Chapter II

REVIEW OF LITERATURE

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2.1. Phytochemical Analysis

Opole *et al.* (1995) reorted that the leaves may be crushed to make a concoction that is drunk to cure diseases such as scurvy. In many cultures, boiled leaves are regarded as a medicinal meal. In other communities, leaves are boiled and marinated in sour milk for 2-3 days and eaten as a nutritious meal, which is believed to improve eyesight, provide energy and cure Marasmus. It is a highly recommended meal for pregnant and lactating women. The in some communities, leaves boiled in water are believed to dry up a mother's milk. Eating the vegetable is believed to reduce dizzy spells in pregnant women. It is believed that regular consumption of the leaves by pregnant women will ease childbirth by reducing the length of their labour, and will help them regain normal health more quickly afterwards.

Uma *et al.* (2009) investigated that against some bacterial and fungal pathogens isolatedfrom patients with infectious diarrhoea. The various solvents extract like aqueous, methanol, chloroform, petroleum ether and hexane were screened for antimicrobialactivity by disc diffusion method. The preliminary phytochemical analysis of themethanol extract of the plant showed the presence of carbohydrates, alkaloids,flavonoids, amino acids, steroids, sterols and saponins *Cleome gynandra,*

Anbazhagi *et al*. (2009) described the phytochemical screening of the powdered leaf revealed the following compounds Carotenoids, Cardiac glycosides, Cyanogenic Glycosides, Flavonoids, Saponins, Triterpenes, sugars, Tannins etc., found thatthe leaves and seeds are used medicinally as rubefacient and vesicant, and to treat rheumatism, externally as well as internally. An infusion of the roots is used as a medicine for chest pain, the leaves to treat diarrhoea. Spiderplant seeds thrown in water can kill fish, which then float to the surface.

Mishra *et al*. (2011) investigated the glands on the stems and leaves have insect repellent properties; cabbage and related crops intercropped with spiderplant suffer less from diamond back moth larvae. Similarly, in French bean intercropped with spiderplant, the beans are less affected by flower thrips and are therefore of better quality for export.

Annadurai and Ahmed John. (2014) investigation that the extracts from leaf, stem and root of Cleome gynandra L. in different solvent, weresubjected to phytochemical screening. The phytochemical solvent extracts were used for screening. ThePhytochemical studies indicate that the leaf, stem and root contain a broad spectrum of secondary metabolitesTannin, Steroids, cardiac glylosides and Alkaloids were predominantly found in all the three tested solvent extractsof leaf followed by Tannin, Saponins, Steroids, cardiac glylosides and Alkaloids (Acetone, Chloroform and Diethylether). Likewise, Tannins, Saponins, Steroids, Terpenoids, cardiac glylosides and anthrquinonus werepredominantly found in all the tested solvent extracts of the stem. Then root followed by Tannins, Saponins, Steroidsand cardiac glylosides were predominantly found in all the

tested solvent in plant extracts. Flavanoids were notfound in any of the solvent extract of stem, leaf and root.

Srinivas *et al*. (2014) investigation the concentrated on phytochemical screening of leaf crude extracts of *Cleome gynandra* L. indifferent solvents like methanol, ethanol, petroleum ether, chloroform and acetone. Specific tests wereconducted to identify each group of the phytochemicals of various extracts of *Cleome gynandra* L. The leafextracts of *Cleome gynandra* L was extracted separately with methanol, ethanol, acetone, petroleum ether andchloroform that were screened for phytochemical constituents. Among the entire extracts tested methanol, ethanol extracts showed more phytochemicals than the others followed by acetone chloroform and petroleumether. Analysis revealed the presence of alkaloids, phenols, saponins, steroids, flavonoids, cardiac glycosidesand tannins. The Phytochemical studies indicate that the crude leaf extracts of *Cleome gynandra* L. Tannins,phenols, steroids and cardiac glycosides were mainly found in all the five tested solvent extracts of leaf followedby Saponins and Alkaloids.

