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# Medicinal Properties and Economic Importance of AgNP from Ganoderma Lucidum: a Review

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# MEDICINAL PROPERTIES AND ECONOMIC IMPORTANCE OF AgNP FROM *Ganoderma lucidum*: A REVIEW

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**ABSTRACT**

The medicinal importance of fungi should not be ignored as it plays an important role in fields like Ayurvedic dravyaguna and pharmacognosy. *Ganoderma lucidum* was reported with rich medicinal properties due to having good number of medicinal compounds. Ganoderma *lucidum*, an oriental medicinal fungus showing a variety of biological activities like anticancer activity, anti-diabetic activity, hypoglycemic effect, antimicrobial and antioxidant properties. *Candida*, *Enterococcus*, *Staphylococcus spp*, *Streptococcus spp*, *Escherichia*, *Pseudomonas* are leading pathogens present on ear, nose and throat region. In the present decades, there is a much gaining attention to scientists in green synthesis of silver nanoparticles. The present paper provides information about the Medicinal properties and Economic importance AgNP from *Ganoderma lucidum*.

**Keywords:** *Ganoderma lucidum*, AgNP, Medicinal importance,

## 1. INTRODUCTION

Several fungi like mushrooms are using as medicine as tradition is important in both in India and western countries (Vaidya and Rabba, 1993). Several antimicrobial compounds like lectins, terpenes, polysaccharides have great potential interest on nutritional and medicinal status of different mushrooms. Most of the fungi are saprophytic and non-pathogenic to several living systems like animals, plants, and other microbial species (De Lucca, 2007). The plant-fungi interactions are mediated by primary and secondary metabolites that are available in environment and have several inferences for medicine **(**Scherlach et al., 2013)**.**

Fungi are important in both ancient and modern biological processes include brewing, baking, production of organic acids, antibiotics, enzymes, alcohols, and several pharmaceutical products (Bennett, 1998). Symbiotic associations during co-evolution events between plants and fungi results in nutrient exchange and protective mechanisms based on climatic changes based on evolutionary developmental perspective.

Mushrooms that are belongs to fungi are consumed by ancient and **modern** Homo sapiens throughout the world from past to present. Mushrooms like Button mushroom (*Agaricus bisporus)*, Shiitake mushrooms(*Lentinula edodes*),, Oyster mushrooms (*Pleurotus ostreatus)*, Shimeji mushroom (*Hypsizygus tesselatus*), Porcini mushrooms (Boletus edulis) and Paddy straw mushroom (*Volvariella volvacea)* are rich with guanylic acid, glutamic acid, aspartic acid, protein, fibre, iron, vitamin B, vitamin C, vitamin D, beta-glucan, folic acid, potassium and copper. These can control diseases like diabetics, cancer and weak bones. The mushrooms has numerous health benefits such as better immune function, lowers bad cholesterol, boosts heart health, absorption of calcium, improved metabolic processes and maintain strong bones.

## 2. FUNGI IN MEDICINAL IMPORTANCE

The medicinal importance of fungi should not be ignored as it plays an important role in fields like Ayurvedic dravyaguna and pharmacognosy (Vaidya and Rabba, 1993**).** Members of fungal genera Inonotus and Phellinus are well-known as medicinal fungi (medicinal mushrooms) that are used in treatment of bacterial and viral infections, cancer, diabetes, and ulcer (Lee and Yun, 2011). Fungal β-(1→ 3),(1→ 6)-glucans are non-cellulosic β-glucans that are used clinically in China and Japan as potent immunological activators treating diseases like microbial infections, hypercholesterolaemia, cancer, and diabetes (Chen and Seviour, (2007**).**

