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CHITOSAN APPLICATION IN AGRICULTURE

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ABSTRACT
Chitin, a polysaccharide which is present in the exoskeleton of crustaceans, arthropods and molluscs. It is also found in cell wall of fungi. Chitin act as a derivative for chitosan. Chitosan is an excellent biopolymer which is used in many fields. It is utilized for the production of commercially important products. Chitosan can be extracted from many sources such as shrimp, crab shells and seafood waste. Chitosan is used for several purposes in the field of agriculture. It exhibits powerful properties like antimicrobial and antioxidant activity. Chitosan nanocomposites are made into sprays to boost immunity against fungal pathogens. Chitosan based nanoparticles play a role as fertilizers. This may reduce the use of chemical fertilizers. Soil is not affected since chitosan is biodegradable substance. It can be used as pesticides and herbicides. Chitosan elicits immune response of plants. It increases yield and quality of food products. Chitosan performs the function of plant growth regulators when given appropriately. It is used to control postharvest diseases in crops. Chitosan nanoparticles help plants to overcome abiotic stress. Saline stress is one of the harmful types of stress. Exogenous chitosan treatment enhances plants' tolerance to saline stress. The extraction of chitosan from crustaceans is discussed in this review. Some common applications of chitosan in agriculture are included in this review paper.

Keywords: Chitin, Chitosan, Nanoparticles, Agriculture

INTRODUCTION
Chitin, regarded to be the second most prevalent naturally occurring polysaccharide on the world after cellulose, is the source of chitosan. Significant biochemical parallels between chitin and cellulose can be seen in plant cell walls, which include neutrally charged linear polysaccharide chains [1]. The N-acetyl-D-glucosamine units joined by glycosidic (1,4) bonds produce chitin, a linear biopolymer. The exoskeletons of crustaceans and molluscs as well as the cuticles of insects contain chitin, which is the second most prevalent polysaccharide in nature after cellulose. Chitosan can be made from a variety of sources. Crab and shrimp shells, as well as other waste crustacean shells from the seafood processing sector, are the most typical sources of chitosan. Another source is the exoskeleton of insects like beetles. The fungus kingdom of moulds and macro-mushrooms is another natural source gaining interest and popularity [2]. Chitosan nanoparticles have been researched as a vehicle for the delivery of active ingredients due to their high permeability, cost effectiveness, and great film forming ability for a variety of applications. Additionally, chitosan is well known for its powerful antibacterial and insecticidal properties [3]. Chitosan may easily pass through tight intercellular connections in epithelial cells and across cellular barriers, making it an effective carrier for chitosan nanoparticles. Many of these uses of chitosan have been well examined in the literature. Chitosan-based nanoparticles (CNPs) have been used in agriculture as pesticides, herbicides, insecticides, and to achieve better quality food products with a greater yield. Fresh fruits like strawberries, jujubes, loquats, and longans were preserved during storage using nano-chitosan-based compounds or chitosan mixed with other nanoparticles. Additionally, because to its cationic nature, biodegradability, non-toxicity, and adsorption capabilities, chitosan can be used alone or in conjunction with other substances to function as an encapsulating agent in the creation of slow-release fertilisers [4]. The growing population, shrinking amount of arable land, and rise in plant diseases brought on by pathogens provide significant issues for the agricultural sector. Plant infections produce toxic by-products that delay crop growth and lower yields, which can result in large financial losses. However, relying too heavily on currently available fungicides to address this issue will inevitably have an effect on ecological variety and the security of the general people. Therefore, it is crucial to create antimicrobial medications with fresh targets. The broad-spectrum resistance to bacteria and fungi, biodegradability, biocompatibility, and plant growth-stimulating characteristics of chitosan and its derivatives have made them a research hotspot in the domains of plant growth stimulants and biological antimicrobial insecticides [5].

