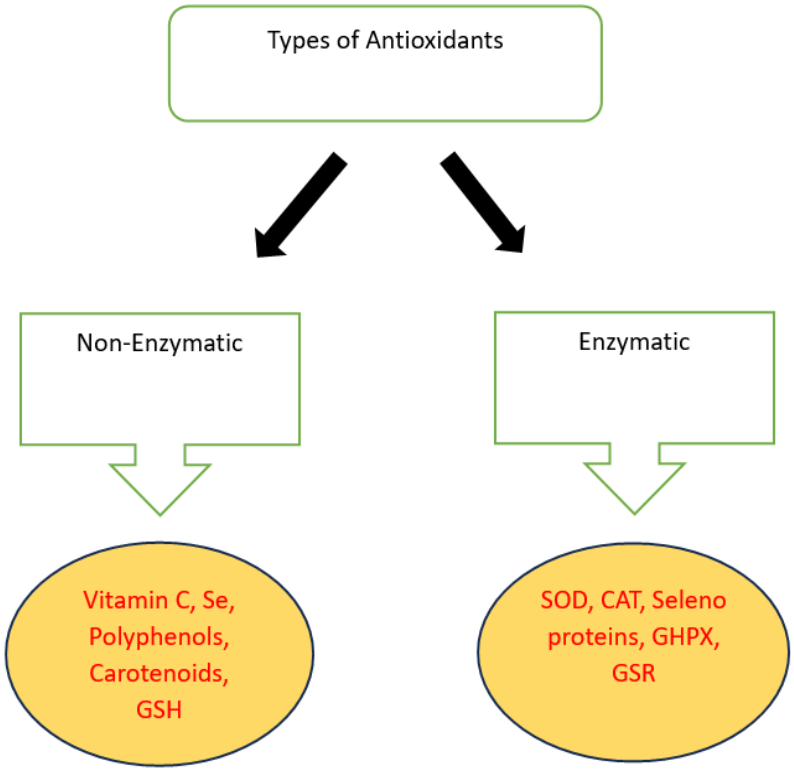

Figure 2: Types of Antioxidants.

is proportional to the amount of free radical scavenger added to the solution containing the DPPH reagent.[28,29]

Super oxide free radical scavenging activity

In vitro superoxide radical scavenging activity is assessed by the riboflavin/light/NBT (Nitro Blue Tetrazolium) reduction method**.** This test is commonly based on the reduction of NBT, which is 1 of the most widely employed techniques for assessing superoxide radical activity**.** The process relies on the auto-oxidation of riboflavin in the presence of light to produce super oxide radicals.[30,31] Superoxide anion radical overproduction leads to redox imbalance and has detrimental physiological effects.

FRAP assay

1 of the simplest tests, FRAP (Ferric Reducing Ability of Plasma), is excellent for routine analysis. Originally employed to ascertain the antioxidant activity of plasma, it was subsequently effectively used to gauge the antioxidant activity of several biological samples and pure compounds.[32,33] The rise in absorbance brought on by the production of ferrous ions from the FRAP reagent containing TPTZ (2,4,6-tri (2-pyridyl)-s-triazine) and FeCl36H2O is used to calculate the antioxidative activity.[34,35]

CUPRAC Assay

CUPRAC is basically an ET-based assay that is frequently used to assess a compound's total antioxidant capacity, or its ability to completely scavenge free radicals. The basic redox reaction between antioxidants and free radicals serves as the basis for this technique, which measures antioxidant activity by converting cupric ions to cuprous ions.[36,37] It is referred to as Cupric ion reducing antioxidant capacity. It is frequently used to assess the antioxidant potential of biological samples, food, plants, human blood, dietary polyphenols, vitamins C and E and other substances.

FCR, the total phenols assay

Tungsten and molybdenum oxides combine to form FCR. This technique was first applied to the examination of proteins with phenolic groups, such as tyrosine,[38] but it was later utilized to determine the overall phenolic content of wine. This approach offers a sensitive and quantitative measurement that is largely unaffected by the presence of proteins, nucleic acids, or ascorbic acid.

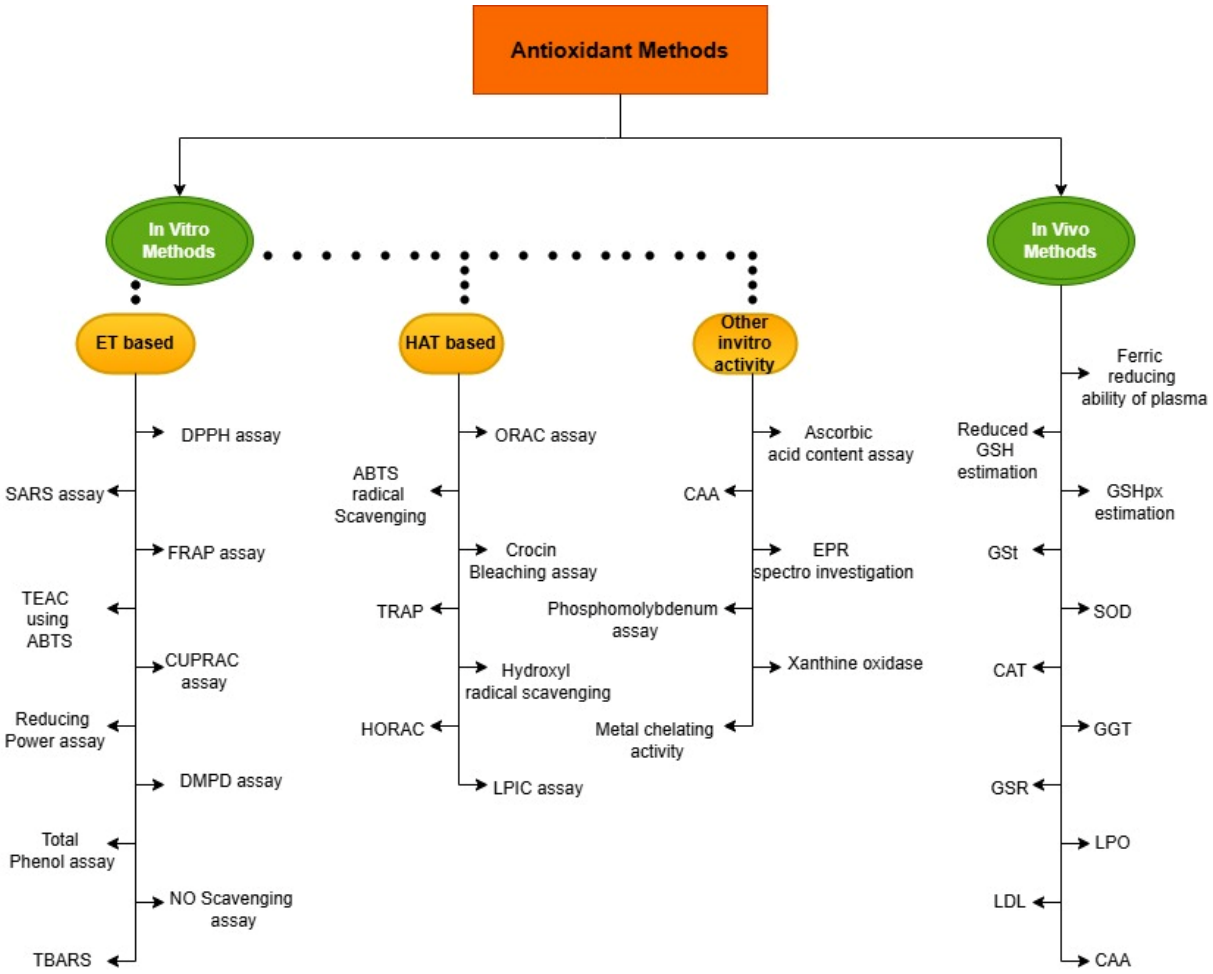

Figure 3: Various Antioxidant Assay Methods.

NO free radical scavenging activity

Numerous biological processes, such as neurotransmission, vascular homeostasis, antibacterial and anticancer activity, are influenced by NO. Additionally, it causes oxidative damage. This technique relies on the Griess reagent's measurement of the suppression of nitric oxide radicals produced by sodium nitroprusside in buffer saline.[39]

ORAC assay

The ORAC assay is a technique for measuring a material's antioxidant power that combines the substance to be evaluated (the antioxidant) with a fluorescent component and a compound that produces free radicals at a defined rate. It determines how well a substance or product guards against potentially harmful free radicals. This analytical process assesses a food's, vitamins, nutritional supplements, or other chemical's capacity to function as an antioxidant or defend against free radical damage. Trolox, a water-soluble vitamin E analogue, is used as a standard in the test to calculate the Trolox Equivalent (TE). After that, the Trolox Equivalent is used to evaluate the ORAC value, which is then converted to ORAC units or value.[40,41]

ABTS assay

It is known as "2,2-azinobis (3-ethyl benzothiazoline, 6-sulfonic acid)". Unlike antioxidant concentration, which may include a portion of physiologically inactive antioxidants, this measure reflects the actual antioxidant activity. Additionally, it makes it possible to quantify the antioxidant activity of drug mixtures, which aids in differentiating between additive and synergistic effects.[42,43]

Hydroxyl radical scavenging activity

The hydroxyl radical is a powerful ROS in the biological system that damages cells by reacting with the polyunsaturated fatty acid moiety of phospholipids in cell membranes. The antioxidant activity of an extract is directly correlated with its ability to scavenge hydroxyl radicals. This process uses the Fenton reaction to create hydroxyl radicals *in vitro* utilizing the Fe^{3+}/ascorbate/EDTA/H_2O_2 system.[44]

Ascorbic acid content assay

The techniques form the foundation for the High-Performance Liquid Chromatography (HPLC) method of ascorbate determination developed by Lee and Coates.[45]

Phosphomolybdenum assay

The assay is based on the ability of the sample analyte to reduce Mo (VI) to Mo (V), which then forms a green phosphate-Mo (V) complex under acidic conditions. This reduction of molybdenum by antioxidant compounds in plant extracts results in the formation of a green molybdenum complex, allowing for the measurement of antioxidant capacity using the phosphomolybdenum assay.[46] The phosphomolybdenum complex is formed in the total antioxidant capacity assay, a spectroscopic technique for quantifying antioxidant capacity.

