# Chitosan biopolymer as effective coating to preserve Fruit and Vegetable

**Mohadeseh Hassanisaadi[1,*]**
**Department of Plant Protection, Faculty of Agriculture, Vali-e-Asr University of Rafsanjan, Rafsanjan, Iran**

**Roohallah Saberi Riseh[2]**
**Department of Plant Protection, Faculty of Agriculture, Vali-e-Asr University of Rafsanjan, Rafsanjan, Iran**

## Abstract
A significant obstacle that the agriculture industry worldwide must overcome is the post-harvest loss of fruits and vegetables. Natural and environmentally friendly solutions, such as chitosan coatings, have been the focus of researchers as they attempt to solve this problem. As a result of its exceptional qualities, including non-toxicity, biodegradability, biocompatibility, and the possibility of applications in post-harvest preservation, chitosan, which is a biopolymer derived from chitin, has garnered a significant amount of attention. The current state of research on chitosan coatings for preserving fruits and vegetables is examined in great detail in this review article, which provides an in-depth research analysis. In addition, it highlights the benefits of using chitosan coatings, such as their natural antimicrobial, antifungal, and antioxidant properties, as well as their capacity to extend the shelf life of products while preserving the quality characteristics of fresh products. Additionally, the review contains a discussion of the mechanisms that are responsible for the interaction between chitosan and agricultural products.

**Keywords**: Chitosan, Coating, Biopolymer, Postharvest.

## Introduction

Postharvest damages of fruits and vegetables pertain to the degradation, decay, or decline in quality that takes place after harvest. These damages can be attributed to various reasons, including mechanical injury, physiological alterations, microbial spoilage, and environmental circumstances [1]. Post-harvest preservation is crucial in the agricultural industry for maintaining product quality, reducing food waste, meeting consumer demand, supporting economic growth, and ensuring food security. It minimizes physical damage, prevents spoilage, and extends the shelf-life of fresh products. Proper post-harvest management also helps meet consumer demand by providing fresh, high-quality products year-round. Various preservation techniques are employed to extend the shelf-life of fruits and vegetables during storage [2-4]. Edible coatings, namely chitosan coatings, are discussed as a preservation approach for prolonging the shelf-life of fruits and vegetables during storage [5]. Several recent studies have been conducted regarding the application of chitosan in agriculture. Edible coatings are thin films placed on the surface of goods to form a barrier that regulates moisture loss, decreases respiration rate, ethylene generation, and ripening, and eliminates microbiological activity [6, 7]. Multiple methods may be used to apply edible coatings on fruits or vegetables, including immersing them in chitosan solutions, spraying, brushing, or panning [1, 8].

Chitosan is an organic compound obtained from chitin, a substance present in the outer shells of crustaceans such as prawns and crabs [9]. Chitosan is utilized in several fields because of its distinctive characteristics. It functions as a highly effective adsorbent in wastewater treatment, efficiently eliminating heavy metals and dyes through adsorption, ion exchange, and coagulation mechanisms [10]. Because of their antimicrobial and antioxidant properties, chitosan coatings are becoming increasingly popular for post-harvest preservation. These coatings also have many other desirable qualities, such as forming films, being biodegradable, having enhanced nutritional value, being compatible with other treatments, and complying with food safety standards [7, 11, 12]. Chitosan coatings are a new innovation in post-harvest preservation that has the potential to improve agricultural sustainability from an economic and environmental perspective. They have shown encouraging results in extending the shelf-life of fruits and vegetables while preserving their quality.

This study aims to thoroughly examine and assess the possible advantages and difficulties linked to chitosan coatings in the preservation of fruits and vegetables following their harvest. This study seeks to elucidate the efficacy of chitosan coatings in mitigating post-harvest losses, preserving product quality, and decreasing dependence on artificial preservatives by examining existing literature and research data. The main goal is to promote using chitosan-based coatings as a sustainable method to improve the post-harvest preservation of fruits and vegetables, benefiting both growers and consumers.

## The properties of chitosan

Chitosan is a naturally occurring biopolymer that is obtained from chitin, a substance present in the outer shells of crustaceans like shrimps and crabs, insects, as well as the cell walls of fungi, plants, different types of algae, and invertebrate creatures. Chitosan is formed by deacetylating chitin, which creates a linear polysaccharide composed of glucosamine and N-acetylglucosamine units [13]. Fig 1 depicts the chitosan structure. Chitosan has garnered interest in the field of agriculture because of its distinctive characteristics, including as biodegradability, biocompatibility, non-toxicity, antibacterial activity, film-forming ability, adsorption capacity, metal ion binding, adhesion, and encapsulation [14, 15]. In summary, the distinct characteristics of chitosan render it a flexible substance with many potential uses in several domains, including but not limited to food science, biomedical engineering, agriculture, and environmental science.