Extraction of Chitosan:
The cuticles of various crustaceans, primarily crabs and shrimp, are the major source of raw material for the synthesis of chitin. Chitin is a component of a complex protein network found in crustaceans, or more precisely shellfish, on which calcium carbonate accumulates to produce the rigid shell. A polysaccharide-protein complex has a modest amount of protein and involves a very close connection between chitin and protein. The removal

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of the two main components of the shell, proteins by deproteinization and inorganic calcium carbonate by demineralization, as well as tiny amounts of pigments and lipids that are typically eliminated, are therefore necessary for chitin extraction from shellfish. In rare situations, an extra decolorization phase is used to get rid of any remaining pigments. Pure chitin has been prepared using a variety of techniques over the years, but there is no accepted standard procedure. Chemical or enzymatic treatments could be used to perform demineralization and deproteinization [6].

Deproteinization: To begin with, dried shrimp and crab shell waste was treated with a 4% (w/v) solution of sodium hydroxide at 45°C for 24 hours to remove the protein. The alkaline soluble fraction was then separated using centrifugation at 4000 rpm for 15 minutes, and subsequent washings with distilled water were carried out until the pH reached a neutral level.

Demineralization: To remove minerals and separate acid-insoluble fraction, deproteinized shells were treated with a 4% (v/v) HCl solution at 30°C for 12 hours. The separated fraction was then thoroughly rinsed with distilled water to remove any traces of acid before being allowed to dry at 40°C overnight to produce chitin. Before beginning the process of chitosan preparation, the acquired chitin underwent a decolorization step because it had a faint pink tint.

Decolorization: After soaking the obtained chitin in 1% potassium permanganate for 30 minutes, it was then treated with 1% oxalic acid for 30 minutes to two hours. The finished product was referred to as pure crab and shrimp shell chitin.

Deacetylation: To transform the decolorized chitin into chitosan, the chitin was treated with 65% (w/v) NaOH for three days at 30°C. Centrifugation was used to remove the alkali fraction present in chitosan for 15 minutes at 4000 rpm. Excess alkali was drained off and rinsed with distilled water until pH was neutral. The obtained chitosan portion was held at room temperature pending further investigation after being dried at 40oC for an overnight period [7].

APPLICATIONS IN AGRICULTURE:

Antimicrobial Activity

The main environmental sources of infection for vegetables include the soil, air, and water as well as some plant infections. Due to the presence of air, high humidity, and increased temperatures during storage, microorganisms can grow more readily in vegetables that are damaged or sliced. Moulds, yeasts, and aciduric bacteria like lactic acid bacteria are easily attracted to vegetables with high carbohydrate content and extremely low protein content. The antibacterial properties of films composed of chitosan and its derivatives are supported by a number of research. Such films demonstrate the effectiveness of chitosan-based materials on bactericidal activity by providing substantial evidence of antibacterial activity against a variety of spoilage and pathogenic microorganisms from the food sectors. The type, MW, DD, viscosity, solvent, and other intrinsic and extrinsic properties of chitosan have a significant impact on its antimicrobial efficacy [8].

The most harmful pathogens for agricultural products are fungi, which are regarded as one of the most common. By creating mycotoxins, it seriously harms fruits, cereals, and other food products before and after harvest. Due to fungal infections, a sizable amount of the world's agricultural products goes to waste in the current food emergency. Chitosan -silver (Ch-Ag) nanocomposites have been created and used as foliar sprays or seed primers to suppress fungal infections. Numerous biological activities resulting from altered physico - chemical properties like size, surface area, cationic nature, active functional groups, and better encapsulation efficiency are the main benefits of composing Ag nanoparticles in the chitosan matrix. Chitosan serves the function of an elicitor, eliciting the defence mechanisms of the plant by increasing the production of pathogen-related proteins, secondary metabolites, and re-enforcing the plant cell wall against the pathogen attack. This enhances the defence mechanism of plants at the cellular level. For the eradication and prevention of bacterial infections in several crops, Ch-NCs have been used. A harmful pathogen for tomatoes known to cause bacterial wilt is Ralstonia solanacearum. It adversely affects the productivity of the tomato crop and significantly reduces farmers' incomes, both in greenhouses and open fields [9].