Xanthine Oxidase method

Using xanthine as a sub-substrate, the xanthine oxidase activity can be spectrophotometrically evaluated using the Noro *et al.* method.[47]

Metal chelating activity

Ferrozine and Fe^{2+} combine to produce chelates, which results in a red complex. The red of the ferrozine-Fe^{2+} complexes decrease as a result of this reaction, which is limited when additional chelating agents are present. The chelating activity to compete with ferrozine for the ferrous ions is determined by measuring the colour reduction.[48]

Some more assays are there which include

TEAC (Trolox Equivalent Antioxidant Capacity), DMPD (N, N-Dimethyl-p-phenylenediamine), TBA (Thiobarbituric Acid) Reactive Substances (TBARS), TRAP (Total Radical-Trapping Antioxidant Parameter), HORAC (Hydroxyl Radical Antioxidant Capacity), LPIC (Lipid Peroxidation Inhibition Capacity), CAA (Cellular Antioxidant Activity).

In vivo assay methods Includes

Ferric reducing ability of plasma

Antioxidant potential is evaluated by observing the rise in absorbance resulting from the generation of ferrous ions through a reaction with the FRAP solution, which includes "TPTZ (2,4,6-tripyridyl-s-triazine)" and "$FeCl_2 \cdot 6H_2O$. The absorbance is then determined using spectrophotometry at 593 nm. This method is 1 of the fastest assays available and is particularly useful for routine analysis.[49]

Reduced GSH estimation

GSH is an intracellular reductant that is essential for transport, metabolism and catalysis. It shields cells from harmful substances like peroxides and free radicals.[50] GSH participates in a transport system that aids in in the process of amino acid reuptake and has a significant function in the kidney as well**.** A cataract develops when the lens's GSH levels are low.

GSHPx estimation

GSHPx is a selenium-containing enzyme, with two thirds located in the cytosol, with 1-3rd present in the mitochondria (liver). In order to create GSH disulfide (GSSG) and the hydroperoxide reduction product, it facilitates the reaction between hydroperoxides and reduced GSH. Four distinct isoenzymes of GSHPx are present in all tissues: Gastrointestinal GSH peroxidase, Cellular GSH peroxidase, extracellular GSH

peroxidase and phospholipid hydroperoxide GSH peroxidase. Patients experiencing oxidative stress for whatever reason should pay particular attention to GSHPx measurement; reduced enzyme activity is among the most 1st signs of a disruption in the prooxidant/antioxidant balance.[51,52]

GSt

Gst, or glutathione S-transferase, is an important enzyme involved in detoxification processes in the body. It is believed that GST has a physiological function in starting the detoxication of chemicals that are pharmacologically active as well as possible alkylating agents. By catalyzing the interaction between these chemicals and GSH's-SH group, these enzymes neutralize the compounds' electrophilic sites and increase the water solubility of the resulting products.[53]

SOD method

It is a crucial antioxidant enzyme that aids in shielding cells from oxidative damage and is commonly referred to as the SOD method. Superoxide radicals are dismutated into oxygen and hydrogen peroxide by SOD. Mccord and Fridovich, 1969[54] provide a thorough description of this technique, which can be used to assess a sample's antioxidant activity.

CAT

The enzyme Catalase (CAT) is responsible for breaking down Hydrogen Peroxide (H_2O_2) into oxygen and water. Its ability to degrade potentially hazardous hydrogen peroxide, a byproduct of numerous metabolic activities, is essential for shielding cells from oxidative damage.[55]

GSR assay

The Glutathione Reductase (GSR) assay measures the activity of the enzyme glutathione reductase, which plays a crucial role in preserving cellular redox equilibrium involves the conversion of oxidized Glutathione (GSSG) to its reduced form (GSH).[56] Several enzymatic reactions rely on the widespread tripeptide GSH, which is the most abundant low-molecular-weight thiol found in nearly all living organisms. 1 of GSH's primary roles is to act as a reductant during oxidation-reduction reactions, which produces GSH disulfide (GSSG). It was found that the liver contains a heat-labile mechanism that can reduce GSSG. The enzyme that is directly responsible for GSSG reduction.

LPO assay

Lipid peroxidation, a sign of oxidative stress, is measured in biological samples using the Lipid Peroxidation (LPO) assay. The term "lipid peroxidation" describes the oxidative breakdown of lipids that produces quantifiable reactive aldehydes like Malondialdehyde (MDA).[57] 1 frequent result of cell death is LPO, an autocatalytic process. This mechanism results in aging, xenobiotic toxicity, cancer and peroxidative tissue damage in inflammation. Malondialdehyde (MDA) is 1 of the end products of the Lipid Peroxidation (LPO) process. It is a well-established marker of LPO and is formed as a byproduct of free oxygen radicals during oxidative damage.

Some more assays are there which include

GGT (Gamma-Glutamyl Transferase), LDL (Low-Density Lipoprotein).

GREEN SYNTHESIZED NANOPARTICLES

This approach focuses on avoiding the use of hazardous or polluting materials in manufacturing, minimizing the consumption and waste of non-renewable resources, reducing or, when possible, eliminating pollution during synthesis and shortening the overall synthesis time. As the father of green chemistry, Paul J. Anastas described it as "a work philosophy that involves the use of alternative tools and pathways to prevent pollution," which encompasses both the design of the synthetic approach and the management of possible by-products that may result from that process.[58,59]

A widely used approach in this process involves utilizing algae, plants or microorganisms such as fungi or bacteria. These organisms work synergistically to produce a range of compounds, including polyphenols, terpenes, alkaloids, proteins, carbohydrates and genetic materials, all of which are crucial to the nanoparticle synthesis process.[60,61] Factors such as the metal ion concentration, reaction time, pH and temperature influence the size and shape of nanoparticles., in addition to the biological resources (plants, algae, or microbes) that are utilized to carry out the synthesis.[62]

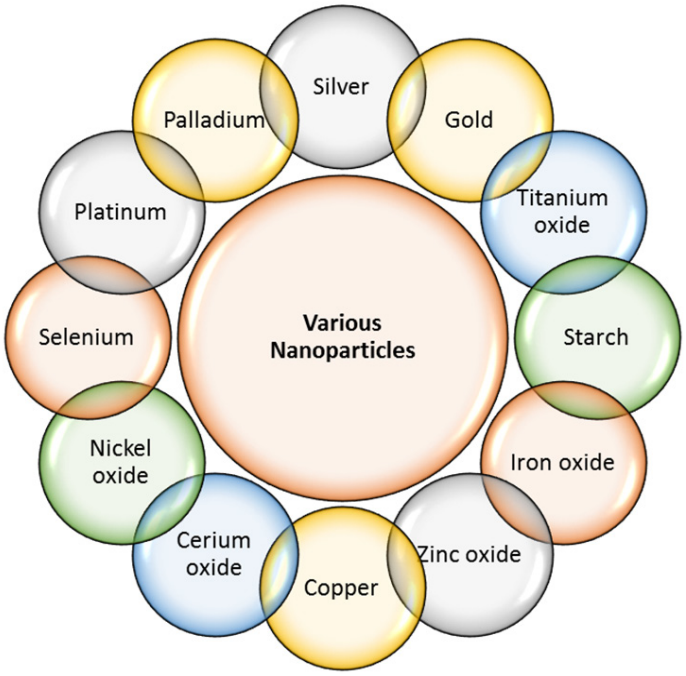

Figure 4: Various metallic nanoparticles.

Biosynthesized nanoparticles have gained substantial interest because of their potential uses in a variety of industries and their ecologically friendly production processes. Here are some key points regarding their importance

Eco-Friendly Synthesis

Plant extracts are commonly used in green synthesis techniques, which minimize the need for harsh conditions and hazardous chemicals. This strategy improves sustainability while reducing its negative effects on the environment.[63]

Biomedical Applications

Green manufactured nanoparticles have potential applications as antibacterial agents, medication delivery and imaging. They are appropriate for medical applications due to their biocompatibility.[64]

Catalytic Properties

By acting as efficient catalysts in a range of chemical reactions, these nanoparticles can support more environmentally friendly industrial operations.[65]

Environmental Remediation

Green manufactured nanoparticles can be used to remove pollutants from soil and water, proving their usefulness in cleaning up the environment.[66]

Agricultural Applications

By acting as environmentally friendly herbicides and promoting plant development, these nanoparticles can help with food security concerns.[67]

Various Green synthesized metallic nanoparticles and their antioxidant potential

Different types of metallic nanoparticles are shown in Figure 4.

Silver nanoparticles (AgNPs) synthesized from *Mussaenda frondose, Tinospora cordifolia, Curcuma longa, Trigonella foenum-graecum, Emblica officinalis, Salacia oblonga, Brassica oleracea, Psidium guajava, Digitaria radicosa, Salvia officinalis, Prunus japonica, Elephantopus scaber, Bergenia ciliata, Salvia aethiopis, Lenzites betulina, Ficus carica, Lippia nodiflora, Vetiveria zizanioides, Alpinia katsumadai, Phyllanthus amarus, Blighia sapida, Morinda lucida, Eucalyptus leucoxylon, Piper longum, Hyacinthus orientalis, Dianthus caryophyllus, Nepeta leucophylla, Physalis angulata, Thymus kotschyanus, Achillea millefolium, Trichoderma harzianum, Sambucus nigra, Cosmos sulphureus*, black currant, *Allium ampeloprasum, Iresine herbstii, Nervalia zeylanica, Passiflora edulis* f. *flavicarpa, Pueraria tubesinens, Echinacea purpurea, Linum usitatissimum* and *Catharanthus roseus* exhibit potent antioxidant properties, enhancing their biomedical applications. **Gold nanoparticles** (AuNPs) derived from *Sumac, Lavandula angustifolia, Vitex negundo, Citrus limetta, Curcumae kwangsiensis, Cannabis sativa, Glaucium flavum, Nerium oleander, Mangifera indica, Pistacia atlantica, Thyme, Acer pentapomicum, Terminalia bellirica* and *Ziziphus nummularia* also show strong antioxidant capabilities, making them beneficial for health applications. **Zinc oxide nanoparticles** (ZnONPs) synthesized from *Capparis zeylanica, Beta vulgaris, Scoparia dulcis*, Mulberry, *Garcinia xanthochymus, Berberis aristata, Pelargonium odoratissimum, Cassia fistula, Polygala tenuifolia, Ceropegia candelabrum, Fumaria officinalis, Peganum harmala* and *Achillea nobilis* demonstrate effective antioxidant activity, contributing to their use in pharmaceuticals and cosmetics. **Iron oxide nanoparticles** (FeONPs) from *Ficus carica* and *Phoenix dactylifera* are recognized for their antioxidant properties, enhancing applications in environmental remediation. **Copper and copper oxide nanoparticles** (CuNPs and CuO NPs) derived from *Abutilon indicum, Eclipta prostrata, Cocculus hirsutus, Cissus vitiginea, Pongamia pinnata, Withania somnifera, Galeopsidis herba, Tinospora cordifolia, Magnolia champaca* and *Achillea nobilis* highlight their significant antioxidant activity, beneficial for agriculture and medicine. **Cerium oxide nanoparticles** (CeO_2 NPs) synthesized from *Euphorbia amygdaloides* and nickel oxide nanoparticles (NiO NPs) from *Calendula officinalis* are noted for their antioxidant properties, enhancing various applications. **Selenium nanoparticles** (SeNPs) from *Crataegus monogyna* and **platinum nanoparticles** (PtNPs) from *Atriplex halimus* and *Tornabea scutellifera* also exhibit considerable antioxidant activity, contributing to health and catalysis. Lastly, **palladium nanoparticles** (PdNPs) synthesized from *Anogeissus latifolia* further emphasizes the effectiveness of plant-derived nanoparticles with antioxidant capabilities. This overview underscores the potential of these nanoparticles in promoting health and combating oxidative stress, driven by the natural antioxidant properties of their plant sources.

