**Green Synthesis of Nanoparticles from Flower Extracts: Innovative Applications in Floriculture**

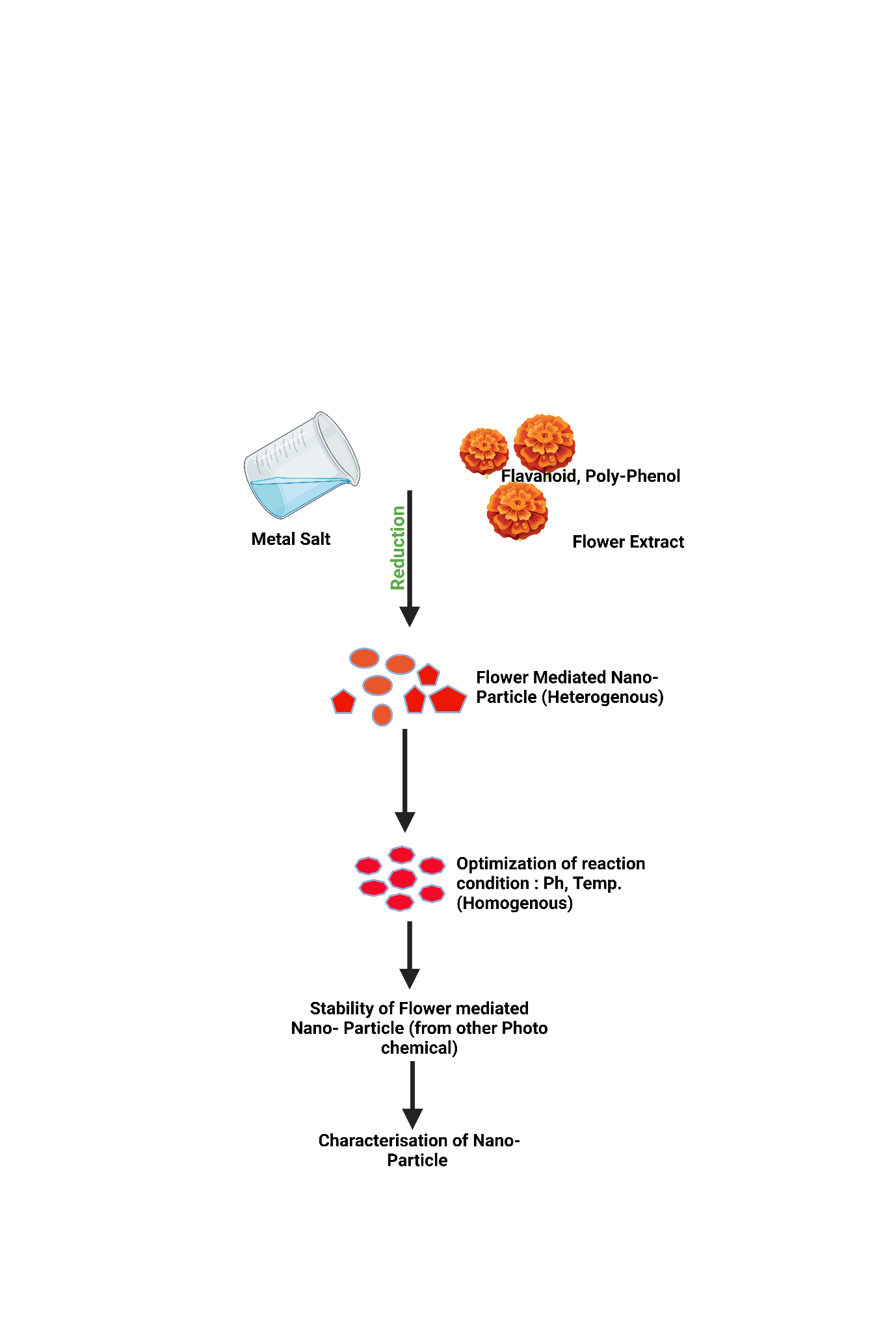
**Abstract**

This review explores about green synthesis of nanoparticles from flower extracts. Green synthesis has gathered significant attention as an environmentally friendly and sustainable approach for the synthesis of a variety of nanomaterials including, metal/metal oxide nanoparticles and bioinspired materials. Flowers are rich in secondary compounds like pigments, volatile molecules which add to fragrance and hold substantial importance predominantly in the context of disease treatment through 'Pushpa Ayurveda' or floral therapy. These phytochemicals from flowers act as efficient reducing and stabilizing agents and offer a unique medium for synthesizing a variety of metal and metal oxide nanoparticles, including gold, silver, copper, zinc, iron, and cadmium. This synthesis process typically occurs at ambient temperatures, making it environmentally friendly and free from the production of toxic by-products. Nanoparticles thus formed can be used to carry ethylene action inhibitors, control the growth and development of microorganisms and to introduce a new generation of packaging material that controls gases and harmful UV rays, while increasing strength, quality and packaging appearance. Furthermore, there are several examples of nanoparticles extracted from bougainvillea that are used in cosmetic industries, in the field of biomedical science, silver NP synthesized from *Hymenocallis littoralis* exhibits strong antimicrobial properties, making them useful in treating infections and enhancing the effectiveness of antibiotics. Gold nanoparticles derived from *Hibiscus rosa-sinensis* are utilized in targeted drug delivery and photothermal therapy for cancer treatment. Thus, Flower-derived nanoparticles find applications in biomedical science, offering health benefits, nanoencapsulation, prolonged vase life for cut flowers, packaging, and diverse uses in various fields.

**Keywords:** Pushpa ayurveda, green synthesis, nanoparticle, flower extract, ornamentals

**Introduction**

“The growing use and applications of nanoparticles have drawn the attention of scientists of different fields. On the basis of their formation, they can be grouped into two types: natural and anthropogenic nanoparticles (NPs). Natural NPs are formed due to natural processes such as erosion and volcanic eruptions, whereas synthetic NPs are made by different processes such as mechanical ball milling techniques, mechano-chemical methods, etching techniques, sputtering, laser ablation, inert gas condensation, chemical vapor synthesis, electrochemical deposition of nanomaterials, chemical precipitation, sol-gel synthesis, sonochemical synthesis, solvothermal decomposition of metal complexes, microwave synthesis, biological synthesis, etc” (Kandiah and Chandrasekaran, 2021;Gupta et al., 2024).  “Nanotechnology is the art and science of manipulating the matter at nanoscale and it can be defined as the design, characterization, production and application of structures, devices and systems by controlling the shape and size at the nanometre scale. Nanotechnology can be a very useful technology in horticulture and particularly in the floriculture industry, with many applications at all stages of product development, handling, storage, packaging and transport of flowers” (Mousavi and Rezai, 2011). “Around 20-80% of flowers are lost due to improper handling practices from harvest to till it reach to consumer. Nanoparticles and nano-porous materials can be used to carry ethylene action inhibitors, control growth and development of microorganisms and to introduce a new generation of packaging material that controls gases and harmful UV rays, while increasing strength, quality and packaging appearance. Nanoencapsulation of biocontrol agents enhances their effectiveness against pest and diseases, and nanogenomices to develop resistance to pest and diseases” (Sarmast and Salehi, 2016; Soriano *et al*., 2018; Ghidan and Antary, 2019; Zahedi *et al*., 2020). For green synthesis of nano-sized components both microbes and plant mediated approaches are in practice. In the synthesis involving microbes, the in-built sophisticated biochemical mechanisms are put into action for reducing of the ions into nano-sized particles, it often leads to well-defined nanoparticles varying in compositions, shapes and sizes accordingly. But when a large scale production is in question, the synthesis involving microbial preparations is challenging. But this could easily be tackled by using plant based extracts for synthesis, where the production rate could be significantly amplified (Thakur et al., 2023; Niveditha et al., 2024).

**Properties of nanoparticles** The more compact the system is, the more evident several physical phenomena become. These include quantum mechanical and statistical mechanical effects, such as the "quantum size effect," which modifies the electrical characteristics of solids at significantly smaller particle sizes. The transition from macro to micro dimensions has no bearing on this effect. However, when the so-called quantum realm—the nanoscale size range—is reached, usually at distances of 100 nanometers or fewer, quantum phenomena take center stage. Furthermore, in comparison to macroscopic systems, a variety of physical (mechanical, electrical, optical, etc.) properties are altered. One illustration is how a material's mechanical, thermal, and catalytic properties might change when its surface area to volume ratio increases. Nanoscale diffusion and reactions, materials, and nanostructures and Nanoionics is the broad term for nanodevices having rapid ion transport. Research in nanomechanics is interested in the mechanical properties of nanosystems. When nanoparticles interact with biomaterials, there may be dangers because of their catalytic activity. Nanoscale materials can display distinct features from their macroscale counterparts, opening new application possibilities (Ahmad *et al*., 2003). “For example, stable materials become flammable (aluminium), opaque substances become translucent (copper), and insoluble materials become soluble (gold). At nanoscales, a substance like gold, which is chemically inert at normal scales, can act as a powerful chemical catalyst. Many of the quantum and surface phenomena that matter displays at the nanoscale are the source of great intrigue for nanotechnology systems. Most of the quantum and surface phenomena that are relevant displays at the nanoscale are the source of great intrigue for nanotechnology systems. To create nanomaterials with a particular shape, size, and function, two basic approaches—the top-down and bottom-up approaches—can be used to create nanoparticles” (Singh *et al*., 2018). The first approach involves the production of nanomaterials and nanoparticles using a variety of processes, including lithographic procedures, sputtering, etching, and ball milling (Cao, 2004). On the other hand, the bottom-up approach commonly employed for nanoparticle synthesis typically utilizes potent reducing agents (like hydrazine and sodium borohydride), along with a capping agent and a volatile solvent such as chloroform and toluene. These techniques prove effective in producing precise and pure metallic nanoparticles.

**Green synthesis of NPs**

The green synthesis process relies on factors like plant extract, pH, and temperature, while stability is crucial for application efficacy. The green synthesis of various metal nanoparticles, including Au, Ag, Pd, and Cu, involves reducing metal ions using plant extracts or microbial agents. These nanoparticles find applications in catalysis, medicine, and antimicrobial studies, highlighting their broad potential in various fields. Several techniques have been established for the synthesis of nanoparticles. The three main categories of these methods are chemical, physical, and biological operations. In any case, because of its simplicity, safety, and affordability, the biological process is the most suitable for creating NP. Since NPs are

**Figure 1: Extraction process of Nanoparticle**

required in areas where humans are directly involved, it is currently imperative to develop sustainable procedures and methodologies including nanoparticles (Shams *et al*., 2013). We may create safe NP usage strategies by learning about green and sustainable technologies, which can be categorized under the following five approaches namely Tollens, Irradiation, polyoxonetalates and polysaccharide method.

**Polysaccharide method**

An example of biological applications for environmental sustainability is the green synthesis of AgNPs by the use of the polysaccharide technique (cellulose). The shoots and roots of the water hyacinth (biological uses) have a high percentage of cellulose. The plant's shoot or roots were used to extract cellulose, which was then employed as a reducing and stabilizing agent. Additionally, the pH of the solution and the reaction time were adjusted to control the size and form of the particles (Mochochoko *et al*., 2013).

**Gold nanoparticles (Au NPs)**

“Green production of Au NPs involves reducing gold ions using reducing agents sourced from plant extracts or microorganisms. The extracts are produced by soaking ground plants in solvents (ethanol, water) in a suitable atmosphere. When the extracts are added to a gold ion solution, the mixture turns red, resulting in the formation of Au NPs” (Tharishini *et al*., 2014; Jafarizad *et al*., 2015; Kumar *et al*., 2019). This method was used to convert chloroauric acid to Au NPs using extracts from Cassia auriculate leaves (Tharishini *et al*., 2014). The concentration of chloroauric acid influences the green production of gold nanoparticles.

