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CHAPTER 5

Synthesis, Biological Studies of Garlic Nanoparticles: A Review

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Abstract: Garlic plants are common cooking ingredient in India. It has many medicinal uses found in literature. In our Indian meal it is one of important ingredients. Which have excellent taste. Literature evidence suggesting they can lower blood pressure and cholesterol. Garlic contains compounds like allicin, which contributes to its various health benefits.

In the literature it was proved that, garlic plants are used in synthesis of metal nanoparticles, which shows different microbial activities. It has medicinal importance like it manage bad cholesterol, cardiovascular health, Anti-platelet, supporting the immune system. It protecting against the common cold. They found good anti-bacterial, anti-cancer, anti-oxidant, etc. microbial activities. Due to these important microbial properties here we have decided to reviews about garlic nanoparticles and their biological studies.

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Introduction

Scientifically Garlic is known as Allium sativum, is versatile and indispensable herb that has graced kitchens and gardens for centuries. Garlic plant belongs to the Alliaceae family, which includes onions, shallots, and leeks. Garlic, which is a spice, additive, and medicinal plant, is widely produced worldwide and utilized as a spice. It has been recommended as a medicinal plant because of its medicinal properties. Like onions, shallots, and leeks, garlic plants are members of the Alliaceae family. Garlic is grown all over the world and is used as a spice, additive, and medicinal herb. Because of its numerous advantages for human health and wellbeing, it has been suggested as a medicinal plant.[1, 2]

According to reports, this compound has a variety of biological activities.[3] Garlic has its precise biological activity mechanism is still unclear. Using garlic extract as a stabilising and reducing agent can help create various nanoparticles (NPs) in an environmentally friendly manner. Because of its therapeutic value, they are utilised in the production of metal and metal oxide nanoparticles.

Now a day garlic extract has been used as reducing and stabilizing agent. Therefore, it acts as an environmentally friendly synthetic method for different nanoparticles. Due to its medicinal importance, they used in the synthesis of metal & metal oxide nanoparticles. Which have different microbial activities. which exhibit varying microbiological activities. To lessen the effects of the MDR-TB epidemic, garlic is used as a natural supplement to traditional therapies. [4, 5]. Nowadays, the majority of research is focused on nanotechnology since it has applications in a wide range of sectors, pharmaceuticals, engineering, environmental science, vehicles, textiles, biomedical science, machineries, space, and more. [6–9]. In essence, a class of materials with at least one dimension in the 1-100 nm range is represented by nanoparticles. Metal and metal oxide nanoparticles are a novel class of materials currently under investigation for use in medicine and biology. Iron nanoparticles, titanium oxide, gold, silver, and other metal nanoparticles are the most often researched metal nanoparticles, and they have a wide range of uses in biomedicine. Microorganisms, plant extracts, and whole PLA are some of the techniques available for synthesizing nanoparticles from metal salts using a greener method. A variety of durable and eco-friendly metallic nanoparticles are produced by plants using phytochemicals.

According to Abidin et al.[10], two crucial methods ‘top-down and bottom-up’ were used to manufacture nanoparticles. Molecules organize themselves due to their intrinsic properties in bottom-up technique. It organizes themselves into increasingly intricate structures, molecule, cluster by cluster, and atom by atom. Whereas, top-down technique involves breaking down bulk materials into extremely small structures. This process reduces solids into progressively smaller fragments until they consist of just a few atoms.[11]

There are several ways to create nanoparticles from metal salts using a more environmentally friendly method. Microorganisms, plant extracts, whole plants, phytoconstituents, vitamins, and

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biodegradable polymers can all be used to create nanoparticles. Plants use phytochemicals, which are durable and eco-friendly reservoirs, to create a range of metallic nanoparticles. The potential for phytochemical-derived nanoparticles to serve as both stabilising and reducing agents has been mentioned in the literature. [12, 13] Biosynthesis of metal nanometals (Cu NPs) is one of the newer methods which are expensive and environmentally friendly method.