The antioxidant activity of green synthesized nanoparticles illustrated in table, the table shows selected research articles of antioxidant activity of nanoparticles synthesized using plant/plant parts organized according to year of publication, the plant used (around 100 plants), type of extract, Nanoparticle types, used doses, mode of administration, duration of experiment, model of study and observed effects (Table 1).

Table 1: Antioxidant activity of green synthesized nanoparticles.

Plant and family	Part used	Type of extract	Nanoparticle type and size	Dose/ duration/ mode	*In vitro*/ Animal model	Effects observed	References
Hyacinthus orientalis L. and *Dianthus caryophyllus* L.	Petals	Aqueous extract	AgNP, 61.45-89.6 nm.	-	*In vitro*	-The antioxidant activity of the herbal AgNP ranged from 88.30 to 97.38%, with white carnation-AgNPs having the highest antioxidant activity (AA=97.38%).	68
Iresine herbstii(family: Amaranthaceae)	Leaves	Ethanolic extract	AgNP,44-64 nm.	100-500 µg/ mL	*In vitro*	- The results indicated a lesser amount of phenolic compounds (7.33±0.58 mg GA/g nanoparticles) attached to the nanoparticles. In milligrams of gallic acid equivalents. - The DPPH scavenging assay demonstrated that the IhAgNPs showed greater inhibition than IHLE. - There was no significant difference seen between the ferric ion reducing and DPPH free radical scavenging activities of IhAgNPs and IHLE.	69
Psidium guajava (family: Myrtaceae).	Leaves	Aqueous extract	TiO_2 NP, 32.58 nm.	-	*In vitro*	- The overall antioxidant capacity of the produced TiO_2 NPs was found to be much higher than that of the aqueous leaf extract of *P. guajava*. It was shown that the nanoparticles DPPH activity increased in a dose-dependent manner. - When compared to *P. guajava* leaf aqueous extract, the produced TiO_2 NPs exhibited a comparatively higher IC_{50} value of 21.4 µg/ mL for free radical scavenging activity.	70
Phyllanthus amarus (family: Phyllanthaceae).	Leaves	Aqueous extract	AgNP	200-1000 µg/ mL.	*In vitro*	- AgNPs on the DPPH radical scavenging was shown to rise as concentration increased, reaching a high of 81.39% at 500 µg/mL and also reduced H_2O_2 radicals.	71
Eucalyptus leucoxylon (family: Myrtaceae).	Leaves and oil	Methanolic extract	AgNP,50 nm	-	*In vitro*	- The methanol extract's polar subfraction in the DPPH system exhibited the strongest radical-scavenging activity (21.0±1.4 µg/mL).	72
Piper longum (family: Piperaceae).	Fruit extract	Aqueous extract	AgNP, 46 nm	100-500 µg/ mL (Reducing power assay), 100-600 µg/ mL (DPPH assay), 50-500 µg/mL (NO radical assay), 10-200 µg/mL (Superoxide scacenging), 10-60 µg/ mL (H_2O_2 scacenging)	*In vitro*	-Compared to extract, PLAgNPs exhibited more reducing activity and it was found that PLAgNPs' reducing activity increased with concentration. -The DPPH assay findings demonstrated that PLFE and PLAgNPs both effectively inhibited free radicals. -In comparison to PLFE's activity, the superoxide radical quenching activity of PLAgNPs was seen to rise with rise in concentration, with an inhibition of roughly 60%. -PLAgNPs' nitric acid quenching activity was evaluated in comparison to PLFE's. In comparison to the activity of PLFE, the NO radical quenching activity of PLAgNPs was observed to rise with rise in concentrations, with an inhibition of 70%. -When it came to scavenging H_2O_2 radicals, PLAgNPs outperformed PLFE in this regard. In fact, their average suppression of H_2O_2 scavenging activity was 96%, which was higher than PLFE's.	73

Beta vulgaris (family: Amaranthaceae).	Roots	Methanolic extract	ZnO NP,52-76 nm.	1000-5000 µg/mL.	*In vitro*	- The results of the investigations show that the synthesized nanoparticles, with an IC_{50} value of 4400 µg/mL, demonstrate moderate antioxidant efficacy by inhibiting DPPH free radicals.	74
Nerium oleander (family: Apocynaceae).	Leaves	Aqueous extract	AuNP,2-10 nm.	0.0-1.2 mg/mL.	*In vitro*	- The DPPH activity data demonstrated that AuNP effectively inhibited free radicals. Concentration of AuNP and antioxidant activity increase in dose dependent manner.	75
Garcinia xanthochymus(family: Clusiaceae).	Fruits	Aqueous extract	ZnO NP,20-30 nm.	0-10000 µg/mL.	*In vitro*	- With an IC_{50} value of 8000 µg/mL, ZnO Nps were shown to be effective at blocking the DPPH free radical scavenging activity.	76
Artocarpus gomezianus(family: Moraceae).	Fruits	Aqueous extract	ZnO NP,11.53 nm.	0.0-12.5 mg/mL.	*In vitro*	- The ZnO NP was found to inhibit DPPH free radical scavenging activity, with an IC_{50} value of 10.8 mg/mL.	77
Pongamia pinnata(family: Fabaceae).	Leaves	Aqueous extract	CuNP,100 nm.	50-300 µg/mL.	*In vitro*	- The extract exhibited a scavenging rate varying from 20% to 78% at concentrations of 50-300 µg/mL, while AgNPs, pAgNPs and conventional ascorbic acid showed 23-80%, 28-84% and 30%, 90%, respectively. - The extract exhibited a scavenging rate varying from 24% to 73% at concentrations of 50-300 µg/mL, while AgNPs, PPAgNPs and conventional ascorbic acid showed 27-75%, 30%-77% and 43.81%, respectively. -When compared to the extract, which demonstrated less action, the pAgNPs (50-300 µg/mL) blocked high superoxide radical scavenging activity. The leaf extract exhibited a scavenging rate ranging from 27% to 68% at doses of 50-300 µg/mL, while AgNPs revealed 28-66%, pAgNPs revealed 29-71% and in normal ascorbic acid 35-82% was seen. - For the extract, the concentrations at 50-300 µg/mL inhibitions were reported to be 31-78%, for AgNPs, 32-80%, for pAgNPs, 33-82% and 42-88% for vitamin C. - The percentage of P. pinnata extract and chemically generated AgNPs that scavenge nitric oxide ranges from 27-86% and 29-77%, respectively, at 50-300 µg/mL. pAgNPs' nitric oxide scavenging activity ranged from 31% to 78%, while its ascorbic ranging activity was between 48% and 82%.Their IC_{50} values were comparable to those of the leaf extract, with pAgNPs showing the highest activity in the DPPH, ABTS and Superoxide assays and the leaf extract performing best in the Hydroxyl Radical assay.	78
Cassia fistula(Family: Fabaceae).	Leaves	Aqueous extract	ZnO NP,5-15 nm.	0-8000 µg/mL.	*In vitro*	- With an IC_{50} value of 2853 µg/mL, the ZnO NP were shown to be highly effective at suppressing the DPPH free radical scavenging activity and the IC_{50} value of the extract is 54 µg/mL. - Extract has been demonstrated to have strong antioxidant activity which contains 12.5% flavonoids and 11% polyphenols and has been utilized to create ZnO nanoparticles.	79