Afolayan *et al*. (2015) investigation the secondary metabolites which accounts for its strong antioxidant ability thus justifying its use as natural occurring antioxidants in folkloric medicine. The study encourages a regular consumption of this wild vegetable in order to avert oxidative stress related diseases.

2.2. Antimicrobial Activity *C. gynandra*

The generation of free radicals has been implicated in the causation of several diseases of known and unknown aetiologies such as, rheumatoid arthritis, diabetes, cancer, etc., and compounds that can scavenge free radicals have great potential in ameliorating these disease processes. The laboratory experimental study on animal models exhibited the anti-oxidant potential of *C. gynandra* leaf extract at a dose of 150 mg/kg body weight for a 30 days' trial on adjuvant induced arthritis in experimental rats. Oral administration of *C. gynandra* leaf extract significantly increased the levels of lipid peroxidase and activities of catalase, glutathione peroxidase and decreased the levels of reduced glutathione and superoxide dismutase activity in arthritis induced rats. The free radical scavenging activity of the plant was further evidenced by histological observations made on the limb tissue. The presence of biologically active ingredients and vital trace elements in the leaves readily account for free radical scavenging property of *C. gynandra.*

Ajaiyeoba *et al.* (2000) reported that the hexane and methanolic extracts of eachof the plant materials of the two plants were screened for antimicrobial properties using eleven clinical strains ofhuman pathogenic microorganisms. At a concentration of 200mg/ml, the extracts displayed various degrees of activity in both bioassays. Of the eight extracts investigated, B. coriaceae stem hexane extract displayed thehighest activities in both assays in the agar cup diffussion technique. The microorganisms that were used included six bacteria and five fungi. Ampicillin and tioconazole were used as standard reference drugs whilemethanol was incuded as a solubilising agent as well as a negative control

in the study. Diameters of zones of inhibition were in the range of 10-24mm for the extracts and drugs.

Uma *et al.* (2009) reported that the Antimicrobial activity revealed that methanol extract of the plant exhibit good activity compared to chloroform and aqueous extracts against all bacterial pathogens tested. Petroleum ether and hexane extracts did not show any activity. None of extracts exhibited antifungal activity. The antimicrobial activities of extracts were compared with standard antibiotics.

Annadurai *et al.* (2014) investigation that the of crude extracts from leaf, stem and root of *Cleome gynandra* L., in different solvent, were subjected to antibacterial activity against the selected Gram positive and Gram negative bacteria. The antibacterial activities were analyzed. All the extracts showed varying degree of inhibitory potential against all the tested bacteria. (Acetone, Chloroform) extracts of leaf had higher inhibitory action against *Pseudomonas*, *Escherichia coli*, *Staphylococcus aureus* and *Salmonella* respectively.

Saravanamoorthy *et al.* (2016) investigated that the study of solvent extracts on plant parts like root, stem and leaves of Studied against the reference bacterial strains of vulgaris. The inhibition of bacterial strains was more pronounced with leaf solvent extract than stem and root. The percentage of inhibition was higher with compare to *E. faecalis*.

2.3. Anticancer Activity of *C. gynandra* on Ehrlich's Ascites Carcinoma Treated Mice

Bala *et al.* (2010) investigated that the anticancer activity of methanol extract of Cleome gynandra (MECG) was evaluated in Swiss albino mice against Ehrlich Ascites Carcinoma (EAC) cell line at the doses of 200 and 400 mg/kg body weight intraperitoneally. MECG was administered for nine consecutive days. Twenty-four hours of last dose and 18 h of fasting, the mice were sacrificed and antitumor effect ofMECGassessed by evaluating tumor volume, viable and nonviable tumor cell count, tumor weight and hematological parameters of EAC bearing host. MECG showed significant decrease in ($p < 0.01$) tumor volume, viable cell count, tumor weight and elevated the life span of EAC tumor bearing mice. Hematological profile such as RBC, hemoglobin, WBC and lymphocyte count reverted to normal level in MECG treated mice. Conclusion: From the result it was showed that the extract has potent dose dependent anticancer activity and that is comparable to that of 5-fluorouraci.