**Table** 1*:* Fungi in medicinal importance

| Name of fungi | Medicinal importance | Description | References |
|---|---|---|---|
| Larch quinine fungus *(Laricifomes officinalis)* | Astringent, Diarrhoea, Water motion, Vomiting, Haemorrhoids spasmodic coughing suppressing lactation | The active ingredient is Agricin | Vaidya and Rabba, 1993 |
| Chaga *(Tchaga)* | Used in Ulcers , Tumours (Pulmonary and Gastric), Chronic Gastritis | Sold under the trade name "Befungin" has been approved within Russian medicinal research | |
| Snuff Fungus *(Daedaleopsis favida)* | Treatment for jaundice, Treatment of chronic diseases | Traditional medicine Mumbai (Bappa sule) | |
| Umbarache Ken | Cures Kidney disorders | Grows on fungus on ficus religiosa linn. | |
| Phansomba *(Fomes fomentarius)* | Diarrhoea and dysentery, healing of wounds | Used mostly by western Indian aqyurvedic doctors introduced into India by the Portuguese in Goa | |
| *Ganoderma lucidum* (Curt.: Fr.) P. Karst. | Showing anticancer and antitumor properties, treatment of hepatopathy, chronic hepatitis, nephritis, hypertension, arthritis, neurasthenia, insomnia, bronchitis, asthma, and gastric ulcers.[ | Contain numerous bioactive compounds including polysaccharides, triterpenes, and immunomodulatory proteins | Chang and Buswell, 1999; Wasser, 2005 |

Fungi play a major role in Ayurvedic methods like Dravyaguna and pharmacognosy shows good medicinal importance in India and western countries (Vaidya and Rabba, 1993)., Fungi also plays an important role as medicinal and human food from past 30 years leads to finding population structure, climatic factors and distribution that influence the of existence of endophytic fungi grows on host plants (Jia, et al., 2016).

## *3. Ganoderma lucidum*

*Ganoderma lucidum* is a wood-degrading fungi that belongs to basidiomycetes is very rare in nature that has pharmacological effects (Boh et al., 2007). In Latin, lucidum means shiny or brilliant appearance on fruiting body showing a symbol of good fortune, happy augury, longevity, good health, and even immortality (Wasser, 2005). It has good therapeutic potential in the promotion of health and longevity that is used extensively as "the mushroom of immortality" in Asian countries like China, Japan, Korea and India from past 2000 years (Sanodiya et al., 2009; Sliva, 2003). The dried powder of *Ganoderma lucidum* is mostly used in the treatment of cancer in ancient China. Ganoderma lucidum, an oriental medicinal fungus (Figure 1) showing a variety of biological activities like anticancer activity (Yuen and Gohel, (2005), anti-diabetic activity (Ma, et al., 2015), hypoglycemic effect (Zhang and Lin, 2004). antimicrobial and antioxidant properties (Zhu et al., 1999; Kamra and Bhatt, 2012).

**Figure 1:** *Ganoderma lucidum*

Herbal medicines are important in health care systems throughout the world from ancient times of mankind that are attracting more attention within the context of health sector reform (Table 2). β-sitosterol and 5α-reductase inhibitor are well-known molecules that were identified in the Ganoderma extracts. Ganoderma is considered to be a natural medicine with clinical benefits like hepatitis, chronic bronchitis, hyperglycemia, hypertension, leucopenia, arteriosclerosis, muscular dystrophy, cancer, and hypercholesterolemia (Nahata, 2013).

**Table 2: Treatment and extraction process f compounds from fungi**

| Compound present | Treatment | Extraction process | Reference/s |
|---|---|---|---|
| 5α-reductase | Prostatic hyperplasia | Petroleum ether extract via high-performance thin-layer chromatography | Nahata and Dixit, .2012 |
| Ganodermin | Inhibited the mycelial growth of Fusarium oxysporum, Botrytis cinerea and Physalospora piricola | Chromatography on DEAE-cellulose, Affi-gel blue gel, CM-Sepharose and Superdex 75. | Wang and Ng. 2006 |
| Laccase | Human immunodeficiency Virus (HIV)-1 | Sequential chromatography on DEAE-cellulose and Affi-gel blue gel and adsorption on Con A-Sepharose,.molecular mass of 75 kDa protein | |
| Triterpenes | Antioxidant, metabolic-regulating, immunomodulatory, and anti-inflammatory activities | Methanol, ethanol, acetone, chloroform, ether, or a mixture of these solvents in normal and reverse-phase HPLC | (Chen et al. 1999; Su et al. 2001). |
| Ganoderic acids A and B | Prostate Cancer | Cellulose-dissolving ionic liquids | Kubota et al., 1982 |
| Ganoderic and lucidenic acids, other triterpenes such as ganoderiols, ganoderals, and ganodermic acids | Antibacterial, antiviral, antitumor, antiosteoclastic differentiation activity, anti-HIV-1, hepatoprotection, antioxidation, antihypertension, cholesterol reduction, and antiaggregation functions. | Based on 7 fractions Column | Nishitoba et al. 1984; Sato et al. 1986; Budavari 1989; |
| Ethyl acetoacetate ethylene acetal<br>Pyridine-3-ol<br>l,4-Dioxane-2,3-diol<br>Butylated Hydroxy Toluene<br>9-Cedranone | AgNPs synthesized using G. lucidum with 70% ethanol extract inhibited the growth of E. coli | GC–MS study | Al-Ansari et al., 2020 |