**Silver nanoparticles (Ag NPs)**

The standard green synthesis method for producing silver nanoparticles (Ag NPs) involves combining silver nitrate solution with reducing agents derived from plant extracts. This procedure, akin to the one described for gold nanoparticles (Au NPs), includes obtaining extracts from plants following established protocols. These extracts, derived from plants like Tephrosia purpurea leaf powder or grass wastes (e.g., hay), are mixed with silver nitrate solution. The synthesis is confirmed when the solution changes to a brownish color, as reported by various studies (Khatami *et al*., 2018; Hemmati *et al*., 2019; Rautela *et al*., 2019; Rahimullah Shaikh and Bhend, 2019; Yu *et al*., 2019).

In one specific instance, Tephrosia purpurea leaf powder is mixed with Milli-Q water and heated to 60 °C for 15 minutes. The resulting solution containing Ag NPs is then obtained by filtering, adding silver nitrate, and centrifuging (Ajitha *et al*., 2014). Another study by Khatami *et al*., (2018) details the synthesis of Ag NPs using grass wastes (e.g., hay). In this case, the hay is washed, disinfected, and then subjected to boiling and filtering to obtain the extract. This extract is subsequently mixed with various concentrations of silver nitrate to produce Ag NPs.

The shapes and sizes of the green-synthesized Ag NPs vary, with the most common forms being spherical, triangular, and hexagonal, as reported in studies by Ping *et al*., (2018), Kumar *et al*., (2017b), and Arokiyaraj *et al*., (2017).

**Palladium nanoparticles (Pd NPs)**

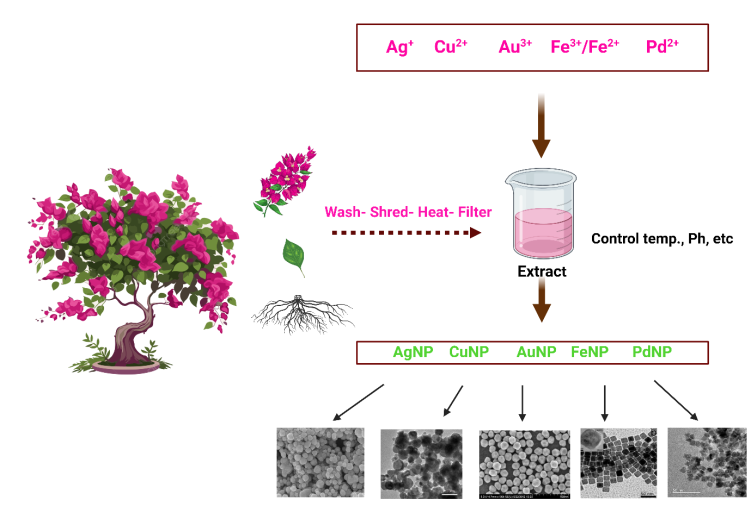
Palladium is a valuable and dense metal, and researchers have successfully generated palladium nanoparticles (Pd NPs) using leaf extracts from *Filicium decipiens* (Sharmila *et al*., 2017). Other materials, such as black tea leaves, *Lithodor ahispidula* leaf, Rosa canina fruit, and *Sapium sebiferum* leaf, have also been employed for Pd NPs synthesis in separate studies (Lebaschi *et al*., 2017, Turunc *et al*., 2017, Veisi *et al*., 2016, Tahir *et al*., 2016). Bentonite/Cu NPs exhibit recyclability up to five times without a loss of activity. Euphorbia granulate leaf extraction has been found to offer a shorter synthesis time, with optimal parameters reported at 80 °C, 20 minutes reaction time, and a 20% dilution ratio (Nasrollahzadeh and Mohammad Sajadi, 2016). The phenolic compounds present in Euphorbia granulate leaves have been identified as potential agents preventing the oxidation of Pd NPs. Additionally, these phenols do not induce agglomeration in copper nanoparticles, as reported by researchers.

**Copper nanoparticles (Cu NPs)**

Due to copper (Cu) being a member of the light transition metals group, direct generation of copper nanoparticles (Cu NPs) from simple copper salts is typically unfeasible. Capping agents, such as surfactants, are necessary to regulate particle size, as highlighted by Shende *et al*., (2015). Plant extracts, including those from *Thymus vulgaris* L., Eucalyptus sp., *and Ginkgo biloba* Linn., have been employed for the synthesis of Cu NPs (Edison *et al*., 2016, Nasrollahzadeh and Mohammad Sajadi, 2015, Issaabadi *et al*., 2015). Aloe Vera flowers have also been utilized in the process, with the protein from the flower coating the particle surface to facilitate Cu NPs synthesis (Karimi and Mohsenzadeh, 2015). Additionally, *Azadirachta indica* leaf extract and *Callistemon viminalis* flower extracts were used for the synthesis of CuO NPs (Rajendaran *et al*., 2019).

Cu NPs, produced through environmentally friendly processes, exhibit a zeta potential of -26 mV, indicating relative stability (El-Saadony *et al*., 2020). Shobha *et al*., (2014) found that Cu NPs demonstrate superior antibacterial activity compared to silver, causing damage to vital proteins.

Green synthesis offers numerous advantages over chemical and physical methods, being non-toxic (Devi *et al*., 2019), pollution-free (Alsammarraie *et al*., 2018), environmentally friendly, economical (Kataria and Garg, 2018), and more sustainable. However, challenges exist in terms of raw material accessibility, reaction speed, and the homogeneity of the end product. Raw materials may not be easily obtainable, the synthesis process can be time-consuming (Subramaniyam *et al*., 2015), and achieving uniform particle size poses a challenge (Gao *et al*., 2016).



**Figure 2: Different nanoparticles that can be extracted from single ornamental plant parts**

**Applications of nanoparticles**

**Medicinal use**

Nanoparticles, particularly those derived from metals like gold and silver, have garnered significant interest in the medical field. Silver nanoparticles (Ag NPs), known for their potent antimicrobial properties, find application in antibacterial coatings and wound dressings. Nanoparticles, including iron oxide and gold nanoparticles (Au NPs), play a crucial role as contrast agents in medical imaging techniques such as computed tomography (CT) and magnetic resonance imaging (MRI), enhancing tissue visibility and aiding in early disease detection. Moreover, nanoparticles offer targeted drug delivery, improving treatment efficacy while minimizing side effects by delivering medicinal drugs specifically to target cells or tissues. In the realm of cancer therapy, nanoparticles, including gold and iron oxide, hold promise for targeted medication delivery, photothermal therapy, and tumor imaging. These nanomaterials exhibit antioxidant and anti-inflammatory qualities and show potential in treating neurodegenerative diseases by assisting therapeutic agents in crossing the blood-brain barrier.

Furthermore, tailored nanoparticles provide opportunities for gene delivery, contributing to advancements in gene therapy and the treatment of genetic conditions. Despite these promising applications, ongoing research in the field of nanomedicine focuses on understanding the long-term effects, safety, and biocompatibility of nanoparticles in medical contexts. Au NPs are also widely used in the medical industry. Au NPs have high surface compatibility and

**Table 1: Summarized list of ornamental plants used for extraction of nanoparticles**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Plants used** | **Nano particle** | **Plant part used** | **Properties** | **Reference** |
| Pedilanthus tithymaloides | AgNP | Latex | Antibacterial | [Patil *et al*., (2012)](https://www.sciencedirect.com/science/article/pii/S187881811931299X#bib101) |
| Cycas | AgNP | Leaf | Antioxidant | [Jha and Prasad (2010)](https://www.sciencedirect.com/science/article/pii/S187881811931299X#bib59) |
| Melia azedarach | AgNP | Leaf | Antitumor activity | Sukirtha  *et al*., 2011 |
| Nelumbo nucifera | AgNP | Leaf | Larvicidal activity against malaria and filariasis vectors | [Santhoshkumar  *et al*., (2011)](https://www.sciencedirect.com/science/article/pii/S187881811931299X#bib123) |
| Azadirachta indica | AgNP | Leaf | Antimicrobial | [Gavhane  *et al*., (2012)](https://www.sciencedirect.com/science/article/pii/S187881811931299X#bib42) |
| *Hibiscus rosa sinensis* | AgNP | Leaf | Fish pathogen A. hydrophila | [Philip (2010)](https://www.sciencedirect.com/science/article/pii/S187881811931299X#bib104) |
| Hibiscus subdariffa | ZnONPs | Leaf | Antibacterial and Antidiabetic | [Bala  *et al*., (2015)](https://www.sciencedirect.com/science/article/pii/S187881811931299X#bib10) |
| *Aloe barbadensis* | ZnONPs | Leaf | Cosmetics | Sangeetha  *et al*., (2011) |
| *Nyctanthes arbor-tristis* | ZnONPs | Flower | Antifungal | [Jamdagni  *et al*., (2018)](https://www.sciencedirect.com/science/article/pii/S187881811931299X#bib55) |
| *Azadirachta indica* | ZnONPs | Leaf | Antimicrobial | [Elumalai and Velmurugan (2015)](https://www.sciencedirect.com/science/article/pii/S187881811931299X#bib35) |
| *Uvaria narum* | Ag NP | Leaf | Antibacterial, Antiangiogenic, Anticancer | Anthyalam  *et al*., (2023) |
| *Zephyranthes candida* | Ag NP | Flower | anti-inflammatory, anti-diabetic, anti-oxidant, anticancer | Kaliammal  *et al*., 2021 |
| *Passiflora  caerulea* | ZnONPs | Leaf | Antibacterial | [Santhoshkumar  *et al*., (2017)](https://www.sciencedirect.com/science/article/pii/S187881811931299X#bib122) |
| *Withania coagulans* | Ag NP | Leaf | Antioxidant, anticancerous | Tripathi  *et al*., (2019) |
| *Ocimum Tenuiflorum and Calotropis Gigantea* | TiO2 | leaf | - | Reddy  *et al*., (2019) |
| *Cassia angustifolia* | Ag NP | flower | Antioxidant | Bharati  *et al*., 2018 |
| *Tagetes erecta* | Ag NP | flower | Antibacterial | Padalia  *et al*., 2014 |

can adsorb a variety of biomolecules, which could provide a greater efficacies for clinical medicine ([Lee *et al*., 2020](https://www.sciencedirect.com/science/article/pii/S2352186422000359#b76)). In order to assist treat diseases, including cancer, Au NPs are utilized, for instance, as a transporter of bioactive compounds such anticancer medicines (Kumari and Meena, 2020). Green synthesis of gold nanoparticles from *Lawsonia inermis* and its catalytic activity following the Langmuir-Hinshelwood mechanism. Physicochemical and Engineering Aspects of Colloids and Surfaces A: 606, 125447. Palladium is a valuable metal with a high density. It is frequently employed as a catalyst, biosensor, and in medical diagnostics (Nasrollahzadeh and Mohammad Sajadi, 2016). It can boost yield and effectively catalyze a variety of chemical processes. The production of Pd NPs has been thoroughly investigated because of its unique ligand-free catalysis (Siddiqi and Husen, 2016). According to Sharmila et al., “steroids, alkaloids, phenolics, flavonoids, saponins, and [tannins](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/tannin) present in leaves extract serve as reducing and stabilizing agents” ([Sharmila *et al*., 2017](https://www.sciencedirect.com/science/article/pii/S2352186422000359#b131)).

The biogenic production of plant-derived nanoparticles (NPs), with a spotlight on their potential as eco-friendly sustainable catalysts, is a major topic of study in the field of plant research, and their potential uses are recently being studied in nanocatalysis research. The biogenic synthesis of NPs from plants appears as a viable and effective strategy to create quick and efficient technologies and, yet, it has seldom been studied. Such NPs are well-suited for a range of biological applications because of their notable antioxidant, antibacterial, and antimicrobial activities. Some of these are also utilized as medications in healthcare, or their structural characteristics have served as a model for the synthesis of more potent synthetic pharmaceuticals. Increasing the synthesis of these secondary metabolites may be accomplished in various ways, one of which is by using nanoparticles that act as elicitors. Nevertheless, nanoparticles may offer various additional advantages for medicinal and aromatic plants, such as accelerated plant development, enhanced photosynthetic efficiency, and general performance, depending on the precise particle size, composition, concentration, and application method. Acknowledging these applications, the current review delved the updated information on exploring the medicinal plants used in NP synthesis.