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2.4. Possible Antidiabetic Drug from *C. gynandra*

Knekt *et al.* (2002) found that the In previous clinical study and In-vitro experiments it has been confirmed that an Indian herb like Eugenia jambolana enriched in Na, Ca, Mg, Cl, Fe, Cu, Se, and Zn, essential nutrients responsible for curing diabetes. Over the past two decades, an expanding body of evidences from epidemiological and laboratory studies have demonstrated that some edible plants as a whole, or their identified ingredients with potent antioxidant properties, especially the predominant polyphenolics as also in *C. gynandra*, have substantial protective effects on human carcinogenesis, cardiovascular and renal disorders, memory and cognitive function, age-related neurological dysfunction such as Alzheimer's disease, diabetes, ulcers and several other human ailments.

2.5. Silver Nanoparticles

Creighton *et al.* (1979), Lee *et al.* (1982) and Henglein, (1989) investigated that the fundamental studies carried out in the last three decade shows that silver nanoparticles exhibit a rare combination of valuable propertiesincluding, unique optical properties associated with the surface Plasmon resonance (SPR), well-developed surfaces, catalytic activity, high electrical double layer capacitance, etc. For that reason, silver nanoparticles serve as a material in the development of new-generation electronic, optical and sensor devices. In the past 20 years, the trend miniaturization and the necessity of modernization of technological processes led to the substantial increase in the number of scientific publication devoted to the synthesis and properties of silver nanoparticles.

Schneider *et al.* (1979) and Lee *et al.* (1982) found that the Synthesis of Ag NPs is based on a twosteps reduction process. In this technique a strong reducing agent is used to produce small Ag particles, which are enlarged in a secondary step by further reduction with a weaker reducing agent.

Henglein, (1989) and Ershov *et al.* (1993) investigated that the some studies showed that use of a strong reductant such as borohydride, resulted in small particles that were somewhat monodisperse, but the generation of larger particles was difficult to control

Barber, (1990) reported that the optical properties of silver nanoparticles were used by glass founders as far back as in the time of the Roman Empire. That evidenced, so-called Lycurgus cup (4^{th} century AD) now exposed in the British Museum. A detailed study of the composition of its bronze-mounted insets of stained glass, carried out in the late 20th century, revealed the presence of metal nanoparticles (with the average diameter of 40 nm) that consists of silver (70 %) and gold (30 %) alloy. It explained the remarkable feature in bowl to change its colour from red in transmitted light to greyish green in reflected light. Before the 1980s, the scientific and practical interest in silver nanoparticles was exclusively caused by the possibility of their use as highly dispersed supports for enhancing the signals from organic molecules in the Raman spectroscopy.

Creighton *et al.* (1994) and Schneider *et al.* (1979) investigated that the use of a weaker reductant such as citrate, resulted in a slower reduction rate, but the size distribution was far from narrow.

Nagy *et al.* (1999) reported that the Silver is used as a catalyst for the oxidation of methanol to formaldehyde and ethylene to ethylene oxide. This band is attributed to collective excitation of the electron gas in the particles, with a periodic change in electron density at the surface.

2.5.1. Synthesis of Ag Nanoparticles

Granqvist *et al*. (1976), Shibata *et al.* (1998) and Shankar *et al.* (2003) investigated that the material scientist's researcher is conducting to develop novel materials, with better properties, functionality and lower cost than the existing ones. Different physical, chemical and biological synthesis methods have been developed to enhance the performance of nanoparticles displaying improved properties with the aim to have a better control over the particle size, distribution and morphology.

Hahn (1997) reported that the Synthesis of nanoparticles to have a better control over particles size, distribution, morphology, purity, quantity and quality, by employing as environment friendly economical processes has always been a challenge for the researchers.