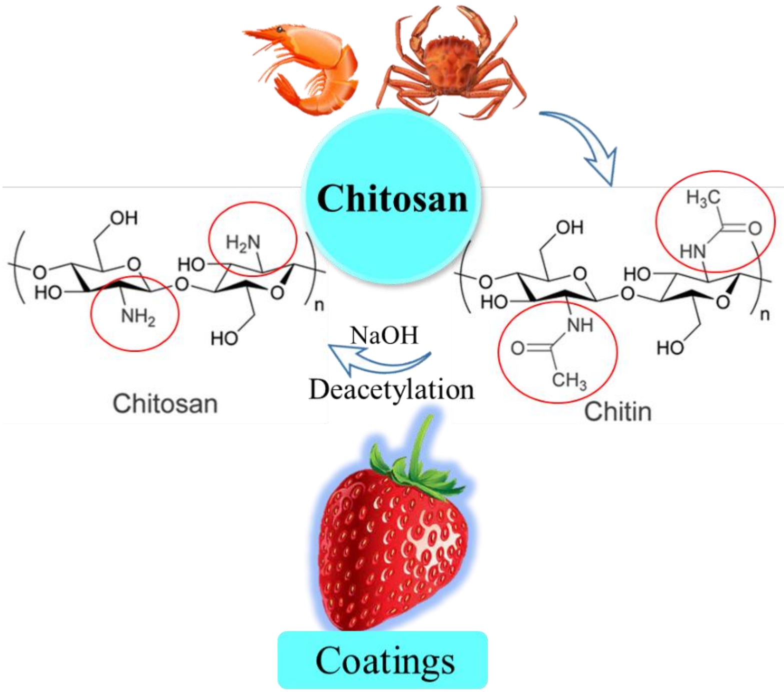


**Fig 1.** Preparation chitosan by deacetylating chitin and chitosan structure

**Utilizing chitosan coatings to enhance the preservation of fruits and vegetables**

The origins of chitosan coatings for fruit and vegetable preservation may be traced back to the late 1980s and early 1990s. Many significant achievements and research teams have driven progress in chitosan coatings. El Ghaouth et al. [16] created a chitosan coating that is safe to eat in order to protect green peppers and cucumbers. These fruits were kept at a temperature of 13℃ and a relative humidity of 85%. Their findings demonstrated a significant decrease in weight loss, wilting, color loss, respiration, and degradation as compared to the uncoated samples. Subsequently, [17] conducted a study on using chitosan coatings to enhance the shelf life of tomatoes. The researchers showed that applying chitosan coatings to fruits resulted in a delay in the ripening process, a decrease in microbial degradation, and the preservation of the overall quality of the fruits. A comparative analysis investigating the impact of chitosan coatings and iprodione on the storage and quality of fresh strawberries revealed that there was no notable distinction between the effects of chitosan coating and synthetic fungicide treatments over a storage period of up to 21 days [17]. In the 20th century, extensive research has substantially contributed to the advancement of chitosan coatings. The researchers have examined many characteristics and uses of chitosan coatings, including their ability to regulate moisture retention, prevent the growth of microorganisms, and decrease deterioration after harvesting a diverse selection of fruits and vegetables [5]. The studies and ongoing research have facilitated the use of nanotechnology in chitosan coatings, augmenting its efficacy as a post-harvest technology. Chitosan nanoparticles have improved physical and chemical characteristics and more potent antibacterial and antioxidant activities compared to chitosan coatings. Their increased effectiveness is attributed to their larger surface area and higher charge density, which enhances their capacity to interact with the negatively charged surfaces of bacteria [18]. Moreover, the application of nanoparticles with antimicrobial characteristics offers a chance to improve the conservation and maintenance of quality and prolong the shelf-life of agricultural goods [19, 20]. Several recent studies have investigated the potential use of nanomaterials in agriculture [21, 22]. To uncover further benefits, one can efficiently integrate nanoscale elements into chitosan coatings [23].

Ultimately, combining nanotechnology and chitosan-based coatings significantly transforms post-harvest technology, providing enhanced preservation and quality improvement for agricultural goods. Through ongoing research and development, this multidisciplinary approach can fundamentally transform the food sector and significantly contribute to the long-term sustainability of agriculture. Two comprehensive review studies thoroughly analyzed the utilisation of chitosan nanoparticles and chitosan-based nanocomposites to improve the quality and prolong the shelf life of fruits and vegetables after they have been harvested. These studies explore the possible advantages and progress achieved by using chitosan-based materials at the nanoscale, providing insight into the bright future of this method in post-harvest technologies [1, 18].