Gymnema sylvestre (Family: Apocynaceae).	Leaves	Aqueous extract	AgNP and AuNP,33 nm, 26 nm.	100-500 µg/mL (Reducing power), 100-3000 µg/mL (DPPH), 100-2500 µg/mL (SO), 100-2500 µg/mL (NO), 10-60 µg/mL (H_2O_2).	*In vitro*	- Both GYAgNPs and GYAuNPs showed better DPPH scavenging activity than GYLE (a plant extracts) and their activity increased with higher concentrations. -In terms of superoxide radical scavenging, GYLE demonstrated excellent activity, comparable to rutin, while GYAgNPs and GYAuNPs showed substantial quenching activity. For NO radical scavenging, GYLE showed high inhibition, similar to rutin, while GYAgNPs and GYAuNPs exhibited average inhibition rates of 82% and 58%, respectively.	80
Polygala tenuifolia (Family: Polygalaceae).	Roots	Aqueous extract	ZnO NP,33.03-73.48 nm.	0.125-1 mg/mL.	*In vitro*	- The free radical scavenging activity of ZnO NP on DPPH increased with concentration: at 0.125 mg/mL, the activity was 40.58%; at 0.25 mg/mL, it increased to 44.66%; at 0.5 mg/mL, it reached 45.01%; and at 1 mg/mL, it further rose to 45.47%.	81
Tinospora cordifolia (Family: Menispermaceae).	Leaves	Aqueous extract	CuO NP,6-8 nm.	0-1400 µg/mL.	*In vitro*	-With an IC_{50} value of 566 µg/mL, the CuO NPs were shown to be strong at inhibiting the DPPH free radical scavenging activity.	82
Anogeissus latifolia(family: Combretaceae).	Whole plant	Aqueous extract	PdNP,4.8±1.6 nm.	1-15 µg/mL.	*In vitro*	- When the concentration of PdNP increased from 1 to 15 µg/mL, the proportion of DPPH that was scavenged increased linearly and reached 81.9% at 15 µg/mL in 60 min whereas the ascorbic acid (positive control) revealed 94.0% of scavenging activity at a concentration of 50 µg/mL.	83
Digitaria radicosa(family: Poaceae).	Leaves	Methanolic extract	AgNP, 90 nm	10-100 µg/mL	*In vitro*	- The highest % of inhibition of SNPs at 100 µg/mL concentration was found to be 82.45±0.84, 75.68±0.19, 79.4±0.7 and 82.3±0.85, respectively for DPPH scavenging, metal chelating, reducing power and H_2O_2 scavenging assays, Moreover, the percentage of inhibition increases in a dose-dependent way.	84
Lavandula angustifolia(family: Lamiaceae).	Leaves	Aqueous extract	AuNP, 30-300 nm	0.2 mL-1.0 mL	*In vitro*	- At lower concentrations, 0.2 mL AuNPs exhibit superior DPPH quenching activity (21.53%), in comparison to extract (4.73%). Since AuNPs are less soluble, they showed the reverse trend (21.53%, 0.2 mL; 19.56%, 0.4 mL; 17.18%, 0.6 mL; 10.55%, 0.8 mL and 4.14%, 1 mL) to the DPPH scavenging activity of LLE, which rise with rise in the concentration (4.73%, 0.2 mL; 7.70%, 0.4 mL; 14.09%, 0.6 mL; 22.27%, 0.8 mL and 34.28%, 1 mL).	85
Prunus japonica(family: Rosaceae).	Leaves	Methanolic extract	AgNP, 26 nm.	12.5-200 µg/mL.	*In vitro*	- An increase in AgNP concentration often results in the rise in the DPPH radical scavenging activity. AgNPs showed a maximum percentage inhibition of 55%, which was less than the standard vitamin C level at the dose 200 µg /mL (93%).	86
Elephantopus scaber(family: Asteraceae).	Leaves	Aqueous extract	AgNP, 78 nm.	50-250 µg/mL.	*In vitro*	-The synthesized AgNPs have the same ability to scavenge free radicals as an aqueous plant extract. There was a dose-dependent increase in the scavenging capacity. - The scavenging ability of AgNP at 50 µg/mL was 15.23±0.04 and it was increased to 85.90±0.08 at measurement 250 µg/mL. (Average IC_{50}-126.6±0.06)	87

Bergenia ciliata(family: Saxifragaceae).	Rhizomes	Methanolic extract	AgNP, 35 nm	-	*In vitro*	- Based on the DPPH activity data, BCAgNPs and BC extract have an effective free radical scavenging percentage of 59.31% and 51.29%, respectively. The total antioxidant activity of the crude extract and nanoparticles was found to be 38.8±1.08 AAE and 60.48±2.2 AAE, respectively.	88
Ficus carica(family: Moraceae).	Fruit	Aqueous extract	AgNP, 20-80, 10-30 nm.	20-100 µg/mL.	*In vitro*	-The highest DPPH scavenging efficacy of the ultrasonicated and heating assisted AgNPs was determined to be 36.68% with 60 µg/mL and 21.59% with 40 µg/mL respectively whereas extract was found to have a dose-dependent increase in DPPH· activity (15.47%, 40 µg/mL; 24.03%, 100 µg/mL). -In contrast to thermal-AgNPs and extract, the ultrasonicated AgNPs demonstrated notably higher antioxidant activity at low doses (40 µg/mL) (AgNPs ultrasonication, 34.99%>AgNPs thermal, 21.59%> extract, 15.47%).	89
*Sambucus nigra (*family: Adoxaceae).	Fruits	Aqueous extract	AgNP, 26 nm.	0.3 mg/b.w, 4 days, orally.	*In vitro* as well as *In vivo*	- The TEAC assay was the *in vitro* technique utilized to measure the antioxidant activity. The antioxidant activity of the extract employed for the synthesis of the AgNPs was found to be 118.44 µM Trolox, whereas the antioxidant capacity of the AgNPs was 177.09 µM Trolox. - *In vivo* results are as follows:Rats treated with extract (64% inhibition; $p<0.05$) and AgNPs (65% inhibition; $p<0.05$) showed a significant difference in the enzymatic activity of GPx at 24 hr when compared to the control group. On the other hand, after 48 hr, the administration of AgNPs led to a noteworthy rise in both GPx and CAT activities (2.26 and 2.21 times higher, respectively, than in the control group; $p<0.01$), indicating that the antioxidant properties of AgNPs persisted for up to 48 hr following the development of oxidative stress. Additionally, extract at 48 hr boosted CAT activity (1.36 times; $p<0.05$). - Regarding these factors, a distinct pattern was seen in the serum. Without affecting antioxidant defense, the phytosynthesized AgNPs showed a protective impact on serum oxidative lipid peroxidation (36% inhibition; $p<0.05$) AgNPs shown encouraging *in vivo* effects, concurrently enhancing the activities of glutathione peroxidase and catalase and lowering the MDA level 48 hr after oxidative stress induction.	90
Cosmos sulphureus(family: Asteraceae).	Leaves	Aqueous extract	AgNP, 55-80 nm.	100-500 µg/mL.	*In vitro*	- It was found that the DPPH activity of the NPs increased in a dose-dependent way. Nevertheless, compared to Cs, the CsAgNPs showed greater inhibition, scavenging more than 60% of the DPPH. Cs and CsAgNPs shown significant scavenging effects against DPPH, with an IC_{50} value of 135.53±1.78 µg/mL and 92.38±1.93 µg/mL, respectively. For this experiment, the standard ascorbic acid's IC_{50} value was 60.78±1.79 µg/mL.	91

Euphorbia amygdaloides(family: Euphorbiaceae).	Whole plant	Aqueous extract	Ce_2O_3 NP, 8.6-10.5 nm.	10-50 µg/mL.	*In vitro*	- At 50 µg/mL concentrations, the results showed that Ce_2O_3 NPs had a greater DPPH radical-removing activity than BHA and α-tocopherol. The computed values for these variables were 87.6, 76.3 and 52.9, in that order. - The FRAP approach revealed that Ce_2O_3 NPs' ability to reduce from Fe^{3+} to Fe^{2+} increased proportionately with concentration. Furthermore, Ce_2O_3 NPs demonstrated increased FRAP activity in comparison to conventional α tocopherol. - The metal chelating ability of Ce_2O_3 NPs was greater than that of the standards. These values were found for αtocopherol (53.36%), BHA (66.98%) and Ce_2O_3 NPs (71.641%). - Ce_2O_3 NPs were shown to have superoxide anion radical scavenging activity at concentrations of 10, 30 and 50 µg/mL. Additionally, they were ranked higher than α-tocopherol and BHA and the order was a follow:76.74 ± 0.2>65.66 ± 1.0 >59.97 ± 6.8. -At a concentration of 50 µg/mL, the scavenging effect of the Ce_2O_3 NPs and standards on the ABTS+ radical cation(s) reduced in the following order: Ce_2O_3 NPs>α-tocopherol>BHA, which were 87.2, 74.9 and 50.1%, respectively.	92
Terminalia bellirica (Family: Combretaceae).	Fruit	Aqueous extract	AuNP, 20-30 nm.	0.2-1.25 Mm/mL.	*In vitro*	-As the concentration of AuNPs increases, radical scavenging activity of the AuNPs boosted its ABTS quenching impact from 20% to 40%. When DPPH and ABTS were compared, the DPPH scavenging activity was greater.	93
Eclipta prostrata(family: Asteraceae).	Leaves	Aqueous extract	CuNP, 31±1.2 nm nm.	100-500 µg/mL.	*In vitro*	- At varying concentrations 100, 200, 300, 400, 500 µg/mL, the CuNPs exhibited measurements of 0.54±0.19, 0.47±0.67, 0.72±0.92, 0.79±0.56 and 0.96±0.30 mg GAE/g while leaf extract showed measurements of 0.26±0.06, 0.39±0.14, 0.43±0.11, 0.59±0.67 and 0.67±0.78 mg GAE/g, respectively. The corresponding measurements for ascorbic acid were 0.51±0.11, 0.56±0.06, 0.64±0.15, 0.71±0.25 and 0.75±0.84 mg GAE/g at the same concentration.The percentage inhibition of DPPH radicals by CuNPs and the extract also increased with concentration. The synthesized CuNPs demonstrated inhibition values of 32%, 34%, 41%, 46% and 53%, while the powdered leaf extract showed values of 29%, 32%, 37%, 43% and 48% at different concentrations 100, 200, 300, 400, 500 µg/mL respectively. In comparison, ascorbic acid (the control) exhibited higher inhibition percentages of 85%, 87%, 89%, 92% and 95% at the same concentrations.	94
Sumac	Powder of whole plant	Aqueous extract	AuNP, 20.83 nm.	25,50,100,200, 400, 800 µM.	*In vitro*	- The NPs exhibited a dose-dependent scavenging activity; at 25 µM, the DPPH effect was 13.43% and at 800 µM, Au-NPs, it reached 85.73%. - Bio formed nanoparticles demonstrated dose-dependent activity, with an ABTS scavenging effect of 96.83% observed at a concentration of 800 µM.	95