2.5.1.1. Synthesis of Ag Nanoparticles by Biochemically

Nair *et al.* (2002) reported that the some chemical approaches are the most popular methods for the preparation of nanoparticles. However, some chemical methods cannot avoid the use of toxic chemicals in the synthesis procedure. The noble metal nanoparticles such as gold, silver and platinum nanoparticles are widely applied to human contacting areas, there is a growing need to develop environmentally friendly processes of nanoparticles synthesis

that do not use toxic chemicals. Some biological methods of nanoparticles synthesis using microorganism. For nanoparticles synthesis using plant can be advantageous over other biological processes by eliminating the elaborate process of maintaining cell cultures.

Shankar *et al.* (2004) found that the It can be suitably scaled up for large-scale synthesis of nanoparticles. The biological systems can provide a number of metal or metal containing particles in the nanometer size range. Some of the examples, the synthesis of magnetite nanoparticles by magneto tactic bacteria.

Pum *et al*. (1999) identifuied that the synthesis of nanoparticles would benefit from the development of clean, nontoxic and environmentally acceptable ‘‘green chemistry’’ procedures and involving organisms ranging from bacteria to fungi and even plants.

Bhattacharya *et al.* (2005) and Sastry *et al.* (2004) reported that the Verticillium sp. and Fusariumoxysporum biomass fungal biomass when exposed to aqueous $AgNO_3$ solution resulted in the intracellular formation of silver nanoparticles and extracellular silver nanoparticles.

Senapati *et al.* (2004) found that the Marine bacteria such as bacteria, yeast, fungi and actinomycetes have been described for the formation of nanoparticles and their applications.

2.5.1.2. Green Synthesis of Nanoparticles

The production of nanoparticles by living organisms or material of biological origin for example, nanoparticles may be synthesized using living bacteria or fungi, or using plant extracts. That techniques provided an

advantages over more traditional methods of synthesizing nanoparticles because they are environmentally friendly, can take place around room temperature or lower, and require little intervention or input of energy. In these methods, organisms involved are generally easily cultured in simple organic media, are a renewable resource, and can usually simply be left to do their work. Various organisms could synthesize inorganic particles, including silica and calcium carbonate, or chalk, that has long been known. Many more Marine bacteria are able to reduce metal ions to metal. Several bacteria can produce magnetic material by the reduction of iron compounds, incorporating magnetic nanoparticles into bodies known as magnetisms within their cells. Some types of bacteria have been successfully employed in the biosynthesis of nanoparticles. This can take place both intracellularly and extracellularly.

2.5.1.3. Plants Derived Nanoparticles

Torresday *et al.* (2002) reported that the Group of researchers developed silver nanoparticles being extensively synthesized using various Plants. Different types of plants are being currently investigated for their role in the synthesis of nanoparticles. Silver nanoparticles with a size range of 2- 20 nm have been aqdvhsynthesized using the live alfa alfa plants *Medicago sativa* (Alfa alfa) and *Heliantusannus* (Sunflower). Certain plants are known toaccumulate higher concentrations of metals compared to others and such plants are termed as hyper-accumulators. Of the plants investigated, *Brassica juncea* had better metal accumulating ability and later assimilating it as nanoparticles

Bali *et al.* (2006) concluded that the three types of Mesophyt were studied benzoquinones, namely, cyperoquinone, dietchequinone, and rem 5irin. It was

reported that catechol under alkaline conditions gets transformed into protocatechaldehyde and finally into protocatecheuic acid.

Jha *et al.* (2009) found that the both these processes liberated hydrogen and it was suggested that it played a role in the synthesis of the nanoparticles. The size of the nanoparticles synthesized studies were using xerophytes, mesophytes and hydrophytes were in the range of 2- 5nm.

Song *et al*. (2009) found that the recently some gold nanoparticles have been synthesized using the extracts of *Magnolia kobus* and *Diopyros kaki* leaf extracts. It was investigated that the effect of temperature on nanoparticle formation was investigated and polydispersed particles with a size range of 5-300nm were obtained at lower temperature while a higher temperature supported the formation of smaller and spherical particles.