The family Ganodermataceae is double-walled basidiospore fungi having 219 species. *Ganoderma* species is having different shape and color (red, white, black, yellow, blue/green, and purple) of the fruit body with host specificity, and geographical origin. The artificial cultivation of *G. lucidum* can be achieved using substrates such as grain, sawdust and wood logs in South China (Black type) and Japan (red type). *G. lucidum* contains 26–28% carbohydrate, 1.8% ash, 59% crude fiber, 3–5% crude fat, and 7–8% crude protein where as mushrooms contain 10% consists of 3–28% carbohydrate, 10–40% protein, 8–10% ash, 2–8% fat, 3–32% fiber, and some vitamins and minerals, with calcium, magnesium, potassium, phosphorus, selenium, zinc, iron, copper, terpenoids, steroids, phenols, nucleotides and their derivatives, glycoproteins, polysaccharides, peptidoglycans, and triterpenes (Wachtel et al., 2011) . *G. lucidum* in used in the treatment of cancer, diabetes, bacterial and viral infection, and liver injury.

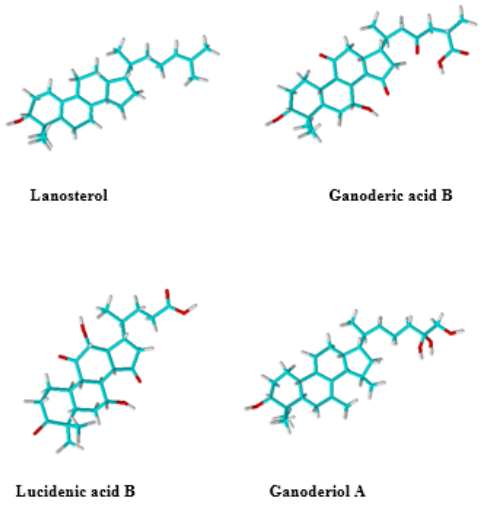


**Figure 2:** Compounds from *G. lucidum*

Two new lanostane-type triterpenoids, ganoderiol A (1) and ganoderiol B (2) together with known ganodermanontriol (3) and ganodermatriol (4). The compounds were identified as 5α-lanosta-7,9(11)-dien-3β,24,25,26-tetraol (1), 15α,26,27-trihydroxy-5α-lanosta-7,9(11),24-trien-3-one (2), 24,25,26-trihysdroxy-5α-lanosta-7,9(11)-dien-3-one (3) and 5α-lanosta-7,9(ll),24-trien-3β,26,27-triol (4), respectively are isolated from Ganoderma lucidum (Sato et al. 1986).

## 4. PATHOGENIC MICROBES ON HUMAN

Microbes and hosts play important interacticve mechanisms towards reciprocal relationship. Humans contain dynamic and complex community of microbes known as microbiome that processes a "metaorganism" towards pathogenic or symbiotic relationships to the host (Cho and Blaser, 2012,). Yeast and fungal proteins including (1,3)-β-glucan, high levels of fungal polysaccharides diffuse mycoses in the peripheral blood of patients that chronic fungal infections may increase risk. Composition of the human microbiome and exposure to pathogens changes with age, diet, lifestyle, and biological environment.