Salvia officinalis(family: Lamiaceae).	Whole plant	Aqueous extract	AgNP, 16 nm	200-1000 µg/mL	*In vitro*	- Green synthesized AgNPs demonstrated a free radical scavenging action, with IC_{50} values for DPPH and ABTS radicals of 830 and 800 µg/mL, respectively.	96
Lippia nodiflora(family: Verbenaceae).	Aerial parts	Aqueous extract	AgNP, 30-60 nm.	25-500 µg/mL.	*In vitro*	- Ag-NPs ability to scavenge free radicals, superoxide, H_2O_2, hydrogen radical and reducing power tends to rise as their concentration increases. Interestingly, at 500 µg/mL, AgNPs show 67% greater antioxidant activity. At the same concentration, the typical BHT showed 83% inhibition. - At a measurement of 500 µg/mL, AgNPs exhibited a maximal suppression of superoxide radical scavenging activity of around 70%, whereas BHT exhibited an activity of 84%. - While BHT, demonstrated excellent effectiveness in hydrogen radical scavenging with 75% activity at 500 µg/mL, AgNPs demonstrated considerable scavenging ability at all tested concentrations, with a peak inhibition of 69% at 500 µg/mL. -AgNPs demonstrated a significantly higher reducing power than BHT. AgNPs and BHT both had reducing powers of 0.115 and 0.095 at 500 µg/mL, respectively. AgNPs and BHT both had H_2O_2 scavenging activities of 71.1% and 68.2% at 500 µg/mL, respectively.	97
Alpinia katsumadai (family: Zingiberaceae).	Seed extract	Aqueous extract	AgNP, 12.6 nm.	100-500 µg/mL.	*In vitro*	- It is evident that AgNPs and AKSE have the ability to effectively inhibit free radical activity, DPPH radical, hydroxyl radical and FRAP activity in contrast to AKSE, AgNPs' suppression of the DPPH radical scavenging activity increases quickly as concentration rises. It's interesting to note that AgNp exhibited a better scavenging activity for DPPH, reaching a maximum scavenging efficacy of 89.9% at 500 µg mL^{-1} in just 30 min higher than that of AKSE (85.0%). - The reducing capabilities of AKSE and AgNPs at 500 µg mL^{-1} is 73.7% and 79.0% in FRAP experiment respectively. - Hydroxyl radical scavenging action, reaching a maximum scavenging efficacy of 92.3% with 5 mL of AgNPs (equal to 100 µg mL^{-1}) in 60 min.	98
Abutilon indicum (family: Malvaceae).	Leaves	Aqueous extract	CuO NP, 16.78 nm	60-1000 µg/mL	*In vitro*	- The concentration of 1000 µg/mL produced the greatest IC_{50} value (84±0.32 µg/mL), whereas 60 µg/mL produced the lowest IC_{50} value (40±0.23 µg/mL). The DPPH radical scavenging activity of the CuO NP at 1000 µg/mL was comparable to that of BHT (standard), with an IC_{50} value of 68±0.29 µg/mL. - In the FRAP assay, 1000 µg of CuO nanoparticles exhibited the highest antioxidant activity of 9.10±0.21 TE/mL. The FRAP values for CuO nanoparticles at doses 500, 250, 125 and 60 µg were 4.57, 2.98, 1.90 and 0.65 g/100g TE/mL respectively.A minimum total phenolic content (19.7±0.21 mg/100 g GAE) was found in 60 µg of methanol concentrate and high proportion of TPC (0.86±0.08 mg/100 g as GAE) was noted in 1000 µg of the methanol concentrate.	99

Physalis angulata (family: Solanaceae).	Leaves	Aqueous extract	AgNP, 35 nm.	0-100 µg/mL.	*In vitro*	- As DPPH radical scavenging activity concentration increased, a greater degree of inhibition of AgNP activity was noted. In this study, 100 µg/mL AgNPs with 85% DPPH scavenging activity showed the maximum level of inhibitory activity. -In the presence of a 100 µg/mL H_2O_2 scavenging concentration, the degree of inhibition for AgNPs and ascorbic acid was found to be 93.31% and 85.35%, respectively. Compared to DPPH scavenging activity, the scavenging activity of H_2O_2 on produced AgNPs exhibited a greater degree of inhibition.	100
Actinidia deliciosa (family: Actinidiaceae).	Fruits	Ethanolic extract	AgNP and AuNP, 25-40 nm (Ag), 7-20 nm (Au).	100-300 µg/mL.	*In vitro*	- The biosynthesized AgNPs and AuNPs demonstrated superior free radical scavenging activity compared to the extract. The DPPH radical scavenging ability rise in a dose-dependent manner. At the minimum concentration of AgNPs (100 µg/mL), the scavenging activity was 43.53±0.45%, which increased to 76.70±0.43% at 300 µg/mL, with an average IC_{50} value of 115.03±0.71. Similarly, the scavenging ability of AuNPs at 100 µg/mL was 46.36±0.50%, rising to 82.66±0.32% at 300 µg/mL, with an average IC_{50} value of 104.61±0.93.	101
Acalypha indica(family: Euphorbiaceae).	Leaves	Aqueous extract	AgNP, 34 nm.	2-8 mg/mL.	*In vitro*	- The DPPH assay demonstrates that the AgNPs have superior antioxidant properties compared to the standard ascorbic acid, with an IC_{50} value of 5 mg/mL compared to the standard's 6-7 mg/mL.	102
Ceropegia candelabrum (Family: Apocynaceae).	Leaves	Aqueous extract	ZnO NP, 12-35 nm	20-100 µg/mL	*In vitro*	-The results of the study showed that as ZnO-NP concentration increased accompanied by the Radical scavenging activity. With an IC_{50} value of 95.09 µg mL^{-1}, the biosynthesized ZnO-NPs demonstrated significant ($p \leq 0.05$) RSA, ranging from 0% to 55.43%. In contrast, the positive control ascorbic acid, demonstrated 75% inhibition at 50 µg mL^{-1}.	103
Lithospermum officinale (Family: Boraginaceae).	Root	Aqueous extract	AgNP, 7 nm.	50-300 µg/mL.	*In vitro*	- The findings showed that the AgNP exhibited higher antioxidant activity when compared to the extract; the IC_{50} values were 79±0.9 and 142±2.1 µg/mL, respectively. - The AgNPs had a greater Total Phenolic Capacity (76.83±0.15 mg/g) than the extract (57.9±0.23 mg/g) and that the TPC and antioxidant capability were positively correlated.	104

Mehani (Polyherbal)*Tinospora cordiofolia, Curcuma longa Trigonella foenum gracum Emblica officinale and Salacia oblonga*	-	Methanolic extract	Ag/Fe NP, 40-60, 60-80 nm	50-250 µg/mL	*In vitro*	- At 250 µg/mL, the scavenging activity was determined to be significant among the investigated concentrations. FeNPs exhibited the highest proportion of 74.5% inhibition, surpassing that of normal ascorbic acid. - In comparison to AgNPs, FeNPs exhibited superior action, with the maximum percentage of inhibition at 250µg/mL (62.65%). The activity of ascorbic acid was slightly higher at 71.11% in nitric oxide scavenging activity. - At 250 µg/mL, the H_2O_2 scavenging activity was significant among these concentrations. Ascorbic acid had the highest activity, followed by FeNPs at 64.75% and AgNPs at 58.6%. -It was found that as concentrations of AgNPS, FeNPs and regular ascorbic acid increased, so did their reducing capacities.	105
Psidium guajava (family: Myrtaceae).	Leaves	Aqueous extract	AgNP, 20-25 nm.	10-120 µg/mL.	*In vitro*	- High radical scavenging activity shown by the synthesized P-AgNPs for both DPPH with (IC_{50} values 52.53±0.31µg/mL) and ABTS (IC_{50} values 55.10±0.29µg/mL).	106
Lenzites betulina(family: Polyporaceae).	Whole plant	Aqueous extract	AgNP, 45-330 nm.	-	*In vitro*	-The antioxidant activity of AgNPs capped with *L. betulina* was significantly increased compared to the raw extract. The enhanced reactivity of silver nanoparticles towards DPPH can be ascribed to their larger surface area-to-volume ratio, which in turn increases the antioxidant activity of AgNPs capped with *L. betulina*.	107
Nepeta leucophylla (family: Lamiaceae).	Roots	Methanolic extract	AgNP, 20 nm.	50-250 µg/mL.	*In vitro*	- Maximum values of 79.41±0.004 in 250 µg/mL for AgNP and 68.29±0.004 in 250 µg/mL for extract were observed for their DPPH radical scavenging capabilities.	108
Thymus Kotschyanus (family: Lamiaceae).	Whole plant	Aqueous extract	AgNP, 50-60 nm.	20-100 µg/mL.	*In vitro*	- When compared to BHT (standard) Ag NPs' DPPH free radical scavenging capabilities show significant suppression. It was demonstrated that increasing the dose-dependent method of Ag NPs biosynthesized by extract increased its free radical scavenging activity.	109
Nervalia zeylanica(family: Ranunculaceae).	Leaves	Aqueous extract	AgNP, 34.2 nm.	12.5-200 µg/mL.	*In vitro*	- DPPH activity was reported to be as follows:The extract and AgNP-NZ have IC_{50} values of 92.83 and 15.20 µg mL^{-1}, respectively. It suggests that AgNP-NZ has a greater capacity for scavenging than the extract.	110
Pueraria tuberosa(family: Fabaceae).	tuber	Aqueous extract	AgNP, 162.72±5.02 nm.	1-40 µg/mL.	*In vitro*	- The AgNPs produced with PTAE exhibited a greater overall antioxidant capacity, as measured by their Copper Reducing Equivalent (CRE), in comparison to PTAE.	111
Pistacia Atlantica(family: Anacardiaceae).	Fruit and leaves	Aqueous extract	AuNP, 40-50 nm.	20-100 µg/mL.	*In vitro*	- AuNPs' DPPH free radical scavenging ability is effectively inhibited when compared to BHT (standard). As demonstrated, increasing the dose-dependent approach led to a rise in the free radical scavenging activity of AuNPs biosynthesised by extract.	112
Thyme(family: Lamiaceae).	Whole plant	Aqueous extract	AuNP, 40 nm.	20-100 µg/mL.	*In vitro*	- The AuNPs' ability to scavenge free radicals using DPPH is effectively inhibited when compared to BHT (Standard). It was demonstrated that synthesized AuNP increase radical scavenging activity in dose dependent way.	113