The synthesis of copper nanoparticles by Sharmila Pradhan Amatyal and Leela Pradhan Joshi[14] was accomplished through the reaction of garlic (Allium sativum) extract and copper.

Solution of copper sulphate ($CuSO_4.5H_2O$) over a magnetic stirrer at 80°C for one hour. The reaction was tracked by looking at how the colours changed over different time periods. Following ($CuSO_4.5H_2O$), the production of copper nanoparticles was verified.

The colours were changed at different points in time to track the reaction. The creation of copper nanoparticles was confirmed upon characterisation. The microbiological activity of copper nanoparticles against Gram-positive (Staphylococcus aureus) and Gram-negative (Escherichia coli) bacteria was investigated using the Agar well diffusion method. Copper nanoparticles (CuNPs) were found to be substantially more susceptible to Gram-negative bacteria than Gram-positive ones, based on the findings of the antibacterial test.

Natasha Saleem Kakar *et al.*[15] was reported green synthetic methodology for synthesis of nickel nanoparticles (Ni NPs) using extract from garlic. In that methodology the Garlic extract used as reducing agent and nickel nitrate as a reacting salt in the synthesis of nickel nanoparticles (Ni NPs). Size, shape, crystallinity, and their impact on bacterial and fungal strains were all considered in their characterization. Nickel nanoparticles, or Ni-NPs, were found to be effective against Salmonella typhi, Escherichia coli, Staphylococcus aureus, and Klebsiella pneumoniae in that study.

Additionally, nanoparticles have demonstrated the ability to stop fungal development like, Aspergillus Niger and Mucor Mucedo. Advance technologies in nanobiotechnology resulted in intriguing discoveries in science. Biosynthesis of economically and environmentally beneficial metal nanoparticles can now be done using this technology in the fields of agriculture, medicine, etc. plant component including leaves, roots, and fruits are used for biosynthesis applications, also known as green synthesis.

Pedram Zahedi Mohammadi [16] employed garlic (Allium sativum) leaf extract, which was characterized using a range of analytical techniques. Proteus mirabilis, Escherichia coli, Klebsiella pneumoniae, Staphylococcus aureus, and Enterococcus faecalis were the five bacterial strains against which the microbial activity of silver nanoparticles (AgNPs) was evaluated using the disc diffusion method. According to the previously indicated microbiological data, the NPS outperformed the other examined microbial strains in its ability to combat S. aureus and E. faecalis. This implies that Gram-positive bacteria were significantly impacted by the biosynthesised silver nanoparticles (Ag NPs).

Gold nanoparticles (AuNPs) were successfully synthesised by Yoki Yulizar *et al.*[17] using an aqueous extract of garlic (Allium sativum L. (ASL)) as a stabilising and reducing agent. FTIR

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spectroscopy and phytochemical analysis were used to identify the active components in the aqueous ASL extract, and various analytical techniques were used to characterise the synthesised AuNPs. The optimal pH for the interaction between the synthesised AuNPs and melamine was found to be 3.6.

Melendez-Villanueva *et al*.[18] synthesised gold nanoparticles (AUNPs-As). An antiviral activity of AUNPS was assessed. About 50% effective concentration (EC50) of 8.829 μg/mL, these nanoparticles effectively prevented MeV replication in Vero cells. The resulting selectivity index (SI) was 16.05. AuNPs-As have a strong virucidal effect and most likely prevent viral infection by directly blocking viral particles. A promising method for managing and treating MeV and other related enveloped virus infections may be the use of gold nanoparticles.