The suggested mechanisms of action of NPs on the modulation of plant secondary metabolism and biomedical applications are also discussed. This highlights that a deeper study to understand the intricate complexities involved in NPs action is essential.

Silver nanoparticles (AgNPs) made by green synthesis offer a variety of biochemical properties and are an excellent alternative to traditional medications due to their low cost. In the current study, we synthesised AgNPs from the leaf extract of the medicinal plant *Uvaria narum*, commonly called narumpanal. The nanoparticles were characterised by ultraviolet-visible (UV-Vis) spectroscopy, Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) and transmission electron microscopy (TEM). SEM analysis showed that AgNPs are highly crystalline and spherical with an average diameter of 7.13 nm. The outstanding catalytic activity of AgNPs was demonstrated by employing the reduction of 4-nitrophenol to 4-aminophenol. The AgNPs showed antiangiogenic activity in the chick chorioallantoic membrane (CAM) assay. AgNPs demonstrated anticancer activity against Dalton’s lymphoma ascites cells (DLA cells) in trypan blue assay and cytotoxicity against three fish cell lines: Oreochromis niloticus liver (onlL; National Repository of Fish Cell Lines, India (NRFC) Accession number—NRFC052) cells, *Cyprinus carpio* koi fin (CCKF; NRFC Accession number—NRFC007) cells and Cyprinus carpio gill (CyCKG; NRFC Accession number—NRFC064). Furthermore, the AgNPs demonstrated their ability to inhibit pathogenic microorganisms, *Staphylococcus aureus*, and Escherichia coli. The results from the study displayed green synthesised AgNPs exhibit antiangiogenic activity, cytotoxicity, and antimicrobial and catalytic properties, which are crucial characteristics of a molecule with excellent clinical applications.

“Silver nanoparticles (AgNPs) have great potential for their mechanistic role in biomedical researches. Recently, green biosynthetic approaches have received much attention in plant science for nanoparticles production. Therefore, in the present study AgNPs have been synthesized utilizing in-vitro grown leaf extract of anti-diabetic medicinal plant *Withania coagulans* Dunal by the reduction of silver nitrate solution. *W. coagulans* synthesized silver nanoparticles (WcAgNPs) were characterized by UV–visible spectroscopy, scanning electron microscopy, energy dispersive X-ray analysis, transmission electron microscopy, X-ray powder diffraction and Fourier transform Infrared spectroscopy. All cumulative results showed that WcAgNPs were ~14 nm in size having spherical shape with face centred cubic structure. High-performance liquid chromatography confirmed the involvement of withanolides in AgNPs synthesis as a reducing/capping agent. Synthesized WcAgNPs showed greater antioxidative potential when compared with *W. coagulans* leaf extract. WcAgNPs have efficient antimicrobial potential and suppress the growth of both gram positive and gram-negative bacteria. In our finding, we also observed cytotoxicity of WcAgNPs against SiHa (cervical cancerous, hyper-triploid) cell lines and apoptosis in SiHa cells after 48 hour incubation with 13.74 μg ml−1 (IC50) concentration of WcAgNPs. As results suggested, this is the first report which explains that *W. coagulans* leaf extract have potential as bio-reducing agent for the synthesis of silver nanoparticles, which can be exploited as an anti-oxidant, antimicrobial and anti-cancerous agent and depicts an effective way for utilizing bioactive resources in the restoration of medicinal properties of this plant with high efficacy” (Tripathi *et al*., 2019).

“The flower like TiO2 nanoparticles have been identified as potential electrode material for efficient next-generation electrochemical energy storage devices. The present work reports, a novel green approach to synthesize high surface area TiO2 nanoparticles using medicinal plant leaf extracts namely *Ocimum Tenuiflorum* Plant and Calotropis Gigantea Plant. The TiO2 nanoparticles synthesized using Calotropis Gigantea plant confirmed rutile phase from X-ray powder diffraction and Raman spectra. The fourier transform infrared spectroscopy spectra of the sample indicate the presence of TiO2 vibrational bonds. The field emission scanning electron microscopy images revealed the flower-like shape of nano-granules with an average granule size of 200 nm. The presence of Ti and O elements was qualitatively confirmed using energy dispersive spectroscopy spectra, which shows the good stoichiometry in the sample. The flower-like shapes with nano petals were further disclosed with the help of high resolution transmission electron microscopy. The corresponding optical band gap was observed to be 3.0 eV. The electrochemical investigations of the sample exhibited a high specific capacitance of 224 F g-1 at 0.5 A g-1 with 71% of capacitive retention after 5000 cycles”.( Reddy *et al*., 2019)

**Therapeutic use**

Nanoparticles, both natural and artificial, have been proposed as carriers for drugs in cancer treatment due to the fact they may boost the therapeutic effect by increasing drug accumulation in target tissues.(Zocchi *et al*., 2020).

**Extending post-harvest life**

To meet the demands of consumers, countries worldwide are fiercely competing for cut flowers, and the quality of post-harvest flowers is a crucial factor in the competitive dynamics of the global flower market. The industry has faced significant challenges due to the limited vase life of flowers, leading to substantial waste in fresh-cut and loose flowers. Flowers such as tulips, carnations, gerberas, orchids, lilium, and anthurium, among others, are particularly vulnerable to ethylene, a primary factor contributing to the reduction in their vase life (Naing and Kim, 2020). The decrease in the vase life of cut flowers is primarily attributed to microbial infection, specifically bacteria causing stem blockage at the cut end, vascular occlusion, and physiological injuries. Other factors influencing the reduction in postharvest life include water imbalance, depletion of carbohydrate reserves, and ethylene synthesis (Carrillo-López *et al*., 2016). The use of nanoparticles has emerged as an innovative solution to extend the vase life of cut flowers by combating key adversaries in the floriculture sector, including bacteria, fungi, and ethylene. Nanoparticles, with sizes less than 100 nanometres, are effectively employed in nanocomposites to address various challenges in the flower industry, such as reducing product waste, enhancing packaging materials, managing plant diseases, and protecting stored products from harmful gases and sunlight (Manzoor *et al*., 2020).

This application of nanoparticles has proven to improve the durability of packaging materials, leading to a 20–30% reduction in waste in the supply chain (Manzoor *et al*., 2020; Yadollahi *et al*., 2010; Ruffo *et al*., 2019). For instance, silver nanoparticles (SNPs) synthesized from Mexican tea (*Chenopodium ambrosioides* L.) have been shown to promote flower opening and extend the vase life of chrysanthemums (*Dendranthema grandiflora*) by combating bacteria and ethylene (Carrillo-Lopez *et al*., 2016). “Similarly, SNPs synthesized from betel leaves (*Piper betle*) have retained the vase life of gladiolus (*Gladiolus grandiflorus*) by acting as a bactericide and a signalling molecule that scavenges reactive oxygen species (ROS) to reduce lipid peroxidation and maintain membrane stability” (Maity *et al*., 2019). “The synthesis of SNPs from lasia (*Lasia spinosa*) extract has maintained membrane stability index and total soluble solids (TSS) while suppressing bacterial proliferation in cut rose stems” (Aier *et al*., 2017). “The biological synthesis of SNPs offers numerous advantages, including stable production with controlled shape and size, along with rapid synthesis, making it a cost-effective technique conducted at ambient temperature and pressure, which is faster than other methods” (Singh *et al*., 2016; Tran and Le, 2013).

**Table 2: Different type of nano particles used in enhancing the vase life of flowers**

|  |  |  |  |
| --- | --- | --- | --- |
| S.No. | Name | Used for | Mechanism |
| 1 | Silica Nanoparticles (SiNPs) | water use efficiency, water translocation, and relative water content, contributing to prolonged flower life | ability to penetrate plant tissues  have a high surface-to-volume ratio, which allows them to efficiently interact with plant structures |
| 2 | Silver Nanoparticles (AgNPs) | antimicrobial properties | Their application in floriculture aims to reduce microbial contamination in vase water |
| 3 | Zinc Oxide Nanoparticles (ZnO NPs) | enhancing plant growth and stress tolerance. | contribute to improved water uptake and nutrient absorption, promoting overall flower health and longevity |
| 4 | Carbon Nanotubes (CNTs) | maintaining proper water balance in cut flowers | unique structural and mechanical properties, have been investigated for their role in improving water transport within plant tissues. |
| 5 | Copper Nanoparticles (CuNPs) | antimicrobial properties | contribute to maintaining water quality by reducing microbial contaimination |

Nanomaterial-based sensors play a significant role in the postharvest management of climacteric fruits like apples and peaches, as well as in the food industry, particularly in the packaging of vegetables (Cristescu *et al*., 2012). In the context of cut flowers, the application of nano-sensors has the potential to enhance vase life by enabling the continuous monitoring of ethylene concentrations in storage areas of major growers and wholesale markets. However, a comprehensive cost-benefit analysis is imperative to assess whether the additional expenses associated with nano-sensor implementation would be justified by the prolonged vase life observed across diverse flower species and within specific market conditions.

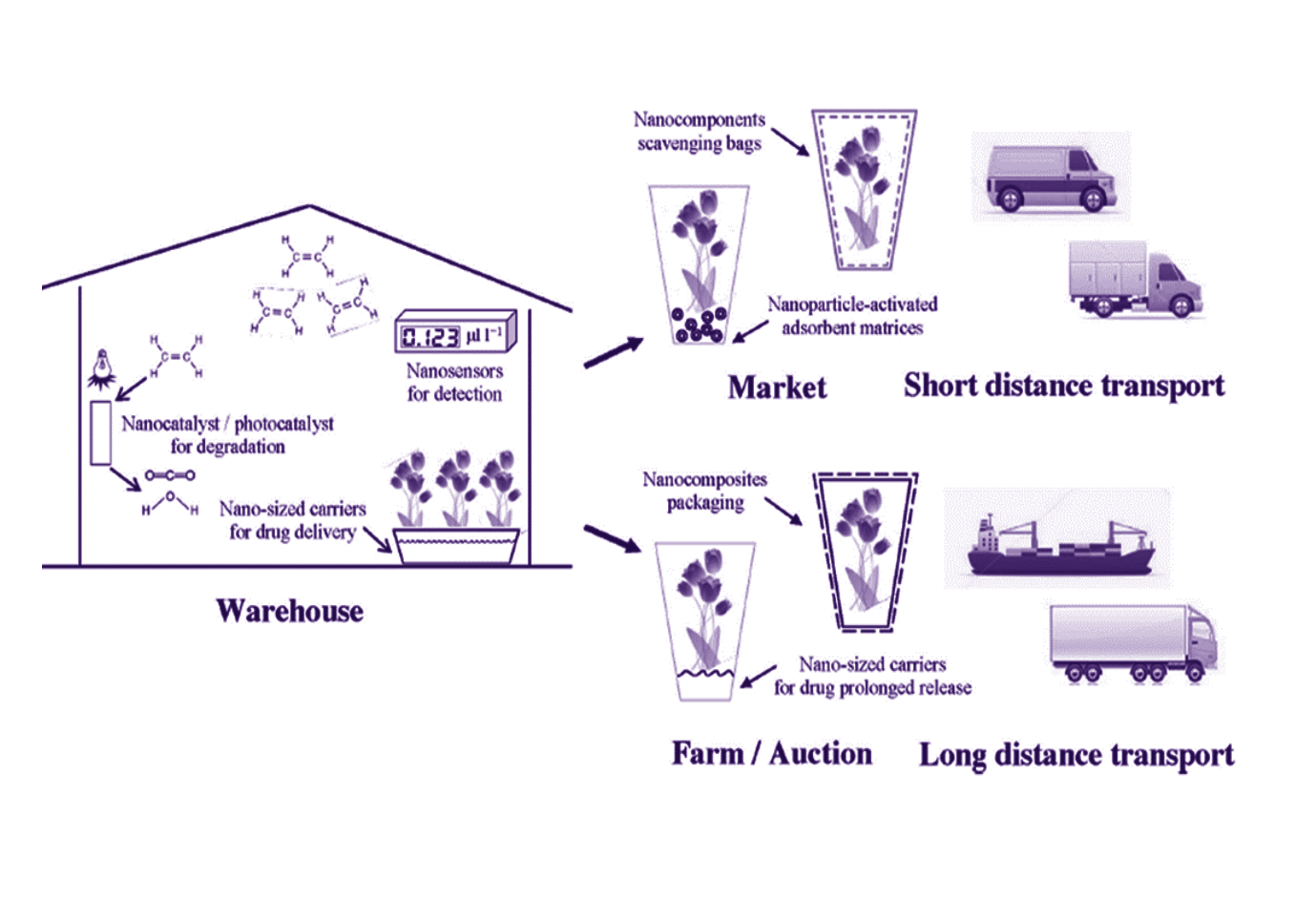
Nano-sized silver (Ag+) particles (NS) find extensive use as antimicrobials in various applications (Furno *et al*., 2004). “Leveraging their high surface area-to-volume ratio, NS are deemed more effective in preventing the growth of bacteria and microorganisms compared to other oxidation states of silver. NS release Ag+” (Lok *et al*., 2007), “which has been reported to interact with cytoplasmic components and nucleic acids, inhibit respiratory chain enzymes, and disrupt membrane permeability” (Russell and Hugo, 1994; Park *et al*., 2005). “While relatively new in the context of pulse and vase solution treatment for cut flowers, studies have explored the efficacy of NS in extending the vase life of various flowers, such as carnations, gerberas, acacias, and roses” (Moradi *et al*., 2012; Nazemi Rafi and Ramezanian, 2013). The observed positive impact of NS pulse treatment is attributed to the inhibition of bacterial growth in the vase solution and at the cut stem ends.