Calophyllum tomentosum(family: Calophyllaceae).	Leaves	Aqueous extract	AgNP, 24 nm.	10-100 µg/mL.	*In vitro*	- CtAgNPs demonstrated a significant and dose-dependent DPPH activity. As a result, the CtAgNPs shown more inhibition, scavenging 90% of the DPPH as comparable to BHT (standard). - CtAgNPs and ascorbic acid were reported to have values of 83.94 and 79.68%, respectively, of inhibition at 100 µg/mL in H_2O_2 scavenging activity. - The biosynthesized CtAgNPs demonstrated concentrated dependant NO scavenging activity of 78.46% at higher concentrations of 100 µg/mL, which was lower than normal BHT (79.11%). - The reducing power activity (74%) of CtAgNPs is nearly identical to that of normal BHT (83%).	114
Galeopsidis herba (Family: Lamiaceae).	Whole plant	Aqueous extract	CuO NP, 10±5 nm	-	*In vitro*	-Using a DPPH radical assay, the IC_{50} value for biosynthesized CuO nanoparticles was 4.12 µg/mL. The outcome demonstrated that the CuO nanoparticles that were produced have strong antioxidant activity.	115
Acer pentapomicum (Family: Sapindaceae).	Leaves	Aqueous extract	AuNP, 19-24 nm	0-250 µg/mL	*In vitro*	- DPPH radical scavenging activity of AuNP was evaluated at 250 µg/mL which was recorded 96% of its antioxidant activity. This was followed by 93%, 92% and 90% at 125, 100 and 50 µg/mL, respectively.	116
Agaricus bisporus and *Acorus calamus*	Fruiting bodies	Aqueous and methanolic extracts	AgNP, 15 to 25 nm	-	*In vitro*	- The methanolic extract of *A. bisporus* and *A. calamus* demonstrated the highest levels of inhibition, at 19.1% and 66.3%, respectively, whereas the silver nano aqueous extract demonstrated 23.8% and 40% inhibition. -*A. bisporus* and *A. calamus* silver nano extracts were more effective at scavenging DPPH radicals in methanol. As concentration rose, so did the extracts' respective reducing powers.	117
Gymnema sylvestre (family: Apocynaceae).	Whole plant	Methanolic extract	StNP, 19.8 nm.	100 µg/mL.	*In vitro*	- StNPs exhibited the maximum DPPH radical scavenging activity, measuring 74.41±0.54%. Furthermore, it was discovered that the StNPs and standard (ascorbic acid) had IC_{50} values of 66.69 µg/mL and 61.99 µg/mL, respectively, it also exhibited the maximum metal ion chelating activity, measuring 66.71±0.34% and the maximum reducing power of StNPs was revealed to be 0.385±0.002.	118
Vitex negundo(family: Lamiaceae).	Leaves	Aqueous extract	AuNP, 20-70 nm.	20-120 µg/mL.	*In vitro*	- Synthesized AuNPs have the ability to scavenge DPPH radicals, as demonstrated by the results. Scavenging activity reached 84.64% at a measurement of 120 µg/mL and their IC_{50} was visually determined to be 62.18 µg. -The antioxidant capability of synthesized nanoparticles was further demonstrated by the nitric oxide assay findings. The scavenging activity of the nanoparticle reached 69.79% at a measurement of 120 µg/mL and the calculated IC_{50} was 70.45 µg.	119

Berberis aristata(family: Berberidaceae).	Leaves	Aqueous extract	ZnO NP, 20-40 nm.	1-6 µg/mL.	*In vitro*	- The synthesized ZnO NP from extract demonstrated a dose-dependent radical scavenging activity. At a dose of 1 µg/mL, the nanoparticles exhibited 32.06% inhibition, which increased to 61.63% at 5 µg/mL. In comparison, the standard compound, ascorbic acid, showed 42.16% inhibition at 1 µg/mL and 87.76% at 5 µg/mL. Additionally, a clear increase in DPPH activity was observed with increasing concentrations of ZnO nanoparticles.	120
Parkia speciosa(family: Fabaceae).	Leaves	Aqueous extract	AgNP, 35 nm.	10-50 µg/mL.	*In vitro*	- The DPPH assay showed that PAgNPs had a maximal antioxidant activity of 91.83% at 50 µg/mL. The DPPH experiment showed that PAgNPs are powerful radical scavengers, with an IC_{50} value of 15.26 µg/mL.	121
Allium saralicum(family: Amaryllidaceae)	Leaves	Aqueous extract	AgNP, 20-40 nm.	10-1000 µg/mL.	*In vitro*	- The DPPH experiment results showed that the AgNPs had an IC_{50} of 193 μgmL^{-1}, while BHT had an IC_{50} of 384 μgmL^{-1}. AgNPs' ability to scavenge free radicals increased in a dose-dependent way.	122
Brassica oleracea(family: Brassicaceae).	Leaves	-	AgNP, 20 nm.	50-200 µg/mL.	*In vitro*	- DPPH radical scavenging activity showed a dose-dependent pattern. The maximum antioxidant activity (79%), for BO-AgNPs, was seen at a concentration of 200 µg/mL. - Additionally, the IC_{50} value of BO-AgNPs was approximately 50.37 µg/mL, which was equivalent to the IC_{50} value of ascorbic acid, which was 44.10 µg/mL and also antioxidant activity as determined by nitric oxide assay was shown to be effective in the range of 50-81%. At a measurement of 200 µg/mL, BO-AgNPs were shown to have a 70% superoxide radical and a 35-71% hydroxyl scavenging activity.	123
F. sellowiana(family: Myrtaceae).	Leaves	Methanolic extract	AgNP, 20-50 nm.	-	*In vitro*	- Using this approach, the antioxidant activity of Feijoa leaf extract was evaluated and determined to be 80 mg/mL. Compared to their crude extract, SNPs in this investigation shown a greater DPPH-scavenging activity (IC_{50}=51.5 mg/mL). Although the IC_{50} value of BHA as a reference was 59 mg/mL, the synthesized AgNPs have the potential to be used as an effective scavenger of free radicals. -The leaf extract of *F. sellowiana* has been shown to have an iron-chelating activity with an IC_{50} of 240=mg/mL. Fe^{2+} chelating capacity was found in our examined nanoparticles (IC_{50}=214 mg/mL). As a standard, EDTA showed extremely high activity (IC_{50}= 18 mg/mL).	124
Blighia sapida (family: Sapindaceae).	Leaves	Methanolic extract	AgNP, 50-70 nm.	50-150 µg/mL.	*In vitro*	- AgNPs at varying concentrations (50, 75, 100, 125 and 150 µg/mL) significantly reduced the amount of DPPH by 58.10, 59.26, 62.33, 71.24 and 75.42%, in that order. - At 150 µg/mL, the green synthesized AgNPs showed a maximal reducing capability of 53.52%, which is less than ascorbic acid's (70.19%) in reducing power assay. - The AgNPs have a TPC of 36.52 µg/g and a TPC of 10.14 µg/g at 150 µg/mL.	125

Clerodendrum inerme (family: Lamiaceae).	Leaves	Aqueous extract	AuNP, 5.82 nmAgNP, 5.54 nm.	125-1000 µg/mL.	*In vitro*	-The fact that the leaf extract exhibits greater antioxidant strength than the synthetic Ag and AuNPs is interesting. Though they are marginally less potent than BHT, CI-Ag and CI-Au NPs exhibit the 2nd and 3rd greatest levels of antioxidant capacity. - CI-Ag and CI-Au NPs demonstrated % DPPH scavenging 75.85%±0.67% and 78.87%±0.19%.	126
Achillea millefolium (family: Asteraceae).	Whole plant	Aqueous, ethanolic, methanolic extract	AgNP, 20.77, 18.53, 14.27 nm.	10-50 µg/mL.	*In vitro*	-The methanol AgNPs shows a stronger inhibition of DPPH radicals, with an IC_{50} value of 7.03±0.31 µg/mL.	127
Mangifera indica (family: Anacardiaceae).	Seeds	Aqueous extract	AuNP, 19.45 nm.	80-480 µg/mL (DPPH), 160-960 µg/mL (SO), 20-120 µg/mL (ABTS).	*In vitro*	- DPPH, SO and ABTS free radical scavenging activity demonstrated dose-dependent antioxidant activity, the IC_{50} value for DPPH activity was 256 µg /mL, whereas the IC_{50} values for SO and ABTS were 555 µg/mL and 62 µg /mL, respectively.	128
Black currant(family: Grossulariaceae).	Pomaces	Aqueous extract	AgNP, 40-60 nm.	0.1-0.8 mg/mL.	*In vitro*	-The AgNPs formed using BCPE demonstrated a DPPH scavenging activity ranging from 59.1% to 99.6%. The DPPH reducing activity of these AgNPs was evaluated by observing the colour change, which indicated potent scavenging activity. When compared to the standard antioxidant, BHT, the BCPE-AgNPs exhibited stronger DPPH inhibition. The DPPH scavenging activity of the BCPE-AgNPs was high and dose-dependent, with more than 90% inhibition, surpassing the activity of the BCPE alone. Overall, the BCPE-AgNPs exhibited greater antioxidant potential than the BCPE extract.	129
Allium ampeloprasum(family: Amaryllidaceae).	Aerial parts	Aqueous extract	AgNP, 8-50 nm.	18.75-150 µg/mL.	*In vitro*	- This study exhibited the antioxidant effects of AgNPs and extract on the ability to scavenge DPPH radicals. As can be seen, both of them had dose-dependent antioxidant activity. The percentage of inhibition for the extract at its maximum concentration (150 µg/mL) was 32%, but the AgNPs had an 81% value.	130
Cissus vitiginea(family: Vitaceae).	Leaves	Aqueous extract	CuNP, 5-20 nm.	20-120 µg/mL.	*In vitro*	-At various doses, the percentage of inhibition of synthesized CuNP was observed. For extract and CuNP, the maximum inhibition was determined to be 19% and 21%, respectively using DPPH assay.	131
Cestrum nocturnum(family: Solanaceae)	Leaves	Aqueous extract	AgNP, 20 nm	-	*In vitro*	The study found that AgNPs had a higher antioxidant activity (29.55%) compared to vitamin C (24.28%). However, when it came to scavenging hydrogen peroxide, vitamin C showed better results with 65.63% activity, while AgNPs had 45.41%. Similarly, vitamin C had a stronger ability to scavenge superoxide (32%) compared to AgNPs (8%).	132
Cassia obtusifolia(family:Fabaceae)	leaves	Aqueous extract	AgNP, 57.42 nm	25-100 µg/mL	*In vitro*	-When utilizing the DPPH assay, the results demonstrated that AgNP had a better antioxidant activity than extract alone and it increased with increasing concentration. In contrast, extract has a higher reducing power than AgNP.	133