Fertilizer

There are several different physical forms of chitosan and its composites, including resins, microspheres, hydrogels, membranes, and fibre. Chitosan mixtures are first converted into the desired physical shape by combining the blend's component liquids and using the proper shaping techniques. Understanding the controlled release procedure, which would serve as a direct evaluation of a Controlled Release Fertilizer (CRF) performance, is crucial. In a general sense, it is difficult to imagine a controlled release system because it

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depends on a number of variables, including the composition of the coating materials, the type of CRF, farming circumstances, and more. CRF made of chitosan hydrogel can increase soil water retention. Chitosan releases active components by breakdown and diffusion, in contrast to hydrophilic polymers, which make up hydrogels (such as polyvinyl alcohol), which release active chemical compounds by diffusion [10].

Saline Stress

Saline stress is a detrimental type of abiotic stress that inhibits plant growth and function and can reduce crop yields by 10% to 25% in many agricultural crops. Because plants are sessile, they must have developed a number of mechanisms to cope with high salinity conditions. These mechanisms include ion toxicity, hyperosmotic stress, nutritional imbalance, oxidative damage, metabolic abnormalities, and photoinhibition. Chitosan has three different functional groups on its backbone: the primary and secondary hydroxyl groups, the amino/acetamido group, and others that increase its affinity for ions and many contaminants. Since Rouget's discovery of chitosan in 1859, numerous research on rice, maize, safflower, sunflower, and creeping bent grass have demonstrated its involvement in promoting plant development and raising plants' resistance to abiotic stress. The reduction of oxidative stress and the chitosan-induced increases in water use efficiency, mineral nutrient uptake, chlorophyll content, and photosynthesis are largely responsible for chitosan's positive role in stress mitigation. Exogenous chitosan treatment boosts plants' resistance to several stresses, including drought, salt, osmotic, and low-temperature stress. Exogenous chitosan at certain concentrations has been utilized to improve plant tolerance to a variety of biotic and abiotic stressors by promoting antioxidant activity, enhancing water usage efficiency, and controlling the concentration of osmotic regulatory compounds.

The leafy vegetable lettuce (Lactuca sativa L.) is typically eaten fresh or in salad dressings. The top three lettuce-producing countries in the world—China, the United States, and India—produce the majority of the world's lettuce. Lettuce is a vegetable with a moderate to high sensitivity to salt. Salinity lowers the rate of seed germination, the number of leaves, photosynthesis, and cell proliferation while increasing the formation of ROS, all of which are detrimental to the growth and yield of lettuce. Although the detrimental effects of salinity on lettuce have been researched, data on the impact of chitosan on lettuce production and growth in saline environments is sparse. As a result, the current study assessed the efficacy of exogenous CTS in reducing the negative effects of salt on the physiological characteristics and growth of lettuce plant [11].

Pesticide Delivery

Recent research addresses the creation and application of chitosan nanoparticles as a pesticide delivery mechanism. Furthermore, the encapsulation in chitosan nanoparticles aids in resolving solubility issues. Brassinosteroids and diosgenin derivatives, for instance, were enclosed in chitosan microspheres. Rotenone, a naturally occurring insecticide which is not water soluble, was made more soluble by being enclosed in nano-micelles made of an amphiphilic chitosan derivative, and azadirachtin, a biopesticide, was made more water soluble by using a material made of carboxymethyl chitosan and ricinoleic acid. These in vitro outcomes sparked interest in in vivo research. For instance, microcapsules of chitosan and sodium alginate were prepared and used for efficient imidacloprid release against the coleopteron Martianus dermestoides. Microspheres made of chitosan and cashew tree gum were also used to carry the essential oil of Lippia sidoides, an effective insecticide against A. aegypti larvae[12].

More recently, oleoyl-chitosan nanoparticles and sodium tripolyphosphate nanoparticles were synthesised and effectively tested for the inhibition of rice blast fungus (Pyricularia grisea) were created and employed to spread antifungal medications.

CONCLUSION

Chitosan play a vital role in various aspects of agriculture. Several studies demonstrated the characteristics of chitosan. Chitosan based nanoparticles developed as fertilizers , insecticides help to reduce the harmful effects caused by inorganic chemicals. It is the second abundant biopolymer. So it can be further studied to replace non biodegradable ,toxic substances used in agriculture. Increase in chitosan production will provide ways to bring additional new products and technology. The chitosan nanoparticles should be easily accessible by farmers across the country.

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