## 4.1 PATHOGENIC MICROBES IN EAR, NOSE, THROAT INFECTIONS

***Staphylococcus spp, Streptococcus spp, Escherichia, Pseudomonas*.** are leading pathogens present on ear, nose and throat region, The common bacteria isolated from ear exudate, are ***Staphylococcus aureus*** *(45%), Pseudomonas aeruginosa (34%), Proteus mirabilis (16%)* and Other organisms, were isolated is less frequently. microorganisms can protected by extrinsic pathogenic threats (Agha and Al-Delaimi, 2021). When imbalance occurs, the organism is susceptible to a cause of infections. Synthetic drugs used to help the body fight against from fungal, bacterial, or viral burden (Table 3). They may produce undesirable consequences such as toxicity, adverse effects, and drug resistance. Therefore, research focused on developing novel formulations which is based on natural compounds for safer and more efficient alternatives. The microbiomes of the ear, nose, and throat, and pathogenic microorganisms, and related infections the mode of action of antimicrobial drugs that are used to treat those infections. A haemolytic *Streptococcus* infection. Respiratory tract infection (RTI) with followed by Staphylococcus aureus

(14%), *Klebsiella pneumoniae* (11%), *Escherichia coli* (07%) and *Enterobacter cloacae* (07%) patients is considered as major health problem in Throat Infections in Lower Himalayan Region (Singh, 2020).

**Table 3:** Pathogenic microbes and infection caused from ENTmicrobes

| Human Part | Pathogenic Microbes | Infection | References |
|---|---|---|---|
| Ear | *Pseudomonas aeruginosa*<br><br>*Aspergillus niger & Candida albicans.*<br><br>*Streptococcus pneumoniae & Haemophilus influenzae & Moraxella catarrhalis* | Swelling, inflammation, irritation, and drainage of pus and/or blood,<br><br>Permanently damage the ear canal, leading to hearing loss wimmer's ear. | *Keene et al., 2004.*<br><br>*Ho et al., 2006* |
| Nose | *S. pneumoniae*, *Haemophilus influenzae*, *and Moraxella catarrhalis*,<br><br>*S. aureus* | Colonize the nasal passages of healthy children.<br><br>Colonization of the nasal passages is adults. | Liu et al., 2015. |
| Throat | *Firmicutes, Fusobacteria, Streptococcus , Neisseria, Gemella* | Pain and sensation of heat in the throat, fever, cough, congestion, flu-like symptoms, swollen lymph nodes | Hong-Li Gong et al.,2013 |

*Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Proteus spp*. and *Klebsiella* spp. are leading pathogenic microbes in paediatric patients. Most of the isolates showed high resistance to some antibiotic like cephalosporins. (Abernethy *et al.*,2017). Infections remain the causes of disease, in upper respiratory infections causes hearing loss and disability of learning found in children. In developing countries, name chronic otitis-media causes serious ear infection. Otitis-media, now known to be the most common childhood infection, which leads annually death of over 50,000 children under 5 years, in nasal conditions case of nasal myiasis/maggots in the nose.

**Some factors affect the diseases**

1- Air pollution directly affect the nose and larynx causing irritation, inflammation and infections, ear is also affected and causing impairment of middle ear, when pollutant enter the mucosa of the tuba.

2- Environmental pollution increasing resistance of microorganisms associated with ENT infections.

3- Emotional stress often with significant impairment of the daily life affected patients. With increase in global population.

## 5. SYNTHESIS OF ETHANOLIC AgNO3 EXTRACT OF *GANODERMA LUCIDUM*

*Ganoderma lucidum* was reported with rich medicinal properties due to having good number of medicinal compounds (Al-Ansari et al., 2020). Fungal bioactive compounds show potential biomedical application for alternative therapy for alimentary infections. In the present decades, there is a much gaining attention to scientists in green synthesis of silver nanoparticles (AgNPs) from plant extracts due to abundance, environmental issue and the cost-effective solution. AgNPs can be characterized by techniques like UV-Vis spectrophotometer, X-ray diffraction (XRD), FTIR, energy-dispersive X-ray spectroscopy (EDX), SEM, and transmission electron microscopy (TEM) (Nguyen et al., 2021).

## 6. BIOCHEMICAL PROPERTIES OF *Ganoderma lucidum*

Biochemical properties of mushroom fruiting bodies are numerous, and higher Basidiomycetes mushrooms have been used in folk medicine throughout the world since ancient times. *Ganoderma lucidum* reportedly has anti-inflammatory properties. TLC analysis suggested that the active principles in vivo were triterpenoids. These results indicate that the triterpenoids fraction of *G. lucidum* might be a useful ingredient in the treatment of benign prostatic hyperplasia (Table 4).