Magnolia champaca (Family: Magnoliaceae)	Flowers	Aqueous extract	CuO NP, 20-40 nm	100-500 µg/mL	*In vitro*	-At high concentrations (500 µg/mL), the highest radical inhibition (76.30%) was reported with GS-CuO produced from extract. However, at '500 µg/mL concentration', ascorbic acid had a little lower activity (66.41%) in comparison to the percentage of DPPH activity. At '500 µg/mL concentration', the ABTS assay revealed a maximal inhibition rate of 88.53% of GS-CuO whereas ascorbic acid demonstrated a somewhat lower inhibitory effect (66.46%).	134
Mussaenda frondosa (family: Rubiaceae).	Leaves	Aqueous extract	AgNP, 30-60 nm.	-	*In vitro*	- Green synthesized AgNPs had 91% DPPH scavenging activity at a concentration of 5 µg/mL, while chemically manufactured ones only show 79% at the same concentration.	135
Ficus carica(family: Moraceae).	Leaves	Aqueous extract	FeO_2 NP, 43-57 nm.	-	*In vitro*	- The DPPH test yielded the antioxidant activity of 1 g of NP, which is equal to 5.14 mg of ascorbic acid. SC_{50} value of DPPH test for nanoparticle is 12.118 mg/mL. -The ORAC method was also used which reveals that 1 g of nanoparticles can scavenge oxygen radicals with an equivalent potency of 7.360 mg of Trolox.	136
Salvia aethiopis (family: Lamiaceae).	Leaves	Aqueous extract	AgNP, 74.09 nm.	-	*In vitro*	- Synthesized AgNPs showed a substantially higher activity (IC_{50}, µg/mL, 24.37) in the DPPH test than the extract (IC_{50}, µg/mL, 45.41). However, neither extracts nor synthesized AgNPs' activities were as high as the standards (BHT). -Synthesized AgNPs showed ABTS scavenging activity with 4.93 (IC_{50}, µg/mL) compared to standards with 8.34 (IC_{50}, µg/mL). -The reducing power activity of Synthesized AgNPs was reported to be 4.52 (µmol TE/mg extract) while the standard BHT value was 488 (µmol TE/mg extract).	137
Vetiveria zizanioides (family: Poaceae).	Whole plant	Aqueous extract	AgNP	10- 50 µL	*In vitro*	- The percentage of inhibition was 46.9% for 10 µL, 56.9% for 20 µL, 61.5% for 30 µL, 67.3% for 40 µL and 72.4% for 50 µL. Consequently, the highest concentration of 50 µL was found to exhibit maximal inhibition.	138
Curcumae Kwangsiensis (family:Zingiberaceae).	Leaves	Aqueous extract	AuNP, 8-25 nm.	0-1000 µg/mL.	*In vitro*	- Examining the DPPH data reveals that they have increased in a way that is dose-dependent. The IC_{50} values for BHT and Au nanoparticles in the antioxidant test were 202 and 153, µg/mL respectively.	139
Cannabis sativa (family: Cannabaceae).	Leaves	Aqueous extract	AuNP, 18.6 nm.	0-1000 µg/mL.	*In vitro*	- The aqueous extract of C. sativa, BHT and AuNPs shown a significant concentration-dependent DPPH radical scavenging property. The *C. sativa* extract, BHT and AuNPs had IC_{50} values of 361, 324 and 196, respectively.	140

Trichoderma harzianum (family: Hypocreaceae).	Whole plant	Aqueous extract	AgNP, 72 nm.	0.20-1.00 mg/mL.	*In vitro*	- According to the study's findings, AgNPs had the highest DPPH scavenging activity when compared to the fungal filtrate. AgNPs' DPPH scavenging activity was measured and its IC_{50} value was 0.79 mg/mL. Gallic acid's IC_{50} value was 0.23 mg/mL. -AgNPs (0.2-1.0 mg/mL) and culture filtrate both had ferric reducing antioxidant powers that rose with concentration, peaking at 1 mg/mL with 66.4% and 73.98%, respectively. At 1 mg/mL, ascorbic acid, the standard, had the highest reduction power of 97.49%. The study's findings showed that, in contrast to filtrate, biosynthesized AgNPs had more FRAP activity.	141
Echinacea purpurea(family: Asteraceae)	Aerial parts	Aqueous extract	AgNP, 68.24 nm.	-	*In vitro*	-The AgNP showed lesser antioxidant activity (IC_{50}, 39.6 µg/mL) in the DPPH scavenging investigation than extract (IC_{50}, 21.9 µg/mL). - The AgNPs demonstrated superior ABTS radical cation scavenging activity, with an IC_{50} measurements of 8.0 mg/mL, outperforming the plant extract, which had an IC_{50} of 10.7 mg/mL. Furthermore, the reducing power of AgNPs was notably greater than that of the extract, with measurements of 2.7 mmol TE/mg extract and 1.71 mmol TE/mg extract, respectively. However, both the extract and the AgNPs showed lower activity compared to the standard references.	142
Catharanthus roseus(Family:Apocynaceae).	Leaves	Aqueous extract	AgNP, 5-40 nm.	-	*In vitro*	-In the DPPH radical scavenging assay, the extract, CrAgNPs and Vitamin C exhibited antioxidant activities of 46.32%, 44% and 63.34%, respectively. For hydrogen peroxide scavenging, the *C. roseus* extract, CrAgNPs and Vitamin C showed scavenging activities of 55.45%, 72.34% and 66.25%. In the hydroxyl radical scavenging assay, the *C. roseus* extract, CrAgNPs and Vitamin C demonstrated activities of 67.45%, 73.20% and 70.25%, respectively. Additionally, in the superoxide scavenging assay, the *C. roseus* extract, CrAgNPs and Vitamin C exhibited activities of 41.45%, 70.42% and 76.25%, respectively. Notably, CrAgNPs exhibited greater reducing power than both the *C. roseus* extract and Vitamin C, highlighting their superior potential in mitigating oxidative stress.	143
Azadirachta indica(family: Meliaceae).	Leaves	Aqueous extract	AgNP, 2-14 nm.	0-10 mg/mL.	*In vitro*	- The free radical scavenging activity of AgNPs was determined at concentrations ranging from 5 mM-9 mM. The results showed that as the concentration of AgNPs increased, their antioxidant effectiveness also enhanced.	144
Tagetes erecta (Family: Asteraceae).	Leaves	Aqueous extract	AgNP, 46.26 nm.	-	*In vitro*	- The IC_{50} values for te-AgNPs were 23.80 µg/mL for DPPH, 4.46 µg/mL for ABTS and 2.79 µmol/mg sample for FRAP, demonstrating strong antioxidant properties.	145
Calendula officinalis (Family: Asteraceae)	Leaves	Aqueous extract	NiO NP, 60.39 nm	0-1000 µg/mL	*In vitro*	-The potential for DPPH free-radical scavenging in extract and NiO NPs in a broad range of doses shown outstanding prevention comparable to that of BHT as a conventional antioxidant agent. The IC_{50} values for BHT, NiO NPs and C. officinalis leaf aqueous extract were 328, 204 and 192 µg/mL, respectively.	146

Atriplex halimus(family: Amaranthaceae)	Leaves	Aqueous extract	PtNP, 1-3 nm.	12.5-50 µg/mL.	*In vitro*	- In the study, when the concentration of At-PtNPs rose from 12.5 to 50 µg/mL, the scavenging % of DPPH increased drastically from 13.77% to roughly 72%. Furthermore, the excellent antioxidant effectiveness of At PtNPs was confirmed by the determination of the IC_{50}, which was 36 µg/mL. When the concentration of the extract grew in the same way as the At-PtNPs concentration, the extract's efficacy improved from 9.83% to 48.35%. Vitamin C, the positive control, demonstrated DPPH scavenging of 14.45%, 31.8% and 47.75% at concentrations of 12.5, 25 and 50 µg/mL, respectively. These results are less than those of At-PtNPs.	147
Ziziphus nummularia(family: Rhamnaceae).	Leaves	Aqueous extract	AuNP, 11-12 nm.	160-960 µg/mL (DPPH), 100-600 µg/mL (SO), 160-960 µg/mL (ABTS), 20-200 µg/mL (RC)	*In vitro*	- Antioxidant activity exhibited by synthesized AuNPs was dose-dependent in all these assays An inhibition of 15-87% was predicted for AuNPs in the concentration range of 160-960 µg/mL, whereas the IC_{50} value of AuNPs was 520 µg/mL.- In superoxide radical assay, an inhibition of 32-76% was anticipated for AuNPs at the concentration range of 100-600 µg/mL, while the IC_{50} value of AuNPs was 330 µg/mL. - In ABTS radical assay, an inhibition of 15-60% was anticipated for AuNPs at the concentration range of 160-960 µg/mL and the IC_{50} value of the synthesized AuNPs was 690 µg/mL.	148
Achillea Nobilis(family: Asteraceae)	Flowering branch	Methanolic extract	CuO NP and ZnO NP, 5.89-24.55 nm and 14-56 nm.	-	*In vitro*	- DPPH activity demonstrated that radical scavenging activity of biologically synthesized ZnO and CuO NPs is higher than chemically synthesized ZnO and CuO NPs but lesser than plant extract.	149
Citrus limetta(family: Rutaceae)	Peel	Aqueous extract	AuNP, 64 nm.	20-100 µg/mL.	*In vitro*	-The findings demonstrated the ability of AuNPs to DPPH scavenging activity, scavenge hydroxyl radical, scavenge H_2O_2 radical, superoxide anion scavenging efficiency, LPO inhibition and ABTS radical scavenging ability rise in dose dependent manner. -A 50% DPPH radical scavenging activity was reported at 51.84µg/mL of AuNP concentration, the scavenging was reported as follows; The standard (vitamin E) and gold nanoparticles have IC_{50} values of 35.5 µg/mL and 45.15 µg/mL, respectively, For NO scavenging activity, gold nanoparticles IC_{50} value was 59.39 µg/mL. The 50% H_2O_2 scavenging activity was detected at 56.58 µg/mL of gold nanoparticle concentration. In terms of superoxide anion scavenging capacity, AuNPs' IC_{50} value was 74.25 µg/mL, The activity of lipid peroxidation inhibition increased as gold nanoparticle concentration increased (20-100 µg/mL). For AuNPs, the IC_{50} value was 39.64 µg/mL and it was discovered that the gold nanoparticles' IC_{50} value was 54.39 µg/mL for ABTS scavenging activity.	150
Citrus limon(family: Rutaceae)	Fruits	Aqueous extract	AgNP, 7-28 nm.	0-100 µg/mL.	*In vitro*	-In DPPH assay, the biosynthesis of AgNP using extract exhibited superior antioxidant activity, with an IC_{50} value of approximately 42.56±0.02 µg/mL, which is significantly better than the plant extract alone, which showed an IC_{50} of 84±0.079 µg/mL.	151