2.5.1.4. Biosynthesis of Nanoparticles by Algae

Singaravelu *et al* (2007) reported that the review of literature revealed that the synthesis of nanoparticles using algae as source has been unexplored and underexploited. Recently, there are few, reported that algae being used as a biofactory for synthesis of metallic nanoparticles, which implemented an efficient approach for synthesis of stable gold nanoparticles by the reduction of aqueous $AuCl_4$ using *Sargassum wightii.*

2.5.1.5. Nanoparticle Synthesis Using Bacteria

Fu *et al*. (1999, 2000) found that the mainly, silver nanoparticles in the size range of 10- 15 nm were produced by treating dried cells of *Corynebacterium sp*. SH09 with diammine silver complex.

Sastry *et al.* (2003) investigated that the most cases of bacteria, most metal ions are toxic and therefore the reduction of ions or the formation of water insoluble complexes is a defence mechanism developed by the bacteria to overcome such toxicity.

Shankar *et al*. (2004) investigated that the examples of bacteria synthesizing inorganic materials include magnetotactic bacteria (synthesizing magnetic nanoparticles) and Slayer bacteria which produce gypsum and calcium carbonate layers.

Fu *et al*. (2006) reported that the ionized carboxyl group of amino acid residues and the amide of peptide chains were the main groups trapping (Ag (NH_4)) $^{2+}$ onto the cell wall and some reducing groups such as aldehyde and ketone were involved in subsequent bioreduction, but it was found that the reaction progressed slowly and could be accelerated in the presence of OH.

Gericke and Pinches (2006) found that the Synthesis of metal nanoparticles by using of microbial cells has emerged as a novel approach. Recently, the efforts directed towards the biosynthesis of nanomaterials, the interactions between Marine bacteria and metals have been well documented and the ability of Marine bacteria to extract and/or accumulate metals is employed in commercial biotechnological processes such as bioleaching and bioremediation. Bacteria are well known to produce inorganic materials either intracellularly or extracellularly. Marine bacteria are concluded as a potential biofactory for the synthesis of nanoparticles like gold, silver and cadmium sulphide.

Husseiny *et al*. (2007) reported that the some types of Marine bacteria stay alive at high metal ion concentration due to their resistance to the metal. That mechanism involved: efflux systems, alteration of solubility and toxicity via reduction or oxidation, biosorption, bioaccumulation, extra cellular complication or precipitation of metals and lack of specific metal transport systems. For example, of *Pseudomonas stutzeri* AG 259 isolated from silver mines has been shown to produce silver nanoparticles.

Mohanpuria *et al*. (2007) investigated that the several marine bacteria are known to produce nanostructured mineral crystals and metallic nanoparticles with properties similar to chemically synthesized materials, while exercising strict control over size, shape and composition of the particles. Some examples are the formation of magnetic nanoparticles by magneto tactic bacteria, the production of silver nanoparticles within the periplasmic space of *Pseudomonas stutzeri* and the formation of palladium nanoparticles using sulphate reducing bacteria in the presence of an exogenous electron donor.

Gericke and Pinches (2006) investigated that the though it is widely believed that the enzymes of the organisms play a major role in the bioreduction process, some studies have indicated it otherwise. Some studies are indicated, that some Marine bacteria could reduce silver ions where the processes of bioreduction were probably non enzymatic. For an example, dried cells of *Bacillus megaterium* D01, *Lactobacillus sp*. A09 were shown to reduce silver ions by the interaction of the silver ions with the groups on the microbial cell wall.

2.5.1.6. Use of Fungi to Synthesize Nanoparticles

Duran *et al.* (2005) reported that the indicates that probably the reductases in *F. moniliformae* were necessary for the reduction of Fe (III) to Fe (II) and not for Ag (I) to Ag (0) Nanocrystalline zirconia was produced by cationic proteins at room temperature while were similar to silicatein secreted by *F. Oxysporum.*

Mohanpuria *et al*. (2007) investigated that the Promising synthesis of nanoparticles appears by the use of specific enzymes secreted by fungi. This would lead to the possibility of genetically engineering Marine bacteria to over express specific reducing molecules and capping agents and thereby control the size and shape of the biogenic nanoparticles.