**Table 3: List of nanoparticles extracted from different spp. of flowering/foliage plants and their impact**

|  |  |  |  |
| --- | --- | --- | --- |
| **Species** | **Treatments with optimal concentration** | **Impact** | **Reference** |
| Alstomeria | NS (10 mg L−1 ) | Reducing bacterial growth and improving water uptake | Ershad Langroudi *et al*., (2020) |
| *Anthurium andreanum* | NS (10 mg L−1 ) | Reducing bacterial growth and improving water uptake | Amin (2017) |
| Alstroemeria (*Alstroemeria aurea*) | Vase solution 15 mg L-1 | Improved floret diameter and flower fresh weight | Alimoradi *et al*., (2013) |
|  | Vase solution 4 mg L-1 | improved anthocyanin content in flower petal | Moradi *et al*., (2012) |
| chrysanthemum (*Chrysanthemum morifolium* L | NS 5mg | decreases water stress and increased vase life, reduce stem bacteria | Sedigheh Kazemipour *et al*., |
| gerbera (*Gerbera jamesonii* cv. ‘Dune’) | NS 5 mg L−1 | Improved Relative Fresh Weight | Solgi *et al*., 2009 |
| *Gerbera jamesonii* cv. 'Balance' | NS 5 mg L−1 | antimicrobial property and delayed senescence in cut gerbera | Safa *et al*., 2015 |
| Gladiolus | NS 4 mg L−1 | maintain spikes fresh and dry weight, reduce the vascular blockage, improve the antioxidative defense, and stabilize the membrane integrity that leads to delay senescence | Maity *et al*., 2019 |
| *Rosa Hybrida* L. | SiNP 2 mg | maximized the longevity by reducing lipid peroxidation | R.S. El-Serafy 2019 |
| *Gerbera jamesonii* | ZnO-NP | increase the shelf life of cut flowers, antimicrobial | Gupta *et al*., 2018 |
| Roses var. Taj Mahal | NS 50 ppm | Improved water uptake, reduced transpirational loss, reduced bacterial growth | Amingad *et al*., 2017 |
| Carnation | NS (5 or 10 mg L−1 ) + GA3 (5 or 10 mg L−1 ) + BA (80 mg L−1 ) | Increased water intake | Hamidimoghadam *et al*., (2014) |
| Carnation | NS (40 mg L−1 ) | Reduced bacterial growth and ethylene production | Xia *et al*., (2017) |
| Carnation | NS (15 mg L−1 ) | Inhibited microbial growth | Hashemabadi (2014) |
| Carnation | NS (2.3 mM) | Reduced bacterial growth | Liu *et al*., (2018) |
| Carnation | NS (25 mg L−1 ) | Reduced ethylene content and bacterial growth | Naing *et al*., (2017b) |
| Carnation | NS (0.23 mM) + Sucrose (58 mM) | Reduced ethylene content and bacterial growth | Park *et al*., (2017) |
| Carnation | NS (15 mg L−1 ) pulsing2 , NS (7.5 mg L−1 ) | Reduced bacterial growth | Liu *et al*., (2008) |
| Rose cv. ‘Movie Star’ | NS (50 mg L−1 ) | Reduced bacterial growth | Li *et al*., (2012) |
| Rose cvs.‘Avalanche’ and ‘Fiesta’ | NS (200 mg L−1 ) | Reduced bacterial growth | Nazemi Rafi and Ramezanian (2013) |
| Rose cv. ‘Movie Star’ | NS (50 or 100 mg L−1 ) | Reduced bacterial growth | Lü *et al*., (2010) |
| Rose cv. ‘First Red’ | Biologically synthesized NS (50 ppm) + Sucrose (4%) | Reduced bacterial growth | Aier *et al*., (2017) |
| Tulip cv. ‘White Parrot’ | NS (10 mg L−1 ) | Increased RFW | Byczyńska (2017) |
| Peony | NS (10 mg L−1 ) | Reducing bacterial growth and improving water uptake | Zhao *et al*., (2018) |
| Orchid | NS (5 mg L−1 ) | Reduced bacterial growth | Rahman *et al*., (2019) |
| Gardenias ‘fortuniana’ | NS (15 mg L−1 ) | Reducing bacterial growth and improving water uptake | Lin *et al*., (2019a) |
| Gladiolus ‘Eerde’ | NS (15 mg L−1 ) | Reducing bacterial growth and improving water uptake | Li *et al*., (2017) |
| Rosa hybrida cv. Black magic | CTS-NP 10 mg L−1 | enhance light usage efciency, promote production of additional carbohydrate products for plant growth | Seyed Hajizadeh *et al*., 2023 |
| Lisianthus ( *Eustoma grandiflora* cv. Echo) | silicon nanoparticle 40 mg L−1 | inhibited microbial growth, ethylene | Fereshteh Kamiab 2017 |
| Carnation and chrysanthemum | CuNPs 20 mg L-1 | inhibiting the growth of bacterial population | **Nahid Rashidiani** *et al*., **2020** |
| Chrysanthemum cv. Snowball | Green CuNPs 75 ppm | Antimicrobial, enhanced relative water uptake | Sewali Saikia *et al*., 2022 |

**Packaging**

“Utilizing nanocomposite technology and materials presents an opportunity to enhance the physical properties of packaging materials, including mechanical strength, thermal stability, gas barrier, physicochemical characteristics, and recyclability” (Arora and Padua, 2010). To maintain the quality and freshness of plant products during commercialization and consumption, thoughtful material selection and the adoption of packaging technologies capable of preserving the desired atmosphere are crucial. Nanotechnology provides effective scavengers with selective capabilities to eliminate various gases such as oxygen and ethylene. Specifically, the incorporation of nanoscale fillers like Pd into the matrix can improve the impermeability of plastic films to ethylene (Neethirajan *et al*., 2011). Nanoparticles serve as small physical barriers, hindering the movement of gas molecules by obstructing their path through the material.

“Achieving nano-catalytic degradation of ethylene and other pollutants represents a challenging yet highly desirable objective in the development of environmentally friendly catalysts” (Rickerby *et al*., 2000). This process involves the actual breakdown of organic contaminants rather than their mere transfer from one phase to another. Pd and TiO2 fixed on activated carbon have demonstrated effectiveness as catalysts for practical ethylene removal. “Titanium dioxide (TiO2) has garnered attention for its light-activated photocatalytic degradation under ultraviolet (UV) irradiation, whether from natural (sun) or artificial (lamp) sources, owing to its physical and chemical stability, low cost, availability, and non-toxicity” (Hussain *et al*., 2011). While the application of nanocomposites and nanocatalysts in floriculture is presently limited, ongoing advancements in packaging materials and formats indicate promising prospects for future developments.**Figure 3: Diagram representing the use of nanoparticle based packaging/products while transportation and post-harvest management of flowers**

**Control of pest and diseases**

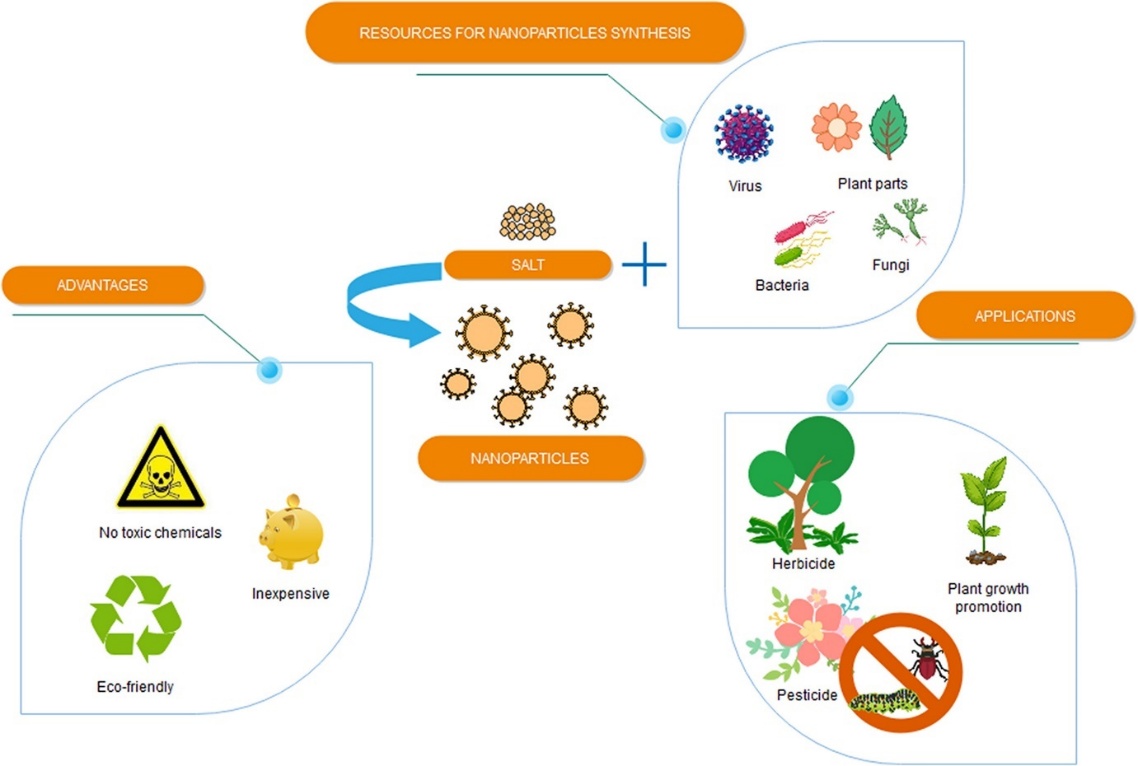
Ag NPs have several uses, including being a potent catalyst and microbial growth inhibitor. Researchers discovered that Ag NPs had a strong inhibitory effect on both Gram-positive and Gram-negative bacteria using the disk diffusion experiment, something that Au NPs were unable to accomplish (Nayem *et al*., 2020). Terminalia arjuna plant extracts were used to generate Cu NPs, which showed strong anti-bacterial activity against S. aureus and E. coli, but reduced efficaciousness against S. typhi and P. aeruginosa (Lebaschi *et al*., 2017). The Cu NPs utilized in antibacterial research were produced by Nerium oleander leaf extract (Karimi and Mohsenzadeh, 2015). *Staphylococcus aureus* was significantly inhibited by the Fe NPs that