*Ganoderma lucidum* species is mostly using in the formulation of functional foods and as nutraceuticals. The fungi are recognized in modern and traditional medicine and pharmacology systems for the presence of biochemical compounds. The process of glycosylation of proteins plays an important role in the occurrence of biochemicals within the fungi.

**Table 4:** Biochemicals from *G. lucidum*

| Extract | Part | Biochemicals | Reference |
|---|---|---|---|
| Ethanolic extracts | Mycelium | Polysaccharides, phenol, proteins | Saltarelli et al., 2009 |
| *Ethanol* | Mycelium | Triterpenoids | Liu et al., 2007 |
| Ethanolic extracts | Whole fungi | Flavonoids (quercetin, rutin, myricetin, and morin), protein, Phenols | Saltarelli, et al., 2015 |
| Hexane, dichloromethane, ethyl acetate, and methanol | Fruit body | phenols, flavonoids and ascorbic acid | Kamra and Bhatt,2012 |
| All | Mycelia and spores | 400 different bioactive substances, including polysaccharides (Glucose, mannose, galactose, xylose, fucose and arabinose), triterpenoids, nucleotides, sterols, steroids, fatty acids, proteins/peptides and trace elements | Zeng et al., 2018 |

## 7. BIOLOGICAL PROPERTIES OF *Ganoderma lucidum*

### 7.1 Antioxidant activity

*Ganoderma lucidum* **is a** famous Chinese medicinal mushroom that is mostly cultivated procedurally, harvested seasonally and should be dried for preservation. Oxidative metabolism in the body is essential that are present in foodstuffs for the survival of cells (Antolovich et al., 2002). Free radical scavenging properties by ascorbic acid have many health benefits in biological systems have many important bioactive compounds showing pivotal role in delaying oxidative rancidity (Table 5).

**Table 5***: Antioxidant activity of G. lucidum*

| Extract | Type | Reference |
|---|---|---|
| Hot water extract | Antioxidative effect on lipid peroxidation and superoxide scavenging activity in mouse heart homogenate | Wong et al., 2004 |
| Water- extract | Antioxidant activities by hydroxyl radical, reducing power, 2, 2-diphenyl-1-picryl-hydrazyl (DPPH) free radical and ferric-reducing antioxidant power tests. | Zeng et al., 2019 |
| Ethanol | DPPH scavenging ability<br>ABTS radicals scavenging activity | Lin et al., 2015 |

### 7.2 Antimicrobial properties

Most of the plant and mushrooms are showing medicinal properties for thousands of years for the investigations into its mode of action as antimicrobial agents (Table 6). Antioxidant antibacterial, antifungal, insecticidal and antiviral properties have been investigated in several plants**.**

**Table 6:** Antimicrobial activity of *G. lucidum*

| Extracts | Microorganisms | Description | Reference |
|---|---|---|---|
| Ethyl alcohol, methanol, acetone and distilled water. | *Escherichia coli (MTCC-443), Staphylococcus aureus (MTCC-737), Klebsiella pneumoniae (MTCC-2405), Bacillus subtilis (MTCC-1789). Salmonella typhi (MTCC-531) and Pseudomonas aeruginosa (MTCC-779)* | Good antimicrobial activity with ethanol and acetone extracts against most of the pathogens. | Quereshi, et al., 2010 |

| | | | |
|---|---|---|---|
| Hexane, dichloromethane, ethyl acetate, and methanol | *Bacillus subtilis, Enterococcus faecalis, Listeria monocytogenes, Streptococcus mutans, Klebsiella pneumoniae, Proteus vulgaris, Salmonella typhimurium and Pseudomonas aeruginosa* | Methanol and aqueous extract exert strong antimicrobial activity. | Kamra and Bhatt,2012 |
| Methanol (MeOH) and Dichloromethane (DCM) | *Staphylococcus aureus ATCC 29213, Staphylococcus aureus MRSA ATCC 43300, Enterococcus faecalis ATCC 29212, Escherichia coli ATCC 25922, Pseudomonas aeruginosa ATCC 27853, Klebsiella pneumoniae ATCC 700603, Acinetobacter baumannii ATCC 19606, Candida albicans ATCC 10231, Candida krusei ATCC 34135 ATCC 13803, and Candida glabrata ATCC 90030* | Ntural antimicrobial agent against all tested microorganisms. | Celal, 2019 |