Balaji *et al.* (2009) reported that the Several Fungi has been widely used for the biosynthesis of nanoparticles and the mechanistic aspects governing the nanoparticle formation have also been documented for a few of them. In addition to monodispersed nanoparticles can be obtained using fungi as Compared to bacteria, fungi could be used as a source for the production of large amount of nanoparticles. Yeast, belonging to the class ascomycetes of fungi has shown to have good potential for the synthesis of nanoparticles. Gold nanoparticles have been synthesized using the fungi *V. luteoalbum*. Here, the rate of particle formation and therefore the size of the nanoparticles could an extent be manipulated by controlling parameters such as pH, temperature, gold concentration and exposure time. The extracellular secretion of the Marine bacteria offers the advantage of obtaining large quantities in a relatively pure state, free from other cellular proteins associated with the organism with relatively simpler downstream processing. The hypothesis indicated that

proteins, polysaccharides and organic acids released by the fungus were able to differentiate different crystal shapes and were able to direct their growth into extended spherical crystals.

2.5.1.7. Use of Actinomycetes to Synthesize Nanoparticles

Ahmad *et al.* (2003) investigated that the Actinomycetes are microorganism's share some characteristics of fungi and prokaryotes such as bacteria. In an effort to elucidate the mechanism or the processes favouring the formation of nanoparticles with desired features, studied the formation of monodisperse gold nanoparticles by *Thermomonospora sp.* and concluded that extreme biological conditions such as alkaline and slightly elevated temperature conditions were favourable for the formation of monodisperse particles. Based on this hypothesis, alkali tolerant actinomycete, *Rhodococcus sp.* has been used for the intracellular synthesis of monodisperse gold nanoparticles.

2.5.1.8. Use of Yeast to Synthesize Nanoparticles

Ahmad *et al.* (2003) investigated that industrially important strain of yeast (eukaryotic microorganism) has been found to be a prominent candidate for biological synthesis of quantum semiconductors nanoparticles. For the first time, the biological synthesis of cadmium sulphide (CdS) quantum nanocrystals was produced by the strain of *Candida glabrata*. The yeast biomass produces the intracellularly, monodispersed spherical shaped quantum nanocrystallites using cadmium salts and by neutralizing the toxicity of metal ions (metalthiolate complex). This finding gives an idea that the greater amount of formation of CdS nanocrystals mainly depends on the nature of growth profile of yeast biomass.

More recently, the strain of *Yarrowia lipolytica* NCIM3589 was found to be a goodcandidate for synthesis of gold nanoparticles associated with cell wall.

Ortiz *et al,* (2008) reported that the The mechanism involves two different steps, initially, an enzyme named phytochelatin synthase activated to synthesize phytochelatins, this reaction leads to forma low molecular weight metal-thiolate complex and eventually transport complex to across the vacuolar membrane by an ATP-binding cassette-type vacuolar membrane protein (HMT1).

Kalishwaralal *et al.* (2010) found that the reduction of gold ions occurred in pH dependent manner at pH 2.0; it produced hexagonal and triangular gold crystals due to the nucleation on the cell surfaces.

Jain *et al.* (2011) found that the documented that the addition of sulphide to the metal-thiolate complex in the membrane and that results in formation of high molecular weight PC CdS2-complex that allow them to sequestered into vacuole.

Kowshik *et al*. (2011) described that the extra cellular production of silver nanoparticles was reported using silver tolerant yeast strain MKY3, which synthesized hexagonal AgNP (2-5nm) in log phase of growth. Recently, yeast biomass has been identified for their ability to produce gold nanoparticles, whereby controlling growth and other cellular activities controlled size and shape of the nanoparticles was achieved.