**Table 4: Nanoparticle expressing anti-bacterial properties against various phytopathogens**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Plant(Scientific name)** | **Plant part** | **Ionic element** | **Size and shape** | **Phytopathogen tested** |
| Lemongrass (*Cymbopogan citratus*) | Leaves | Al2O3 | 34.5 nm  Spherical | *Pseudomonas aeruginosa* |
| Neem (*Azadirachta indica* A. Juss), | Flowers, leaves, Peels | Au | 20–30 nm  Spherical | *Pseudomonas aeruginosa* |
| Climbing lily (*Gloriosa superba* L.) | Leaves | CeO2 | 5 nmSpherical | *Pseudomonas aeruginosa* |
| White leadtree (*Leucaena leucocephala* L.) | Leaves | CdO | 36–57 nmSpherical | *Pseudomonas aeruginosa*,*Aspergillus niger* |
| Tulsi (*Ocimum sanctum* L.) | Leaves | Cu | 25 nmRod, cylindrical and elliptical | *Alternaria carthami*,*Aspergillus niger*,*Colletotrichum gloeosporioides*,*Colletotrichum lindemuthianum*,*Drechslera sorghicola*,*Fusarium oxysporum* f.sp. *carthami*,*Fusarium oxysporum* f.sp. *cicero*,*Fusarium oxysporum* f.sp. *udum*,*Macrophomina phaseolina*,*Rhizoctonia bataticola*,*Rhizoctonia solani*,*Xanthomonas axonopodis* pv. *citri*,*Xanthomonas axonopodix* pv. *punicae* |
| Lambʼs ears (*Stachys lavandulifolia* Vahl.) | Flowers | CuO | 80 nm | *Pseudomonas aeruginosa* |
| Water hyacinth (*Eichhornia crassipes* (Mart.) Solms) | Leaves | CuO | 28 nm | *Aspergillus flavus*,*Aspergillus niger*,*Aspergillus fumigatus*,*Fusarium oxysporium*,*Fusarium culmorum* |
| Savila (*Aloe vera* L.) | Leaves | Se | 50 nmSpherical | *Colletotrichum coccodes*,*Penicillium digitatum* |
| Ashwagandha, bufera(*Withania somnifera* L.) | Leaves | Se | 45–90 nmSpherical | *Bacillus subtilis* |
| Bermuda grass (*Cynodon dactylon*) | Leaves | Si | 62.1 nmSpherical | *Pseudomonas aeruginosa* |
| Coral jasmine (*Nyctanthes arbor-tristis* L.) | Flower | ZnO | 12–63 nm | *Alternaria alternata*,*Aspergillus niger*,*Botrytis cinerea*,*Fusarium oxysporum*,*Penicillium expansum* |
| Bala (*Sida cordifolia* L.) | Leaves | Fe2O3 | 10–22 nm | *Staphylococcus aureus* |
| Neem (*Azadirachta indica* A. Juss.) | Leaves | Fe2O3 | 20–80 nm | *Alternaria mali*,*Botryosphaeria dothidea*,*Diplodia seriata* |
| Yuquilla (*Ruellia tuberosa* L.) | Leaves | FeO | 52.78 nm | *Staphylococcus aureus* |
| Eucalyptus (*Eucalyptus robusta* Sm.) | Leaves | Fe2O3 | 8 nmSpherical | *Pseudomonas aeruginosa*,*Bacillus subtilis* |
| Cadillo (*Tridax procumbens* L.) | Leaves | Fe2O3 | 26 nmSpherical | *Sclerotium rolfsii*,*Fusarium oxysporum* |

were generated using *Gardenia jasminoides* (Naseem and Farrukh, 2015).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Plant(Scientific name)** | **Plant part** | **Ionic element** | **Size and shape** | **Phytopathogen tested** |
| Muicle(*Justicia spicigera* Schltdl.) | Leaves | Ag | 86–100 nm Spherical | *Colletotrichum* sp.,*Fusarium solani*,*Alternaria alternata*,*Macrophomina phaseolina* |
| Persian clover(*Trifolium resupinatum* L.) | Seed | Ag | 17 nm | *Neofusicoccum parvum*,*Rhizoctonia solani* |
| Grass | Leaves | Ag | 15 nm Spherical-oblate | *Fusarium solani*,*Rhizoctonia solani* |
| Pine cone(*Pinus coulteri* D. Don*)* | Leaves | Ag | 20–100 nm triangular and hexagonal | *Bacillus megaterium*,*Pseudomonas syringae*,*Burkholderia glumae*,*Xanthomonas oryzae* pv. *oryzae* |
| Myriostachya(*Myriostachya wightiana* Nees ex Steud.) | Leaves | Ag | 15–65 nm Irregular shape | *Xanthomonas campestris*,*Ralstonia solanacearum* |
| *Drosera binata*, *Drosera indica* L., *Drosera spatulata*, *Dionaea muscipula* Sol. ex J. Ellis | Leaves | Ag | 5–10 nm Spherical | *Pectobacterium atrosepticum*,*Pectobacterium parmentieri*,*Pectobacterium wasabie*,*Dickeya dadantii* |
| Indian acalypha(*Acalypha indica* L.) | Leaves | Ag | 10–50 nm | *Alternaria alternata*,*Sclerotinia sclerotiorum*,*Macrophomina phaseolina*,*Rhizoctonia solani, Botrytis cinerea*,*Curvularia lunata* |



**Figure 4: Advantages of plant extracted nanoparticle**

The effectiveness of green generated copper nanoparticles in treating chrysanthemum *(Dendranthema grandiflora)* cv. Snowball leaf spot disease. Additionally, the CuNPs were examined in a vase solution including chopped chrysanthemums. The findings demonstrated that, in comparison to the standard fungicide's (48.57%) mycelial growth inhibition, the green produced CuNPs demonstrated mycelial growth inhibition at 60.52%, 57.13%, and 52.44% for night jasmine, allamanda, and yellow oleander, respectively. Allamanda mediated CuNPs at 75 ppm and night jasmine-mediated CuNPs at 75 ppm were shown to be the most effective among all other treatments that extend the vase life of cut chrysanthemum beyond custom. It is possible to deduce from the study that green synthesis of nanoparticles from decorative plants Chrysanthemum leaf spot disease can be effectively managed and the vase life of cut chrysanthemums can be extended with the use of yellow oleander and allamanda. But it was discovered that CuNPs mediated by night jasmine were more successful (Saikia *et al*., 2022).

Nano-scale systems could be applied to cut flowers for ethylene detection, removal and photocatalytic degradation in the store environment. Nanocomposites are used in active packaging and they are able to enhance vase life by scrubbing ethylene. The use of new natural formulations (e.g nanosponges) is able to increase the bio-availability of the active ingredients.

They help to minimize the impact of agriculture on the environment and to reduce production costs. In contrast, green synthesis of NPs using plant extracts is an economical, clean, time saving, easy and eco-friendly technique because of the minimum use of toxic chemicals that pollute the environment.

**Future prospects**

The efficiency and the economic benefit of applying each strategy to the flower industry need to be evaluated in the different crop/market contexts. Focused research is required in the use of nanoparticles in preservative solutions and Nanopacking to improve the Quality and the postharvest life of flowers.

**Conclusion**

Modern agriculture makes considerable use of chemicals to increase quality and productivity. However, there are health and environmental risks associated with their use. Due to their negative effects on the environment, several compounds that presently extend the shelf life of flowers by affecting the synthesis or action of ethylene may soon be outlawed. Conscientious resource use and production methods that are safe for the environment and human health have become essential in recent decades to achieve the objective of more sustainable plant production. Therefore, using a systems biology approach to integrate existing bio-, info-, and nanotechnologies will be necessary for continued advancement.

There has been discussion about the green synthesis of Au, Ag, Fe, Cu, and Pd NPs. The green synthesis of nanoscale metals is possible, according to studies conducted on a variety of plant materials. Numerous studies on the green synthesis of nanoscale metal have been published in recent years. The practical production and use of green synthesized nanomaterials, however, requires overcoming a number of obstacles, including low yield, irregular particle sizes, intricate extraction processes, seasonal and regional raw material availability, and other issues. Therefore, improving the yield of nanoscale metal particles, using low-cost raw materials, and employing simple energy-saving technology are the research directions needed in the future. At present, there have been successful cases of using grass to synthesize Ag NPs. Therefore, it is possible that green synthesis of nanoscale metals has a broad prospect and a great potential for development.

**Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

**References**

Al Brahim, Jehan. (2021). Employment of Cassia angustifolia leaf extract for zinc nanoparticles fabrication and their antibacterial and cytotoxicity. Saudi Journal of Biological Sciences. Volume 28. Pages 3303-3308. <https://doi.org/10.1016/j.sjbs.2021.02.075>.

Alagesan, V., & Venugopal, S. (2019). Green synthesis of selenium nanoparticle using leaves extract of Withania somnifera and its biological applications and photocatalytic activities. *Bionanoscience*, *9*, 105-116.

Al-Sheddi, E. S., Farshori, N. N., Al-Oqail, M. M., Al-Massarani, S. M., Saquib, Q., Wahab, R., Musarrat, J., Al-Khedhairy, A. A., & Siddiqui, M. A. (2018). Anticancer potential of green synthesized silver nanoparticles using extract of *Nepeta deflersiana* against human cervical cancer cells (HeLa). *Bioinorganic Chemistry and Applications, 2018*, Article 9390784. <https://doi.org/10.1155/2018/9390784>.

Al-sammarraie, F. K., Wang, W., Zhou, P., Mustapha, A., & 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.

Arokiyaraj, S., Vincent, S., Saravanan, M., Lee, Y., Oh, Y. K., & Kim, K. H. (2017). Green synthesis of silver nanoparticles using Rheum palmatum root extract and their antibacterial activity against Staphylococcus aureus and Pseudomonas aeruginosa. *Artificial cells, nanomedicine, and biotechnology*, *45*(2), 372-379.

Al-Shmgani, H. S. A., Mohammed, W. H., Sulaiman, G. M., & Saadoon, A. H. (2017). Biosynthesis of silver nanoparticles from *Catharanthus roseus* leaf extract and assessing their antioxidant, antimicrobial, and wound-healing activities. *Artificial Cells, Nanomedicine, and Biotechnology, 45*(7), 1234–1240.

Aier, S., Borthakur, P. K., Boro, R. C., Boruah, H., Goswami, G., & Ram, L. (2017). Improvement in post-harvest quality of cut flowers of *Rosa hybrida* cv. ‘First Red’ using biologically synthesized silver nanoparticles. *Journal of Ornamental Horticulture, 20*(1), 21–30.

Amingad, V., Sreenivas, K. N., Fakrudin, B., Seetharamu, G. K., Shankarappa, T. H., & Venugopalan, R. (2017). Comparison of silver nanoparticles and other metal nanoparticles on postharvest attributes and bacterial load in cut roses var. Taj Mahal. *International Journal of Pure and Applied Bioscience*, *5*(6), 579-584.

Amin, O. A. (2017). Influence of Nanosilver and Stevia extract on cut Anthurium inflorescences. *Middle East Journal of Applied Sciences*, *7*(2), 299-313.

Ansari, M. A., Khan, H. M., Alzohairy, M. A., Jalal, M., Ali, S. G., Pal, R., & Musarrat, J. (2015). Green synthesis of Al 2 O 3 nanoparticles and their bactericidal potential against clinical isolates of multi-drug resistant Pseudomonas aeruginosa. *World Journal of Microbiology and Biotechnology*, *31*, 153-164.

Arumugam, A., Karthikeyan, C., Hameed, A. S. H., Gopinath, K., Gowri, S., & Karthika, V. (2015). Synthesis of cerium oxide nanoparticles using Gloriosa superba L. leaf extract and their structural, optical and antibacterial properties. *Materials Science and Engineering: C*, *49*, 408-415.

Alimoradi, M., Jafararpoor, M., & Golparvar, A. (2013). Improving the keeping quality and vase life of cut *Alstroemeria* flowers by post-harvest nano silver treatments. *International Journal of Agriculture and Crop Sciences, 6*(11), 632–635. <https://doi.org/10.15835/nsb539095>.

Ajitha, B., Reddy, Y. A. K., & Reddy, P. S. (2014). Biogenic nano-scale silver particles by Tephrosia purpurea leaf extract and their inborn antimicrobial activity. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, *121*, 164-172.