### 7.3 X-ray film method

Gelatin is a natural polymer that is non toxic, biodegradable, and biocompatible. Bio-Silver nanoparticles synthesized from *Ganoderma lucidum* have lot of properties; Anti-diabetic, Anti-microbial, anti-inflammatory and wound healing properties (Sneha, 2015) . Drug that are in nano size help in easy targeted and transferred to specific site. Gelatine and bio-silver nanoparticles synthesized from *Ganoderma lucidum* are anticipated the combination effect with nanosized drug (Bio-Silver nanoparticles) compounds results may serve as promising film forming matrix for transdermal delivery of drugs into skin.

## 8. MOLECULAR MECHANISM FOR TRETMENT OF MICROBS IN EAR, NOSE, THROAT INFECTIONS

Amoxicillin is one of the most commonly used antibiotics that is effective against *Streptococcus* species, *Listeria monocytogenes, Enterococcus spp*., *Haemophilus influenzae*, some *Escherichia coli, Actinomyces spp., Clostridium species, Salmonella spp., Shigella spp., and Corynebacteria* species. Amoxicillin is in the class of beta-lactam antimicrobials that bind to penicillin-binding proteins that inhibit process of transpeptidation (Akhavan et al., 2021).

human microbiome is a complex community with different microbial composition, function and microbial niche Specificity present in different human body sites like gastrointestinal tract, skin, and airways (Ear, Nose, Throat) (Kumpitsch et al., 2019). The oral microbiome is commonly associated with systemic diseases that can extend to surrounding tissues, spread and overgrow in the oral mucosae. Many natural compounds from plants, animals and microbes show antifungal, antibacterial, antiviral, and antibiofilm activities. Studies reveled that combining silver nanoparticles with natural extracts have also shown better promising results (Adelina-Gabriela and Alexandru, 2021).

Microbial infections of the ear, nose, and throat are common problems that are encountered by human beings practicing with treatment with antimicrobial drugs are challenging to scientists due to mechanism of resistance developed by the microorganisms (Muhammad et al., 2021). Mechanisms like disruption of the protective extrapolymer matrix, interruption of quorum sensing, inhibition of related genes, mechanical debridement of the biofilm-bearing tissues and macrolides (clarithromycin and erythromycin) are some effective prevention and management strategies in formation of Biofilms during chronic and common antibiotic-resistant during ear, nose, and throat (ENT) infections (Petros et al., 2007).

## 9. IN SILICO STUDIES OF EXTRACT OF *Ganoderma lucidum*

Medicinal fungus *Ganoderma lucidum* Karst. (Ganodermataceae) showing screening using 529 pharmacophore models and 279 compounds has been developed by Ulrike et al., 2015. Systematic isolation, and in silico pharmacological prediction has been conducted to discover potential anti-cancer activity from G. lucidum. Compounds like 3β,7β,15β-trihydroxy-11,23-dioxo-lanost-8,16-dien-26-oic acid, 3β,7β,15β-trihydroxy-11,23-dioxo-lanost-8,16-dien-26-oic acid methyl ester, (4E,8E)-N-D-2′-hydroxypalmitoyl-l-O-β-D-glucopyranosyl-9-methyl-4,8-spingodienine, ganotropic acid, 3β,7β,15α,28-tetrahydroxy-11,23-dioxo-lanost-8,16-dien-26-oic acid, (3β,7α)-dihydroxy-lanosta-8,24-dien- 11-one, 26-nor-11,23-dioxo-5α-lanost-8-en-3β,7β,15α,25-tetrol and stigmasta-7,22-dien-3β,5α,6α-triol were first reported from the genus Ganodema. The research on extraction, isolation, pharmacological prediction, and protein interaction network (PIN) analysis might be useful to predict pharmacological activities rapidly and discovery of novel compounds (Shao et al., 2016).

## 10. CONCLUSION

Most of the plant and mushrooms are showing medicinal properties for thousands of years for the investigations into its mode of action as antimicrobial agents. Antioxidant antibacterial, antifungal, insecticidal and antiviral properties have been investigated in several plants and microbes. There is a much gaining attention to scientists in green synthesis of silver nanoparticles (AgNPs) from plant extracts due to abundance, environmental issue and the cost-effective solution.

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