2.5.1.9. Use of Virus to Synthesize Nanoparticles

Alivisatos *et al.* (1996) investigated that the An Eco-friendly microbial synthesis of nanoparticles has been received great attention and extended

towards intact biological particles (viruses). The biological molecules are plays a vital role in growth of semiconductor as a template, biological molecules include, fatty acids, amino acids, and polyphates.

Wong *et al.* (1998), Archibald *et al.* (1993) and Douglas *et al.* (1998) investigated that the example, by interchanging the ratio of different fatty acids (chain lengths), different nature of CdSe, CdS, and Cd Te nanocrystals can be achieved. Similarly, the variety of other biological materials is also involving in synthesis of inorganic materials. The other important bio-factories like DNA bacterial rapidosomes, S-layers and multicellular superstructures.

Davis *et al.* (1997) investigated that the used as template- mediated production of inorganic nanomaterials and micro structured materials. Interestingly, viral scaffolds were found to be a template for the process of nucleation and assembly of inorganic materials. Certainly, cowpea chlorotic mottle virus and cowpea mosaic virus have been used as nucleation cages for the mineralization of inorganic nanomaterials. In addition to this, tobacco mosaic virus (TMV) used as template for the successful synthesis of iron oxides by oxidative hydrolysis, co-crystallization and mineralization of CdS and lead sulphide (PbS) crystalline nanowire, and the synthesis of SiO_2 by sol-gel condension.

Mao *et al.* (2003) evaluated that the process happened with the help of external groups of glutamate and aspartate on the external surface of the virus. Peptides capable of nucleating nanocrystal growth have been identified from combinatorial screens and displayed on the surface M13 bacteriophage. A hybrid

nanowire (ZnS-CdS) is obtained with a dual peptide virus engineered to express A7 and J140 within the same viral capsid.

2.5.1.10. Synthesis of Silver by Solar Irradiation from *B. amyloliquefaciens*

Silver Nanoparticles (AgNPs) were obtained by using $AgNO_3$ solar irradiation of cell-free extracts of *Bacillus amyloliquefaciens*. Many factors like light intensity, extract concentration, and NaCl addition influenced the synthesis of AgNPs. TEM (Transmission electron microscopy) and XRD (X-ray diffraction) analysis confirmed that circular and triangular crystalline AgNPs were synthesized. The potential value of the AgNPs, possibly caused by interaction with proteins likely explains the high stability of AgNPs suspensions. AgNPs showed antimicrobial activity against *Bacillus subtilis* and *Escherichia coli* in liquid and solid medium.

2.5.2. Application of Silver Nanoparticles

2.5.2.1. Human Health

Koziara *et al.* (2003) and Oberdorster *et al*. (2004) investigatedthat the Exposure of metal containing nanoparticles to human lung epithelial cells generated reactive oxygen species, which lead to oxidative stress and damage of the cells.

Albrecht, (2006), found that the production of nanoparticles has many different effects on human health relative to bulk material. Increase the biological activity of nanoparticles can be determined beneficial, detrimental or both. Nanoparticles are enough to access to skin, lungs, and brain.

Limbach *et al.* (2007) and Xi *et al*. (2006) described that the study on toxic effects of silver nanoparticles was done, that results show a deposition of particles on organs and severe developmental effects. The biocompatibility and toxicity of silver nanoparticles were exhibited at each development stage by observing single silver nanoparticle inside embryos

2.5.2.2. Environment

Xi *et al.* (2006) reported that the Silver nanoparticles have a great concern to wastewater treatment utilities and to biological systems. The inhibitory effects of silver nanoparticles on microbial growth were evaluated at a treatment facility using an extant respirometer technique. The nitrifying bacteria were susceptible to inhibition by silver nanoparticles, which could have detrimental effects on the Marine bacteria in wastewater treatment. The environmental risk of silver nanoparticles was recently investigated by determining released silver from commercial clothing. The sock material and wash water contained silver nanoparticles of 10–500 nm diameter.