Andeani, J. K., Kazemi, H., Mohsenzadeh, S., & Safavi, A. (2011). Biosynthesis of gold nanoparticles using dried flowers extract of Achillea wilhelmsii plant. *Digest Journal of Nanomaterials and Biostructures*, *6*(3), 1011-1017.

Ahmad, A., Senapati, S., Khan, M. I., Kumar, R., Ramani, R., Srinivas, V., & Sastry, M. (2003). Intracellular synthesis of gold nanoparticles by a novel alkalotolerant actinomycete, Rhodococcus species. *Nanotechnology*, *14*(7), 824.

Bharadwaj, K. K., Rabha, B., Pati, S., Sarkar, T., Choudhury, B. K., Barman, A., Bhattacharjya, D., Srivastava, A., Baishya, D., Edinur, H. A., Abdul Kari, Z., & Mohd Noor, N. H. (2021). Green synthesis of gold nanoparticles using plant extracts as beneficial prospect for cancer theranostics. *Molecules, 26*(21), Article 6389. <https://doi.org/10.3390/molecules26216389>.

Banasiuk, R., Krychowiak, M., Swigon, D., Tomaszewicz, W., Michalak, A., Chylewska, A., Ziabka, M., Lapinski, M., Koscielska, B., Narajczyk, M. and Krolicka, A. (2020). Carnivorous plants used for green synthesis of silver nanoparticles with broad-spectrum antimicrobial activity. *Arabian Journal of Chemistry*, *13*(1), pp.1415-1428.

Bernardo-Mazariegos, E., Valdez-Salas, B., González-Mendoza, D., Abdelmoteleb, A., Camacho, O. T., Duran, C. C., & Gutiérrez-Miceli, F. (2019). Silver nanoparticles from Justicia spicigera and their antimicrobial potentialities in the biocontrol of foodborne bacteria and phytopathogenic fungi. *Revista Argentina de microbiología*, *51*(2), 103-109.

Bharathi, D.; Bhuvaneshwari, V. (2018).Evaluation of the cytotoxic and antioxidant activity of phyto-synthesized silver nanoparticles using *Cassia angustifolia* flowers. *BioNanoScience* , *9*, 155–163.

Babu, R. H., Yugandhar, P., & Savithramma, N. (2018). Synthesis, characterization and antimicrobial studies of bio silica nanoparticles prepared from Cynodon dactylon L.: a green approach. *Bulletin of Materials Science*, *41*, 1-8.

Byczyńska, A. (2017). Improvement of postharvest quality of cut tulip ‘White Parrot’ by nano silver. *World Scientific News, 83*, 224–228.

Bala, N., Saha, S., Chakraborty, M., Maiti, M., Das, S., Basu, R., & Nandy, P. (2015). Green synthesis of zinc oxide nanoparticles using Hibiscus subdariffa leaf extract: effect of temperature on synthesis, anti-bacterial activity and anti-diabetic activity. *RSC Advances*, *5*(7), 4993-5003.

Carrillo-López, L. M., Morgado-González, A., & Morgado-González, A. (2016). Biosynthesized silver nanoparticles used in preservative solutions for Chrysanthemum cv. Puma. *Journal of Nanomaterials*, *2016*.

Cristescu, S. M., Mandon, J., Arslanov, D., De Pessemier, J., Hermans, C., & Harren, F. J. (2013). Current methods for detecting ethylene in plants. *Annals of botany*, *111*(3), 347-360.

Cao, G. (2004). *Nanostructures & nanomaterials: synthesis, properties & applications*. Imperial college press.

Devi, H. S., Boda, M. A., Shah, M. A., Parveen, S., & Wani, A. H. (2019). Green synthesis of iron oxide nanoparticles using Platanus orientalis leaf extract for antifungal activity. *Green Processing and Synthesis*, *8*(1), 38-45.

El-Saadony, M. T., Abd El-Hack, M. E., Taha, A. E., Fouda, M. M., Ajarem, J. S., N. Maodaa, S., ... & Elshaer, N. (2020). Ecofriendly synthesis and insecticidal application of copper nanoparticles against the storage pest Tribolium castaneum. *Nanomaterials*, *10*(3), 587.

El-Serafy, R. S. (2019). Silica nanoparticles enhance physio-biochemical characters and postharvest quality of *Rosa hybrida L.* cut flowers. *Journal of Horticultural Research, 27*(1), 47–54. https://doi.org/10.2478/johr-2019-0006.

Edison, T. N. J. I., Lee, Y. R., & Sethuraman, M. G. (2016). Green synthesis of silver nanoparticles using Terminalia cuneata and its catalytic action in reduction of direct yellow-12 dye. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, *161*, 122-129.

Fardsadegh, B., & Jafarizadeh-Malmiri, H. (2019). Aloe vera leaf extract mediated green synthesis of selenium nanoparticles and assessment of their in vitro antimicrobial activity against spoilage fungi and pathogenic bacteria strains. *Green Processing and Synthesis*, *8*(1), 399-407.

Farooqui, M. A., Chauhan, P. S., Krishnamoorthy, P., & Shaik, J. (2010). Extraction of silver nanoparticles from the leaf extracts of Clerodendrum inerme. *Digest Journal of Nanomaterials and Biostructures*, *5*(1), 43-49.

Favero, J., Mohan, V., Walia, A., Lecoultre, M., & Galibert, F. (1993). Inhibition of human immunodeficiency virus infection by the lectin jacalin and by a derived peptide showing a sequence similarity with gp120. *European Journal of Immunology, 23*(1), 179–185. <https://doi.org/10.1002/eji.1830230128>.

Ghidan, A. Y., & Al Antary, T. M. (2019). Applications of nanotechnology in agriculture. In *Applications of nanobiotechnology*. IntechOpen.

Gao, J. F., Li, H. Y., Pan, K. L., & Si, C. Y. (2016). Green synthesis of nanoscale zero-valent iron using a grape seed extract as a stabilizing agent and the application for quick decolorization of azo and anthraquinone dyes. *RSC advances*, *6*(27), 22526-22537.

Gavhane, A. J., Padmanabhan, P., Kamble, S. P., & Jangle, S. N. (2012). Synthesis of silver nanoparticles using extract of neem leaf and triphala and evaluation of their antimicrobial activities. *Int J Pharm Bio Sci*, *3*(3), 88-100.

Hemmati, S., Rashtiani, A., Zangeneh, M. M., Mohammadi, P., Zangeneh, A., & Veisi, H. (2019). Green synthesis and characterization of silver nanoparticles using Fritillaria flower extract and their antibacterial activity against some human pathogens. *Polyhedron*, *158*, 8-14.

Hamidimoghadam, E., Rabiei, V., Nabigol, A., & Farrokhi, J. (2014). Postharvest quality improvement of carnation (Dianthus caryophyllus L.) cut flowers by gibberellic acid, benzyl adenine and nano silver. *Agricultural Communications, 2*(1), 28–34.

Hashemabadi, D. (2014). The role of silver nano-particles and silver thiosulfate on the longevity of cut carnation (Dianthus caryophyllus) flowers. *Journal of Environmental Biology, 35*(4), 661–666.

Hussain, M., Bensaid, S., Geobaldo, F., Saracco, G., & Russo, N. (2011). Photocatalytic degradation of ethylene emitted by fruits with TiO2 nanoparticles. *Industrial & engineering chemistry research*, *50*(5), 2536-2543.

Issaabadi, Z., Nasrollahzadeh, M., & Sajadi, S. M. (2017). Green synthesis of the copper nanoparticles supported on bentonite and investigation of its catalytic activity. *Journal of cleaner production*, *142*, 3584-3591.

Jamdagni, P., Khatri, P., & Rana, J. S. (2018). Green synthesis of zinc oxide nanoparticles using flower extract of Nyctanthes arbor-tristis and their antifungal activity. *Journal of King Saud University-Science*, *30*(2), 168-175.

Jamdagni, P., Rana, J. S., Khatri, P., & Nehra, K. (2018). Comparative account of antifungal activity of green and chemically synthesized zinc oxide nanoparticles in combination with agricultural fungicides. *International Journal of Nano Dimension*, *9*(2), 198-208.

Jafarizad, A., Safaee, K., Gharibian, S., Omidi, Y., & Ekinci, D. (2015). Biosynthesis and in-vitro study of gold nanoparticles using Mentha and Pelargonium extracts. *Procedia Materials Science*, *11*, 224-230.

Kaliammal, R., Parvathy, G., Maheshwaran, G., Velsankar, K., Devi, V. K., Krishnakumar, M., & Sudhahar, S. (2021). Zephyranthes candida flower extract mediated green synthesis of silver nanoparticles for biological applications. *Advanced Powder Technology*, *32*(11), 4408-4419.

Korkmaz, N., Ceylan, Y., Hamid, A., Karadağ, A., Bülbül, A.S., Aftab, M.N., Çevik, Ö. and Şen, F. (2020). Biogenic silver nanoparticles synthesized via Mimusops elengi fruit extract, a study on antibiofilm, antibacterial, and anticancer activities. *Journal of Drug Delivery Science and Technology*, *59*, p.101864

Kumari, P., & Meena, A. (2020). Green synthesis of gold nanoparticles from Lawsoniainermis and its catalytic activities following the Langmuir-Hinshelwood mechanism. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, *606*, 125447.

Kumar, P. V., Kala, S. M. J., & Prakash, K. S. (2019). Green synthesis of gold nanoparticles using Croton Caudatus Geisel leaf extract and their biological studies. *Materials Letters*, *236*, 19-22.

Kataria, N., & Garg, V. K. (2018). Green synthesis of Fe3O4 nanoparticles loaded sawdust carbon for cadmium (II) removal from water: regeneration and mechanism. *Chemosphere*, *208*, 818-828.

Khatami, M., Sharifi, I., Nobre, M. A., Zafarnia, N., & Aflatoonian, M. R. (2018). Waste-grass-mediated green synthesis of silver nanoparticles and evaluation of their anticancer, antifungal and antibacterial activity. *Green Chemistry Letters and Reviews*, *11*(2), 125-134.

Kumar, B., Smita, K., Cumbal, L., & Debut, A. (2017). Green synthesis of silver nanoparticles using Andean blackberry fruit extract. *Saudi journal of biological sciences*, *24*(1), 45-50.

Khatami, M., Heli, H., Mohammadzadeh Jahani, P., Azizi, H., & Lima Nobre, M. A. (2017). Copper/copper oxide nanoparticles synthesis using Stachys lavandulifolia and its antibacterial activity. *Iet Nanobiotechnology*, *11*(6), 709-713.

Kota, S., Dumpala, P., & Anantha, R. (2017). Evaluation of therapeutic potential of the silver/silver chloride nanoparticles synthesized with the aqueous leaf extract of *Rumex acetosa*. *Scientific Reports, 7*, 11566. <https://doi.org/10.1038/s41598-017-11853-2>.

Kamiab, F., Shahmoradzadeh Fahreji, S., & Zamani Bahramabadi, E. (2017). Antimicrobial and physiological effects of silver and silicon nanoparticles on vase life of Lisianthus (*Eustoma grandiflora* cv. Echo) flowers. *International Journal of Horticultural Science and Technology, 4*(1), 135–144. <https://doi.org/10.22059/IJHST.2017.228657.180>.

Khatami, M., Nejad, M. S., Salari, S., & Almani, P. G. N. (2016). Plant‐mediated green synthesis of silver nanoparticles using Trifolium resupinatum seed exudate and their antifungal efficacy on Neofusicoccum parvum and Rhizoctonia solani. *IET nanobiotechnology*, *10*(4), 237-243.

Karimi, J., & Mohsenzadeh, S. (2015). Rapid, green, and eco-friendly biosynthesis of copper nanoparticles using flower extract of Aloe vera. *Synthesis and Reactivity in Inorganic, Metal-Organic, and Nano-Metal Chemistry*, *45*(6), 895-898.