Silver nanoparticles aided by garlic clove extract were easily and affordably synthesised and characterised by Sekar Vijaykumar *et al.*[19]. They investigated their ecotoxicity, antimicrobial, anti-biofilm, anti-helminthic, anti-inflammatory, and anti-cancer properties. Methicillin-resistant S. aureus and P. aeruginosa are clinically significant pathogens that Garlic Silver Nanoparticles (G-AgNPs) have demonstrated increased antibacterial and antibiofilm action against at 100 μg/mL. Garlic silver nanoparticles (G-AgNPs') ability to combat earthworms demonstrated how well they work as an anti-helminthic agent to treat intestinal parasites. Its anti-inflammatory properties are demonstrated by the notable suppression of BSA protein denaturation.

Garlic-silver nanoparticles (G-AgNPs) successfully inhibited the growth of breast cancer cells MCF-7. These nanoparticles are safe for the environment and did not harm C. cornuta. Garlic silver nanoparticles (G-AgNPs) offer a variety of biological applications and can be used as an environmentally benign material without causing environmental damage, according to the information presented above.

K. Khairan *et al.*[20] has been synthesised effectively. Sodium thiosulphate pentahydrate ($Na_2S_2O_3.5H_2O$) sulphur nanoparticles with and without aqueous garlic extract (Allium sativum). Following nanoparticle creation, various analytical instruments were used to compare the particle sizes. The comparison revealed that the sulphur nanoparticles produced with and without aqueous garlic extract had sizes of 55.613 and 70.908 nm, respectively. The results of a disc diffusion method used to assess the antifungal properties of the sulphur nanoparticles revealed that sulphur nanoparticles synthesised with garlic extract were more effective against fungal infections than those synthesised without it. Using NARC G1 garlic (Allium sativum) plant extract, Usama Younas *et al.*[21] created ZnO-NPs in an environmentally friendly manner. Several analytical instruments were used to characterise these nanoparticles. The substantial bioactive potential of NARC G1 garlic, which has applications in the nutraceutical sector, was brought to light by this study. These NPs' promising photocatalytic activity indicates their potential for use in environmental remediation technologies.

Arunkumar *et al*.[22] investigated the antibacterial properties of copper oxide (CuO) nanoparticles made using an environmentally friendly process with extract from garlic bulbs (Allium sativum). It was examined using several characterisation methods. The reduction and stability of the CuO nanoparticles were facilitated by the natural chemicals found in garlic extract. Following nanoparticle size analysis,

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samples were examined for microbiological activity. CuO nanoparticles were tested against gram-positive bacteria, such as Staphylococcus and Cutibacterium acnes, as well as gram-negative bacteria, such as Escherichia coli and pseudomonas aeruginosa. Marwa Ahmed El-Naka *et.al*.[23] were synthesized Pristine silver nanoparticles and garlic capped silver nanoparticles. Garlic capped silver nanoparticles was synthesized through the chemical reduction process. Garlic-capped silver nanoparticles served as a fluorescent sensor for cholesterol measurement in this investigation. Garlic/APTS, garlic/glutathione, 3-aminopropyltriethoxysilane (APTS), glutathione, 8-hydroxyquinoline, and garlic/8-hydroxyquinoline were among the capping agents whose effects on AgNPs were assessed. Several analytical methods were used to characterise these garlic nanoparticles (G-NPs). The spherical, uniformly distributed garlic extract silver nanoparticles ranged in size from 4.52 to 12.8 nm. With a sensitivity of 4.364.36 mM and a limit of detection of 0.186 mM, the fluorescence enhancement-based cholesterol sensor has a strong linear response for cholesterol in the concentration range of 0.4-5.17 mM. In the presence of several interferents, including glucose, cysteine, glycine, urea, sucrose, nickel, copper, and their mixture, the high selectivity towards cholesterol was assessed. The applicability of this developed sensor for real serum samples was detected with a recovery percentage from 99.1 to 101.3%.