2.5.2.3. Catalytic Action

Jana *et al.* (1999 investigated that the Due to high surface area and high surface energy predetermine metal nanoparticles for being effective catalytic medium. Growing small particles of silver have been observed to be more effective catalysts than stable colloidal particles. These growing particles catalysed the borohydride reduction of several organic dyes. Investigated that the reduction rate catalysed by growing particles is distinctly faster compared to that of stable and larger silver particles, which are the final products of growing particles. Catalysis is due to efficient particle-mediated electron transfer from the

BH4- ion to the dye. The catalytic activity of the particles depends on their size, *E*1/2 ofthe dye, and the dye-particle interaction. Catalytic activity of silver nanoparticles can be controlled by its size, as redox potential depends on the nanoparticle size.

2.5.2.4. Antimicrobial Activity of Silver Nanoparticles

Jeong *et al.* (2005) reported that the Due to the non-toxic, safe inorganic antibacterial agent of silver Nanoparticles being used for centuries and is capable of killing about 650 Marine bacteria that cause diseases. Silver has been described as being 'oligo dynamic', that is, its ions are capable of causing a bacteriostatic (growth inhibition) or even a bactericidal (antibacterial) impact. Therefore, it has the ability to exert a bactericidal effect at minute concentration.

Percivala *et al.* (2005) investigated that the significant potential for a wide range of biological application such as antibacterial agents for antibiotic resistant bacteria, preventing infections, and healing wounds and anti-inflammatory.

Taylor *et al.* (2005) investigated that the Silver ions (Ag+) and its compounds are highly toxic to microorganism exhibiting strong biocidal effect on many species of bacteria but have a low toxicity towards animal cells. Bactericidal behaviour of nanoparticles is attributed to the presence of electronic effects that are brought about as a result of change in local electronic structure of the surface due to smaller sizes. The effects are considered to be contributing towards enhancement of reactivity of silver Nanoparticles surface. Silver in ionic form strongly interacts with thiol groups of vital enzymes and inactivates them.

That lead DNA loses its replication ability once the bacteria are treated with silver ions.

Morones *et al.* (2005) found that the Silver Nanoparticles destabilize plasma membrane potential and depletion of levels of intracellular adenosine tri-phosphate (ATP) by targeting bacterial membrane resulting in bacterial cell death. Compounds of silver such as silver nitrate and silver sulfadiazine are used to prevent bacterial growth in drinking water, sterilization and burn care.

2.5.2.5. Silver Acts as Odour Controlling Agent

Due to effective antimicrobial agent activity of silver nanoparticles provide terrific driving force for diffusion. The Silver nanoparticles are assembled with many different shapes, such as spheres, rods, cubes, wires, film, and coatings and can be integrated into a variety of materials like metals, ceramics, polymers, glass, and textiles via fine spraying of silver nanoparticle solution. Some Athletic clothing companies have incorporated silver nanoparticles into their products mainly for reduce the bad smell. Many textile industries insert silver nanoparticles into its products to allow the particles to attach to the filaments. Once the silver nanoparticles encounter sweat from the human body, they naturally release a low concentration of silver ions into the moist environment.

2.5.2.6. Silver as Bactericidal Agent

Nanometers size of bacteria, use enzymes to metabolize nutrients and create energy in a similar fashion as living organisms. They are unicellular with only one compartment of protein and they store all the elements of the cell.

Silver ions attack microbes in three different pathways including; respiration, replication, and cell wall synthesis. Silver nanoparticles penetrate the bacterial cell membrane and change their structural composition by interacting with the bacteria's sulphate groups, which are the active site of enzymes. Silver ions disrupt the bacterial enzymes responsible for energy metabolism and electrolyte transport. The lack of enzyme activity ultimately suffocates the bacteria. As an additional means of attack, these powerful silver ions also detached the bacterial replication process by disrupting their DNA backbone finally creating structural imperfections within the cell's protective layers and speeding the collapse or burst of the bacteria.