Krishnaraj, C., Muthukumaran, P., Ramachandran, R., Balakumaran, M. D., & Kalaichelvan, P. T. (2014). *Acalypha indica* Linn: Biogenic synthesis of silver and gold nanoparticles and their cytotoxic effects against MDA-MB-231, human breast cancer cells. *Biotechnology Reports, 4*, 42–49. <https://doi.org/10.1016/j.btre.2014.07.001>.

Kazemipour, S., Hashemabadi, D., & Kaviani, B. (2013). Effect of silver nanoparticles on the vase life and quality of cut chrysanthemum (*Chrysanthemum morifolium L.*) flowers. *European Journal of Experimental Botany, 3*(6), 298–302.

Krishnaraj, C., Ramachandran, R., Mohan, K., & Kalaichelvan, P. T. (2012). Optimization for rapid synthesis of silver nanoparticles and its effect on phytopathogenic fungi. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, *93*, 95-99.

Krishnaraj, C., Jagan, E. G., Rajasekar, S., Selvakumar, P., Kalaichelvan, P. T., & Mohan, N. (2010). Synthesis of silver nanoparticles using *Acalypha indica* leaf extracts and its antibacterial activity against waterborne pathogens. *Colloids and Surfaces B: Biointerfaces, 76*(1), 50–56.

Lee, Y. J., & Park, Y. (2020). Green synthetic nanoarchitectonics of gold and silver nanoparticles prepared using quercetin and their cytotoxicity and catalytic applications. *Journal of nanoscience and nanotechnology*, *20*(5), 2781-2790.

Langroudi, M. E., Hashemabadi, D., KalateJari, S., & Asadpour, L. (2020). Effects of silver nanoparticles, chemical treatments and herbal essential oils on the vase life of cut alstroemeria (Alstroemeria ‘Summer Sky’) flowers. *The Journal of Horticultural Science and Biotechnology*, *95*(2), 175-182.

Lin, S., Li, H., Xian, X., Lin, X., Pang, Z., Liu, J., & He, S. (2019). Nano-silver pretreatment delays wilting of cut Gardenia foliage by inhibiting bacterial xylem blockage. *Scientia Horticulturae, 246*, 791–796. <https://doi.org/10.1016/j.scienta.2018.11.031>.

Liu, J., Zhang, Z., Li, H., Lin, X., Lin, S., Joyce, D. C., & He, S. (2018). Alleviation of effects of exogenous ethylene on cut 'Master' carnation flowers with nano-silver and silver thiosulfate. *Postharvest Biology and Technology, 143*, 86–91. <https://doi.org/10.1016/j.postharvbio.2018.04.007>.

Lebaschi, S., Hekmati, M., & Veisi, H. (2017). Green synthesis of palladium nanoparticles mediated by black tea leaves (Camellia sinensis) extract: Catalytic activity in the reduction of 4-nitrophenol and Suzuki-Miyaura coupling reaction under ligand-free conditions. *Journal of Colloid and Interface Science*, *485*, 223-231.

Li, H., Li, H., Liu, J., Luo, Z., Joyce, D., & He, S. (2017). Nano-silver treatments reduced bacterial colonization and biofilm formation at the stem-ends of cut gladiolus ‘Eerde’ spikes. *Postharvest Biology and Technology, 123*, 102–111. <https://doi.org/10.1016/j.postharvbio.2016.09.013>.

Li, H., Huang, X., Li, J., Liu, J., Joyce, D., & He, S. (2012). Efficacy of nanosilver in alleviating bacteria-related blockage in cut rose cv. Movie Star stems. *Postharvest Biology and Technology, 74*, 36–41. <https://doi.org/10.1016/j.postharvbio.2012.06.006>.

Lü, P., Cao, J., He, S., Liu, J., Li, H., Cheng, G., Ding, Y., & Joyce, D. C. (2010). Nano-silver pulse treatments improve water relations of cut rose cv. ‘Movie Star’ flowers. *Postharvest Biology and Technology, 57*, 196–202. <https://doi.org/10.1016/j.postharvbio.2010.03.009>.

Liu, J., Zhang, Z., Joyce, D. C., He, S., Cao, J., & Lv, P. (2008). Effect of postharvest nanosilver treatments on cut flowers. *Acta Horticulturae, 847*, 245–250.

Manzoor, A., Bashir, M. A., & Hashmi, M. M. (2020). Nanoparticles as a preservative solution can enhance postharvest attributes of cut flowers. *Italus Hortus*, *27*, 1-14.

Maity, T.R., Samanta, A., Saha, B., Datta, S. (2019). Evaluation of Piper betle mediated silver nanoparticle in post-harvest physiology in relation to vase life of cut spike of Gladiolus. *Bull. Natl. Res. Centre* 43, 9.

Moradi, P., Afshari, H., & Ebadi, A. G. (2012). The effect of benzyl adenine, nano silver, 8-hydroxyquinoline sulfate, and sucrose on longevity improvement and some other quality characteristics of *Dianthus* cv. Cream Viana cut flower. *Indian Journal of Science and Technology, 5*, 2459–2463.

Mousavi, S.R., Rezaei, M., (2011). Nanotechnology in agriculture and food production. *J. Appl. Environ. Biol. Sci.* (1): 414-419.

Naiel, B., Fawzy, M., Halmy, M. W. A., & Mahmoud, A. E. D. (2022). Green synthesis of zinc oxide nanoparticles using Sea Lavender (Limonium pruinosum L. Chaz.) extract: characterization, evaluation of anti-skin cancer, antimicrobial and antioxidant potentials. *Scientific Reports*, *12*(1), 20370. <https://doi.org/10.1038/s41598-022-24805-2>.

Nayem, S. A., Sultana, N., Haque, M. A., Miah, B., Hasan, M. M., Islam, T., ... & Ahammad, A. S. (2020). Green synthesis of gold and silver nanoparticles by using amorphophallus paeoniifolius tuber extract and evaluation of their antibacterial activity. *Molecules*, *25*(20), 4773.

Naing, A. H., & Kim, C. K. (2020). Application of nano-silver particles to control the postharvest biology of cut flowers: A review. *Scientia Horticulturae*, *270*, 109463.

Naing, A. H., Win, N. M., Hang, J. S., Lim, K. B., & Kim, C. K. (2017). Role of nano silver and the bacterial strain *Enterobacter cloacae* in increasing vase life of cut carnation ‘Omea’. *Frontiers in Plant Science, 8*, 1590. https://doi.org/10.3389/fpls.2017.01590

Nasrollahzadeh, M., & Sajadi, S. M. (2016). Pd nanoparticles synthesized in situ with the use of Euphorbia granulate leaf extract: Catalytic properties of the resulting particles. *Journal of colloid and interface science*, *462*, 243-251

Naseem, T., & Farrukh, M. A. (2015). Antibacterial activity of green synthesis of iron nanoparticles using Lawsonia inermis and Gardenia jasminoides leaves extract. *Journal of Chemistry*, *2015*.

Nasrollahzadeh, M., & Sajadi, S. M. (2015). Green synthesis of copper nanoparticles using Ginkgo biloba L. leaf extract and their catalytic activity for the Huisgen [3+ 2] cycloaddition of azides and alkynes at room temperature. *Journal of colloid and interface science*, *457*, 141-147.

Nazemi Rafi, Z., & Ramezanian, A. (2013). Vase life of cut rose cultivars ‘Avalanche’ and ‘Fiesta’ as affected by nano-silver and S-carvone treatments. *South African Journal of Botany, 86*, 68–72. https://doi.org/10.1016/j.sajb.2013.01.004

Neethirajan, S., & Jayas, D. S. (2011). Nanotechnology for the food and bioprocessing industries. *Food and bioprocess technology*, *4*, 39-47.

Ojemaye, M. O., Okoh, S. O., & Okoh, A. I. (2021). Silver nanoparticles (AgNPs) facilitated by plant parts of *Crataegus ambigua* Becker AK extracts and their antibacterial, antioxidant and antimalarial activities. *Green Chemistry Letters and Reviews, 14*(1), 49–59. https://doi.org/10.1080/17518253.2020.1842186

Ping, Y., Zhang, J., Xing, T., Chen, G., Tao, R., & Choo, K. H. (2018). Green synthesis of silver nanoparticles using grape seed extract and their application for reductive catalysis of Direct Orange 26. *Journal of industrial and engineering chemistry*, *58*, 74-79.

Park, D. Y., Naing, A. H., Ai, T. N., Han, J., Kang, I. K., & Kim, C. K. (2017). Synergistic effect of nano silver with sucrose on extending vase life of the carnation cv. Edun. *Frontiers in Plant Science, 8*, 1601. <https://doi.org/10.3389/fpls.2017.01601>.

Padalia, H., Moteriya, P., & Chanda, S. (2015). Green synthesis of silver nanoparticles from marigold flower and its synergistic antimicrobial potential. *Arabian Journal of Chemistry*, *8*(5), 732-741.

Priya Tharishini, P. S. N. C., Saraswathy, N. C., Smila, K. H., Yuvaraj, D., Chandran, M., & Vivek, P. (2014). Green synthesis of gold nano particles from Cassia auriculata leaf aqueous extract and its cytotoxicity effect on in vitro cell line. *Int. J. ChemTech Res*, *6*(9), 4241-4250.

Ponarulselvam, S., Panneerselvam, C., Murugan, K., Aarthi, N., Kalimuthu, K., & Thangamani, S. (2012). Synthesis of silver nanoparticles using leaves of Catharanthus roseus Linn. G. Don and their antiplasmodial activities. *Asian Pacific journal of tropical biomedicine*, *2*(7), 574-580.

Philip, D. (2010). Green synthesis of gold and silver nanoparticles using Hibiscus rosa sinensis. *Physica E: Low-Dimensional Systems and Nanostructures*, *42*(5), 1417-1424.

Rajendaran, K., Muthuramalingam, R., & Ayyadurai, S. (2019). Green synthesis of Ag-Mo/CuO nanoparticles using Azadirachta indica leaf extracts to study its solar photocatalytic and antimicrobial activities. *Materials Science in Semiconductor Processing*, *91*, 230-238.

Rautela, A., & Rani, J. (2019). Green synthesis of silver nanoparticles from Tectona grandis seeds extract: characterization and mechanism of antimicrobial action on different microorganisms. *Journal of Analytical Science and Technology*, *10*(1), 1-10.

Rahman, M. M., Ahmad, S. H., Mohamed, M. T. M., & Ab Rhaman, M. Z. (2019). Improving the vase life of cut Mokara Red orchid flower using leaf extracts with silver nanoparticles. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, 89*, 1343–1350. https://doi.org/10.1007/s40011-018-1055-0

Reddy, P. N. K., Shaik, D. P., Ganesh, V., Nagamalleswari, D., Thyagarajan, K., & Prasanth, P. V. (2019). Structural, optical and electrochemical properties of TiO2 nanoparticles synthesized using medicinal plant leaf extract. *Ceramics International*, *45*(13), 16251-16260.

Rao, Y., Inwati, G. K., & Singh, M. (2017). Green synthesis of capped gold nanoparticles and their effect on Gram-positive and Gram-negative bacteria. *Future Science OA*, *3*(4), FSO239.

Rehana, D., Mahendiran, D., Kumar, R. S., & Selvakumar, P. M. (2017). *In vitro* antioxidant and antidiabetic activities of zinc oxide nanoparticles synthesized using different plant extracts. *Bioprocess and Biosystems Engineering, 40*(6), 943–957. <https://doi.org/10.1007/s00449-017-1758-2>.

Ravichandran, S., Paluri, V., Kumar, G., Loganathan, K., & Venkata, B. R. K. (2016). A novel approach for the biosynthesis of silver oxide nanoparticles using aqueous leaf extract of *Callistemon lanceolatus* (Myrtaceae) and their therapeutic potential. *Journal of Experimental Nanoscience, 11*(6), 445–458. https://doi.org/10.1080/17458080.2015.1077534

Rickerby, D. G., Wächter, N., Horrillo, M. C., Gutiérrez, J., Gràcia, I., & Cané, C. (2000). Structural and dimensional control in micromachined integrated solid state gas sensors. *Sensors and Actuators B: Chemical*, *69*(3), 314-319.