**Mechanism of action of chitosan in fruit and vegetable preservation**

Chitosan coatings have multiple mechanisms of action that contribute to fruit and vegetable preservation. One key mechanism is the modified gas permeability provided by chitosan coatings. They act as a barrier to control the exchange of gases, reducing the permeability of oxygen to preserve color, flavor, and nutritional quality by minimizing oxidation. Chitosan coatings also facilitate the release of carbon dioxide, preventing gas buildup and maintaining optimal levels. Additionally, they regulate moisture content, maintaining appropriate humidity levels to preserve texture and prevent the growth of spoilage microorganisms [15, 24]. Another mechanism is the induction of defense responses. Chitosan stimulates natural defense mechanisms in coated produce, activating defense-related enzymes and antimicrobial compound production. This helps protect against post-harvest diseases, extending shelf-life [25, 26]. Chitosan interacts with plant cell walls, triggering biochemical reactions and gene expression related to defense responses. It reinforces physical barriers, inhibits pathogen growth, and reduces oxidative stress [27]. While chitosan coatings provide some protection, other factors like fruit quality and storage conditions also impact efficacy. Overall, chitosan coatings promise to preserve fruits and vegetables by enhancing natural resistance to pathogens and maintaining quality during storage [28]. Fig 2 depicts the antimicrobial mechanism of chitosan to protect fruits

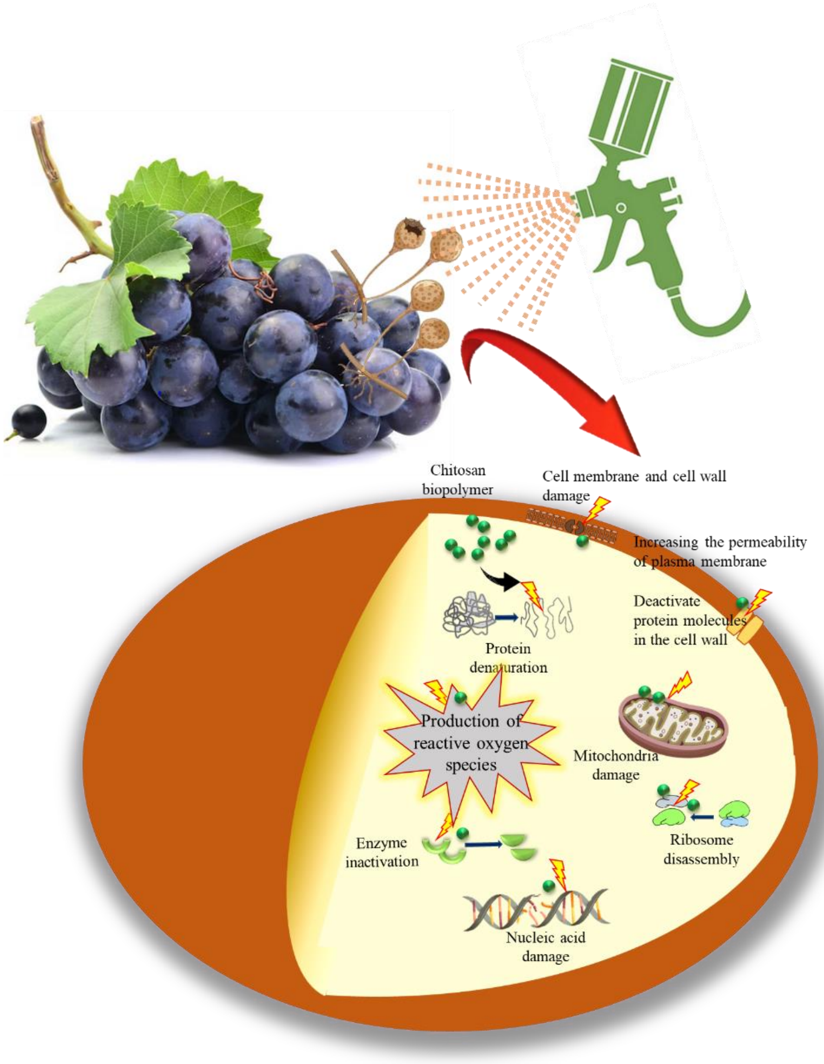


**Fig 2.** The antimicrobial mechanism of chitosan to protect fruits and vegetables

**Conclusions**

Chitosan coatings may preserve fruits and vegetables after harvest. However, this field needs more research. Future research could examine how different chitosan formulations preserve fruits and vegetables. This could involve studying how chitosan concentration, deacetylation, molecular weight, and other factors affect coating effectiveness. Another promising area is chitosan-based composite coatings with antimicrobial and antioxidant compounds like essential oils, biocontrol agents, and plant extracts. Composites may improve chitosan coating preservation and offer other benefits. Chitosan-based stimuli-responsive systems can also release natural antimicrobial and antioxidant compounds in a controlled manner to prevent spoilage and decay. Another promising research area is chitosan-based sensors that monitor fruit and vegetable quality and freshness during storage and transportation, allowing timely intervention to prevent further deterioration.

In conclusion, chitosan coatings for post-harvest fruit and vegetable preservation may reduce food waste and extend fresh product shelf life. The paper discusses how chitosan coatings inhibit microbial growth, preserve fruit and vegetable nutrition, and reduce water loss. Chitosan coatings have great potential, but more research is needed to optimise their formulation and application for different products.

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