The microbiological activity of copper nanoparticles (CuNPs), which were synthesised from garlic (Allium Sativum) plant leaves, against human diseases were investigated by Man Mohan Prakash *et al.*[24]. MIC, disc diffusion, and disc diffusion wall methods were used to measure antibacterial activity. Copper nanoparticles (CuNPs) were produced using a low-cost, pollutant-free, and environmentally safe green synthesis method. Combining them with commercially available medications demonstrated impressive antibacterial activity against three human pathogenic microorganisms. Copper nanoparticles (CuNPs) are therefore a key strategy for applications in nanobiotechnology in the creation of antibiotics to treat various bacterial illnesses.

Tuyishime Abimana Gabriel S. aureus sub. aureus, Poryphyromonas gingivalis, S. mutans, and E. coli were all tested for antibacterial efficacy by Vestine *et al*.[25] using ultrasonicated garlic extract. Using both the agar disc diffusion and the agar well diffusion methods, the antibacterial activity of aqueous ultrasonicated garlic extract was measured against these strains. All studied germs were shown to be susceptible to garlic extracts, both sonicated and non-sonicated, according to the study. The most sensitive bacteria were Streptococcus mutans, while the most resistant bacteria were E. coli. Ultrasonicated garlic extract was discovered to be a strong antibacterial agent in that data. One intriguing therapy option for cancer is gamma delta T cell-based cancer immunotherapies. However, the restricted ex vivo growth and differentiation of the cell pose a challenge to their development. By giving garlic-derived nanoparticles (GNPs) orally, Jialu Xu *et al*.[26] was able to stimulate the Gamma delta T cell activation and proliferation that occurs naturally. It was discovered by his lab that GNPs could greatly increase the activation and proliferation of endogenous gamma delta- T cells in the gut, which would result in a significant production of interferon-γ (IFN γ). Additionally, intestinal gamma delta-T cells in GNP-treated mice had higher levels of the chemokine CXCR3, which can promote gut-to-tumour migration. In addition to providing a different approach to gamma delta-T cell-based immunotherapy, the work provides a basic

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understanding of the complex gut-tumor interactome. Satgurunathan et al.[27] synthesized chromium nanoparticles (CrNPs) from potassium dichromate using an aqueous extract of Allium sativum. When those nanoparticles were analysed using UV-VIS light, FE-SEM, EDX, XRD, and FTIR, their properties were all uniform, mono-dispersive, and incredibly stable. All of those nanoparticles were given as live feed to Macrobrachium rosenbergii post-larvae (PL) for 30 days after being enhanced with 4.94 mg/L of CrNPs at different times. These results showed that ½- and 1-hour enriched Artemia nauplii considerably enhanced the concentrations of tissue biochemical elements, including total protein, amino acid, carbohydrate, and lipid of M. rosenbergii PL, as well as nutritional indices like growth and survival. This implies that M. rosenbergii was not harmed by the concentration of CrNPs. Thus, the previously described optimal concentration of CrNPs was recommended for enrichment of Artemia nauplii during ½- and 1-hour periods as a sustainable material in the M. rosenbergii nursery. Because of its affordability, convenience of use, and economics, zinc sulphide nanoparticles (ZnNPs)-mediated plant extract green synthesis is growing in popularity.

Garlic extract was used as an NP-facilitating agent in the synthesis of Adnan Alnehia *et al.* [28]. Several analytical techniques were used to characterise these synthesised nanoparticles. These nanoparticles were tested for hemocompatibility and antibacterial properties. These analyses showed a 3.75 eV optical bandgap, a cubic phase, and a crystallite size of 2.33 nm. Bioactivity tests against Staphylococcus aureus and Escherichia coli revealed dose-dependent potency that was more similar to the standard azithromycin drug and more effective against Gram-positive (S. aureus) bacteria than Gram-negative (E. coli) bacteria.

Conclusion

Nanoparticles synthesized from garlic plants have very much attention from researchers. Because garlic itself have many medicinal uses. Therefore, nanocrystal or particles prepared from different metals like Ni, Cu, Ag, Au etc. found different antimicrobial activities. Garlic itself acts as reducing agent in this preparation of nanoparticles.

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