Sena, S., Ochatt, S. J., & Kumar, V. (2023). Application of green synthesized nanoparticles in medicinal plant research: revisiting an emerging eco-friendly approach. *Plant Cell, Tissue and Organ Culture (PCTOC)*, 1-40.

Saikia, S., Saud, B. K., Dutta, P., Gogoi, A. K., & Baruah, S. (2022). Efficacy of green synthesized copper nanoparticles towards leaf spot disease and its effects on vase life of chrysanthemum cv. Snowball.

Shameli, R., M., Aminsalehi, M., Shahbandeh, M., Maleki, A., Jonoubi, P., & Rad, A. C. (2021). Anticancer and therapeutic potential of Delonix regia extract and silver nanoparticles (AgNPs) against pancreatic (Panc-1) and breast (MCF-7) cancer cell. *Toxicology and Environmental Health Sciences*, *13*, 45-56. <https://doi.org/10.1007/s13530-020-00067-1>

Shaikh, R., Zainuddin Syed, I., & Bhende, P. (2019). Green synthesis of silver nanoparticles using root extracts of Cassia toral L. and its antimicrobial activities. *Asian J. Green Chem*, *3*(1), 70-81.

Sharmila, G., Thirumarimurugan, M., & Muthukumaran, C. (2019). Green synthesis of ZnO nanoparticles using Tecoma castanifolia leaf extract: characterization and evaluation of its antioxidant, bactericidal and anticancer activities. *Microchemical Journal*, *145*, 578-587. <https://doi.org/10.1016/j.microc.2018.11.022>

Singh, J., Dutta, T., Kim, K. H., Rawat, M., Samddar, P., & Kumar, P. (2018). ‘Green’synthesis of metals and their oxide nanoparticles: applications for environmental remediation. *Journal of nanobiotechnology*, *16*(1), 1-24.

Soriano, M. L., Zougagh, M., Valcárcel, M., & Ríos, Á. (2018). Analytical Nanoscience and Nanotechnology: Where we are and where we are heading. *Talanta*, *177*, 104-121.

Saratale, R. G., Benelli, G., Kumar, G., Kim, D. S., & Saratale, G. D. (2018). Bio-fabrication of silver nanoparticles using the leaf extract of an ancient herbal medicine, dandelion (Taraxacum officinale), evaluation of their antioxidant, anticancer potential, and antimicrobial activity against phytopathogens. *Environmental Science and Pollution Research*, *25*, 10392-10406.

Santhoshkumar, J., Kumar, S. V., & Rajeshkumar, S. (2017). Synthesis of zinc oxide nanoparticles using plant leaf extract against urinary tract infection pathogen. *Resource-Efficient Technologies*, *3*(4), 459-465.

Sharmila, G., Fathima, M. F., Haries, S., Geetha, S., Kumar, N. M., & Muthukumaran, C. (2017). Green synthesis, characterization and antibacterial efficacy of palladium nanoparticles synthesized using Filicium decipiens leaf extract. *Journal of Molecular Structure*, *1138*, 35-40.

Savale, A., Ghotekar, S., Pansambal, S., & Pardeshi, O. (2017). Green synthesis of fluorescent CdO nanoparticles using Leucaena leucocephala L. extract and their biological activities. *J. Bacteriol. Mycol. Open Access*, *5*(5), 00148.

Shende, S., Gaikwad, N., & Bansod, S. (2016). Synthesis and evaluation of antimicrobial potential of copper nanoparticle against agriculturally important phytopathogens. *Synthesis*, *1*(4), 41-47.

Vanathi, P., Rajiv, P., & Sivaraj, R. (2016). Synthesis and characterization of Eichhornia-mediated copper oxide nanoparticles and assessing their antifungal activity against plant pathogens. *Bulletin of Materials Science*, *39*, 1165-1170.

Sarmast, M. K., & Salehi, H. (2016). Silver nanoparticles: an influential element in plant nanobiotechnology. *Molecular biotechnology*, *58*, 441-449.

Siddiqi, K. S., & Husen, A. (2016). Green synthesis, characterization and uses of palladium/platinum nanoparticles. *Nanoscale research letters*, *11*, 1-13.

Singh, P., Kim, Y. J., Zhang, D., & Yang, D. C. (2016). Biological synthesis of nanoparticles from plants and microorganisms. *Trends in biotechnology*, *34*(7), 588-599.

Shende, S., Ingle, A. P., Gade, A., & Rai, M. (2015). Green synthesis of copper nanoparticles by Citrus medica Linn.(Idilimbu) juice and its antimicrobial activity. *World Journal of Microbiology and Biotechnology*, *31*, 865-873.

Subramaniyam, V., Subashchandrabose, S. R., Thavamani, P., Megharaj, M., Chen, Z., & Naidu, R. (2015). Chlorococcum sp. MM11—a novel phyco-nanofactory for the synthesis of iron nanoparticles. *Journal of applied phycology*, *27*, 1861-1869.

Shobha, G., Moses, V., & Ananda, S. (2014). Biological synthesis of copper nanoparticles and its impact. *Int. j. pharm. sci. Invent*, *3*(8), 6-28.

Sangeetha, G., Rajeshwari, S., & Venckatesh, R. (2011). Green synthesis of zinc oxide nanoparticles by aloe barbadensis miller leaf extract: Structure and optical properties. *Materials Research Bulletin*, *46*(12), 2560-2566.

Santhoshkumar, T., Rahuman, A. A., Rajakumar, G., Marimuthu, S., Bagavan, A., Jayaseelan, C., ... & Kamaraj, C. (2011). Synthesis of silver nanoparticles using Nelumbo nucifera leaf extract and its larvicidal activity against malaria and filariasis vectors. *Parasitology research*, *108*, 693-702.

Smitha, S. L., Philip, D., & Gopchandran, K. G. (2009). Green synthesis of gold nanoparticles using Cinnamomum zeylanicum leaf broth. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, *74*(3), 735-739.

Solgi, M., Kafi, M., Taghavi, T.S., Naderi, R. (2009). Essential oils and silver nanoparticles (SNP) as novel agents to extend vase-life of gerbera (*Gerbera jamesonii* cv. ‘Dune’) flowers. *Postharvest Biol. Technol*. 53, 155–158.

Tripathi, D., Modi, A., Narayan, G., & Rai, S. P. (2019). Green and cost effective synthesis of silver nanoparticles from endangered medicinal plant Withania coagulans and their potential biomedical properties. *Materials Science and Engineering: C*, *100*, 152-164.

Turunc, E., Binzet, R., Gumus, I., Binzet, G., & Arslan, H. (2017). Green synthesis of silver and palladium nanoparticles using Lithodora hispidula (Sm.) Griseb.(Boraginaceae) and application to the electrocatalytic reduction of hydrogen peroxide. *Materials Chemistry and Physics*, *202*, 310-319.

Tahir, K., Nazir, S., Li, B., Ahmad, A., Nasir, T., Khan, A. U., ... & Hameed, M. U. (2016). Sapium sebiferum leaf extract mediated synthesis of palladium nanoparticles and in vitro investigation of their bacterial and photocatalytic activities. *Journal of Photochemistry and Photobiology B: Biology*, *164*, 164-173.

Tran, Q. H., & Le, A. T. (2013). Silver nanoparticles: synthesis, properties, toxicology, applications and perspectives. *Advances in natural sciences: nanoscience and nanotechnology*, *4*(3), 033001.

Valsalam, S., Agastian, P., Arasu, M. V., Al-Dhabi, N. A., Ghilan, A. K. M., Kaviyarasu, K., ... & Arokiyaraj, S. (2019). Rapid biosynthesis and characterization of silver nanoparticles from the leaf extract of Tropaeolum majus L. and its enhanced in-vitro antibacterial, antifungal, antioxidant and anticancer properties. *Journal of Photochemistry and Photobiology B: Biology*, *191*, 65-74.https://doi.org/10.1016/j.jphotobiol.2018.12.010.

Vadlapudi, V., & Amanchy, R. (2017). Phytofabrication of silver nanoparticles using Myriostachya wightiana as a novel bioresource, and evaluation of their biological activities. *Brazilian Archives of Biology and Technology*, *60*, e17160329.

Veisi, H., Rashtiani, A., & Barjasteh, V. (2016). Biosynthesis of palladium nanoparticles using Rosa canina fruit extract and their use as a heterogeneous and recyclable catalyst for Suzuki–Miyaura coupling reactions in water. *Applied Organometallic Chemistry*, *30*(4), 231-235.

Velmurugan, P., Lee, S. M., Iydroose, M., Lee, K. J., & Oh, B. T. (2013). Pine cone-mediated green synthesis of silver nanoparticles and their antibacterial activity against agricultural pathogens. *Applied microbiology and biotechnology*, *97*, 361-368.

Yu, C., Tang, J., Liu, X., Ren, X., Zhen, M., & Wang, L. (2019). Green biosynthesis of silver nanoparticles using *Eriobotrya japonica* (Thunb.) leaf extract for reductive catalysis. *Materials, 12*(1), 189. <https://doi.org/10.3390/ma12010189>.

Yasir, M., Singh, J., Tripathi, M. K., Singh, P., & Shrivastava, R. (2018). Green synthesis of silver nanoparticles using leaf extract of common arrowhead houseplant and its anticandidal activity. *Pharmacognosy Magazine, 13*(Suppl 4), S840–S844. <https://doi.org/10.4103/pm.pm_226_17>.

Yokoyama, M. (2014). Polymeric micelles as drug carriers: Their lights and shadows. *Journal of Drug Targeting, 22*(7–8), 576–583. <https://doi.org/10.3109/1061186X.2014.934688>.

Yadollahi, A., Arzani, K., & Khoshghalb, H. (2010). The role of nanotechnology in horticultural crops postharvest management. *Acta Horticulturae*, (875), 49-56.

Xia, Q. H., Zheng, L. P., Zhao, P. F., & Wang, J. W. (2017). Biosynthesis of silver nanoparticles using *Artemisia annua* callus for inhibiting stem-end bacteria in cut carnation flowers. *IET Nanobiotechnology, 11*(2), 185–192. <https://doi.org/10.1049/iet-nbt.2016.0019>.

Zahedi, S. M., Moharrami, F., Sarikhani, S., & Padervand, M. (2020). Selenium and silica nanostructure-based recovery of strawberry plants subjected to drought stress. *Scientific reports*, *10*(1), 17672.

Zhao, D., Cheng, M., Tang, W., Liu, D., Zhou, S., Meng, J., & Tao, J. (2018). Nano-silver modifies the vase life of cut herbaceous peony (*Paeonia lactiflora Pall.*) flowers. *Protoplasma, 255*(6), 1651–1663. <https://doi.org/10.1007/s00709-018-1246-8>.

Gupta, A., Pandey, B. C., Verma, J., Tiwari, I., Sahu, A. N., Manhas, R. K., & Kumari, N. (2024). Biosynthesis of silver nanoparticle from flower extract of Dillenia indica and its efficacy as antibacterial and antioxidant. *Microbial Pathogenesis*, *193*, 106779.

Kandiah, M., & Chandrasekaran, K. N. (2021). Green synthesis of silver nanoparticles using Catharanthus roseus flower extracts and the determination of their antioxidant, antimicrobial, and photocatalytic activity. *Journal of Nanotechnology*, *2021*(1), 5512786.

Niveditha, Mannem, Vijay R Shelar, and Bhalerao B.M. 2024. “Green Synthesis: An Alternative Sustainable Route for Nanotechology”. Journal of Advances in Biology & Biotechnology 27 (7):1054-69. <https://doi.org/10.9734/jabb/2024/v27i71065>.

Thakur, Shabnam Kumari, N. V. L. Suvarchala Reddy V., Ganga Raju M., Poojeetha Sree, Sappa Sowmya, Sree Lakshmi S., and Suchitra J. 2023. “Green Synthesis and Characterization of Silver Nanoparticles from Millingtonia Hortensis and Their Antidiabetic and Antioxidant Efficacy”. Asian Plant Research Journal 11 (5):19-29. https://doi.org/10.9734/aprj/2023/v11i5222.