Scoparia Dulcis (family: Scrophulariaceae)	Leaves	Aqueous extract	ZnO NP, 20 nm	10-500 µg/mL	*In vitro*	- In DPPH assay the synthesised ZnO NPs, showed a good IC_{50} value of 1.78 µg/mL, indicating significant antioxidant activity.	152
Morinda lucida (family: Rubiaceae family).	Leaves	Aqueous extract	AgNP, 11 nm.	0.5-1 mg/L.	*In vitro*	- The overall antioxidant capacity of ML-AgNPs was 40% greater than that of the crude extract. The ML-AgNPs' CUPRAC and reducing potential were two times higher than those of the extract. -At doses ranging from 0.25 to 1.0 mg/l, ML-AgNPs inhibited 75-90% of hydrogen peroxide, whereas M. lucida extract inhibited 50-68% of H_2O_2. Hydroxyl ions (OH^-) were not significantly inhibited by the ML-AgNPs. - ML-AgNPs scavenged 50-60% of the Nitric Oxide (NO) at a concentration of 0.25-1.0 mg/l compared to the M. lucida extract - ML-AgNPs' capacity to scavenge free radicals rise In the order $OH^-<NO<H_2O_2$. - Metal chelating activity ML-AgNPs ranges of 23-92, 19-65 and 2.0-47%, respectively.	153
Phoenix dactylifera (family: Arecaceae).	Leaves	Aqueous extract, Ethanolic extract	FeO2 NP, 44-60 nm.	20-100 µg/mL.	*In vitro*	- The acquired results show that the NP produced from the extracts generated from the dried leaves at lower temperatures had the maximum activity. GS FexOy-NPs-T 25°C (H_2O Ext or Ethanol Ext.) generated better scavenging activity. -The IC_{50} NPs/IC_{50} Ext ratio. Values less than 1 indicate that FexOy-NPs have more scavenging activity than the extracts, while values greater than 1 indicate the opposite. -Particularly at lower drying temperatures, the green nanoparticles made from the ethanolic extract produced the highest values of overall antioxidant activity.	154
Glaucium flavum (family: Papaveraceae).	Leaves	Aqueous extract	AuNP, 32 nm.	125-1000 µg/mL.	*In vitro*	-The ability of the GF-Au NPs to capture DPPH free radicals was demonstrated in a dose-dependent manner. At 125 µg/mL of GF-Au NPs, the ability to reduce DPPH by 23% was attained; at 500 and 1000 µg/mL, it increased to 37% and 44%, respectively.	155
Mulberry	Fruit	Methanolic extract	ZnO NP, 25.2 nm.	20-100 mg/mL.	*In vitro*	- ZnO nanoparticles had a maximum 66% capacity to scavenge free radicals. It is evident that concentration of ZnO NP and scavenging activity increase in dose dependent manner.	156
Pelargonium odoratissimum(family: Geraniaceae).	Leaves	Aqueous extract	ZnO NP, 34.12 nm	3.125-100 µg/mL	*In vitro*	- ZnO NPs have antioxidant activity, according to the DPPH assay, with an IC_{50} value of 28.11 µgmL- 1.	157
Cocculus hirsutus(family: Menispermaceae).	Leaves	Aqueous extract	CuNP, 63.46 nm.	50-250 µg/mL.	*In vitro*	- The antioxidant activity of CH-CuNPs increased with higher concentrations. -The percentage of total antioxidant activity ranged from 61%±0.55 to 84%±0.79, with the highest inhibition observed at a concentration of 250 µg/mL, where CH-CuNPs demonstrated 84%±0.79 inhibition.- In terms of hydrogen peroxide (H_2O_2) scavenging activity, CH-CuNPs also showed superior performance compared to extract. At 250 µg/mL, the CH-CuNPs exhibited the highest percentage of free radical scavenging, with an inhibition of around 71%.	158

Zingiber officinale(family: Zingiberaceae)	Roots	Aqueous and Ethanolic extract	AgNP, 2 nm.	-	*In vitro*	- The antioxidant activity of AgNPs generated using ethanol extract was superior to that prepared using water extract for both fresh and dry ginger (p<0.05). -The antioxidant activity was demonstrated by the AgNPs generated utilizing the ethanol extract of dry peeled ginger and it was shown that DPPH scavenging activity was 64.9%, which was superior to BHT's (42.3%) as well as AgNPs produced using an ethanol extract of fresh ginger peel showed 36.2% and when compared to BHT, there was no significant difference.	159
Withania somnifera(family: Solanaceae).	Root	Aqueous extract	CuNP, 6.28±1.13 nm.	25-400 µg/mL.	*In vitro*	- The antioxidant activity of the biosynthesized NP was evaluated using the DPPH assay. At a concentration of 400 µg/mL, the inhibition percentage was found to be 62%, with an IC_{50} value of 51.53 µg/mL.	160
Capparis zeylanica(family: Capparaceae).	Leaves	Aqueous extract	Ag - ZnO NP, 30.63 nm	100-500 µg/mL	*In vitro*	- Ag-ZnO NPs demonstrated a DPPH free radical scavenging activity value of 340 (IC_{50} µg/mL), which is more than that of ascorbic acid, which was found to be 289.74 (IC_{50} µg/mL).- Ag-ZnO NPs and ascorbic acid had hydroxyl radical scavenging capabilities of 344.35 (IC_{50} µg/mL) and 316.10 (IC_{50} µg/mL), respectively.- Ag-ZnO NPs revealed a slightly lower result (0.498) in the reducing power assay than the conventional ascorbic acid (0.511) and a dose-dependent effect was evident in the reducing power for both the nanoparticles and the standard.	161
Linum usitatissimum(family: Linaceae).	Seed	Ethanolic extract	AgNP, 46.98±12.45 nm.	10-100 µg/mL.	*In vitro*	- AgNPs were more effective than extract at scavenging DPPH. Both the extract and the AgNPs boosted their DPPH activity in a dose-dependent manner. At dosages of 10-100 µg/mL AgNPs demonstrated scavenging activity ranging from 17% to 97%, with an average IC_{50} value of 44.56±0.02 µg/mL.	162
Eryngium carlinae (Family: Apiaceae).	Aerial parts	Aqueous extract	AgNP, 10-20 nm.	30 mg/kg b.w, 45 days, orally.	STZ induced male wistar rats	- The administration of the extract and its AgNPs led to a reduction in blood glucose and triglyceride levels. Additionally, they significantly rejuvenated the activity of superoxide dismutase, glutathione peroxidase and electron transport chain complexes in the brain, while also decreasing the production of reactive oxygen species and lipid peroxidation.	163
Crataegus monogyna (Family: Rosaceae).	Fruit	Methanolic extract	SeNP, 30-60 nm.	-	*In vitro*	- After 24 hr, the CMSeNPs and bulk Se concentrations on MCF-7 and fibroblast were raised, which resulted in an increase in TAC. The nanoparticle containing 30 µg/mL had the maximum catalase activity, measuring around 254 nmol/min/mL. -On fibroblast cell lines, bulk Se and CMSeNPs both enhanced catalase activity in comparison to the control group.	164
Tornabea scutellifera(family: Physciaceae).	Whole plant	Aqueous extract	PtNP, 88.7 nm	0-6 mg/mL.	*In vitro*	- It has been observed that PtNPs produced using extract have antioxidant activity against DPPH that is concentration-dependent and the IC_{50} value was found to be 184.06 ug/mL (R2=0.8727).	165

Erioglossum rubiginosum (Family: Sapindaceae).	Seed and leaf	Aqueous extract	CuNP	62.5-1000 µg/mL.	*In vitro*	- The DPPH assay demonstrated that the leaf and seed extracts exhibited strong antioxidant activity, with percentages of 89.4% and 94.2%, respectively. In contrast, the CuNPs showed significantly lower antioxidant activity, with values of 26.1% for the leaf extract and 28.6% for the seed extract.	166
Fumaria officinalis and *Peganum harmala*	Shoots and seeds	Methanolic extract	ZnO NP, 19.55 and 25.10 nm.	50-400 µg/mL.	*In vitro*	- It is evident that antioxidant activity increases along with ZnO NP concentration. The lowest antioxidant activity was seen at the minimum concentrations of ZnO-NP (50 µg/mL) derived from F. officinalis and P. harmala, whereas the maximum concentrations of ZnO-NP (400 µg/mL) demonstrated the maximum antioxidant activity.	167

CONCLUSION

Green-synthesized nanoparticles are emerging as a promising eco-friendly alternative for combating oxidative stress, offering significant antioxidant potential. These nanoparticles, synthesized using plant extracts and microorganisms, provide a sustainable approach to nanotechnology. However, several challenges still need to be addressed. Variability in the composition of natural sources can affect the consistency of nanoparticle size, shape and stability, leading to discrepancies in their antioxidant activity. Additionally, the mechanisms by which these nanoparticles exert their antioxidant effects remain poorly understood, requiring further exploration.

This review highlights the importance of green-synthesized nanoparticles in various applications, from medicine to environmental protection. By leveraging bioactive compounds from plants and microorganisms, these nanoparticles offer a sustainable solution for mitigating oxidative stress-related diseases, aging and environmental pollution. Their eco-friendly nature and versatility make them attractive candidates for future therapeutic and industrial use.

Future research should focus on optimizing synthesis processes to enhance reproducibility and control over nanoparticle characteristics. Greater understanding of their antioxidant mechanisms is needed to advance their biomedical applications. Additionally, *in vivo* studies are crucial to validate their safety and efficacy. Exploring new natural sources could further improve the effectiveness of these nanoparticles, paving the way for their widespread use in pharmaceuticals, food preservation and environmental remediation.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

BHT: Butylated Hydroxy Toluene, **DPPH Assay:** 2,2-Diphenyl-1-Picrylhydrazyl Assay, **NO radical assay:** Nitric Oxide Radical Assay, **SO scavenging activity:** Superoxide Anion Scavenging Activity, **H_2O_2 scavenging:** Hydrogen Peroxide Scavenging Activity, **MDA** - Malondialdehyde, **TEAC:** Trolox Equivalent Antioxidant Capacity, **BHA:** Butylated Hydroxy Anisole, **ABTS:** 2,2'-Azino-bis (3-ethylbenzothiazoline-6 -sulfonic acid), **TPC:** Total Phenolic Content.

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