CHITOSAN APPLICATIONS IN FOOD INDUSTRY

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Abstract

Chitosan comes from a natural product, chitin, which is found in the exoskeleton (shell) of marine crustaceans (red crabs, shrimps, lobsters etc.) and in the internal structure of other invertebrates (molluscs). Due to its functional activity, chitosan has been widely used in food and medical fields for its antibacterial, antioxidant, inhibitory activity and biodegradability over the last half-century.

The work presents aspects regarding the importance of chitosan in improving people's health, as well as its applications in different fields.

Key words**: **chitin, chitosan, food industry, application

INTRODUCTION

Chitosan has garnered much interest due to its properties and possible applications. Every year the number of publications and patents based on this polymer increase. (*Inmaculada A., Andrés R A., et al. 2021*).

Chitosan is a type of biopolymer obtained by deacetylation of chitin. Its special physicochemical properties, such as biodegradability, biocompatibility, non-toxicity and adsorption capacity, make it an ideal material to be applied in the food industry. In recent years, it has been widely used as a natural food additive due to its various functions.

First, chitosan can be used as an antimicrobial agent in food preservation. Many studies have shown that chitosan and its derivatives have the ability to inhibit the growth of various bacteria, fungi and viruses. This property can effectively prevent food spoilage and extend the shelf life of food products. It can also be used as a coating material to preserve quality, improve appearance and prevent contamination during food processing and storage. Second, chitosan can be used as a thickener, stabilizer and emulsifier in food production. Its high molecular weight and viscosity make it a good thickener that can improve the texture and taste of food products. It also stabilizes emulsions and prevents phase separation in food products. In addition, it is used as a binding agent in meat or fish products, which can improve water retention and increase yield. Third, it can be used as dietary fiber or functional food ingredient. As dietary fiber, it can absorb water and fat and increase faecal weight and transit time. This property can help prevent bowel disorders and promote bowel regularity. Furthermore, it can form gels or films that can encapsulate nutrients or drugs, which can improve their bioavailability and stability. (https://ro.tnnchemical.com/)

Chitosan is a kind of abundant natural polysaccharide obtained from crustaceans such as shrimp and crab. (*Xiaoli Liu, Wenying Liao et al., 2023*)

t was first discovered by the French scientist Bullanoi. To date, it is the only known natural substance that contains active fibers with positive-alkaline charges, with functions similar to collagen of animal origin and high-quality vegetable fibers.

The biologically active supplement "Chitosan" is developed on the basis of traditional Chinese medicine, from the shell of red sea crabs (containing chitin), which live at depths of over 1,000 m.

In the late 1980s, Japan began to promote chitosan as a dietary supplement. At a conference on chitinases and oligosaccharides, chitosan was designated as "the protector of immunity", "the most promising health food of the 21st century" and "the 6th essential element for the body". In 1823, scientists first extracted Chitosan from the outer layers of crustacean shells. Chitosan is found in certain types of cheese, yeast, and also in small amounts in certain varieties of mushrooms.

In the human body, chitosan breaks down into low molecular weight polymer and is easily assimilated by the body. Chitosan decomposes in acidic environment and turns into positive ion group. Chitin, after decomposition acquires the quality of gel (becomes gelatinous and has a strong absorption quality). Chitin is a natural fibrin, non-toxic and has no negative effects.

The scientific world named chitosan the 6th vital element, after proteins, fats, hydrocarbons, minerals and vitamins. The Japanese also call it "the newest element of longevity". Its discovery made a huge contribution to the health of mankind.

The Japanese government has declared Chitosan as a product found among food supplements and medicines that prevent and cure certain diseases.

The concentration of chitosan in Tianshi capsules reaches 85%, having a high purity, being a nutritional supplement that is distributed in USA, South Africa etc., being highly appreciated by consumers.

Finally, as a novelty element, chitosan promises to be used in organ transplants as well as as a reconstruction material, due to the fact that it has a bone-like density and can be precisely shaped with a laser, and it can also be shaped so as to be porous to facilitate the circulation of blood vessels.

Chitosan has many desirable attributes e.g. antimicrobial properties and promoting wound healing, and is used in various applications. (*Shijie (Gabriel) K., Linda Peters et al., 2022*)

Chitosan offers real potential for applications in the food industry due to its particular physico-chemical properties, short time biodegradability, biocompatibility with human tissues, antimicrobial an antifungal activities, and non-toxicity. (*Mohammed Aider 2010*)

Chitosan has been extensively valued as a delivery system for bioactive ingredients. Chitosan encapsulation can protect bioactive ingredients from extreme conditions such as pH and temperature. Chitosan capsules have proved to be suitable carriers for essential oils, flavors, vitamins, antioxidants, and probiotics. (*Gisoo Maleki a, Ernst J. Woltering et al., 2022*)

Chitosan is an acetylated chitin (fig. 1), a product obtained through a process of deacetylation of chitin by removing the acetyl group, thus the carbon compounds that give it hardness.

Chitosan has garnered much interest due to its properties and possible applications.

Chitin and chitosan are the chief, most abundant natural polymers subsequent to cellulose; while it may have diverse foundations, like exoskeletons of crustacean, mollusks, insects, and fungi, the major resource for obtaining this polymer is the shell of crustaceans. Owing to incomparable properties, such as nontoxicity, biodegradability, chelating, anticoagulant, antioxidant and antimicrobial characteristics, and biocompatibility, chitosan has proven useful for the development of bioactive materials. Antimicrobial films for packaging applications have received increasing attention from the food industry in recent years. *(Venkatesan Manigandan, et al., 2018).*

These functional qualities of chitosan place it as an important biological material for applications in the food industry *(Ruchir P., et al. 2020), & (Mohamed E. Abd El-Hack, et al. 2020).*

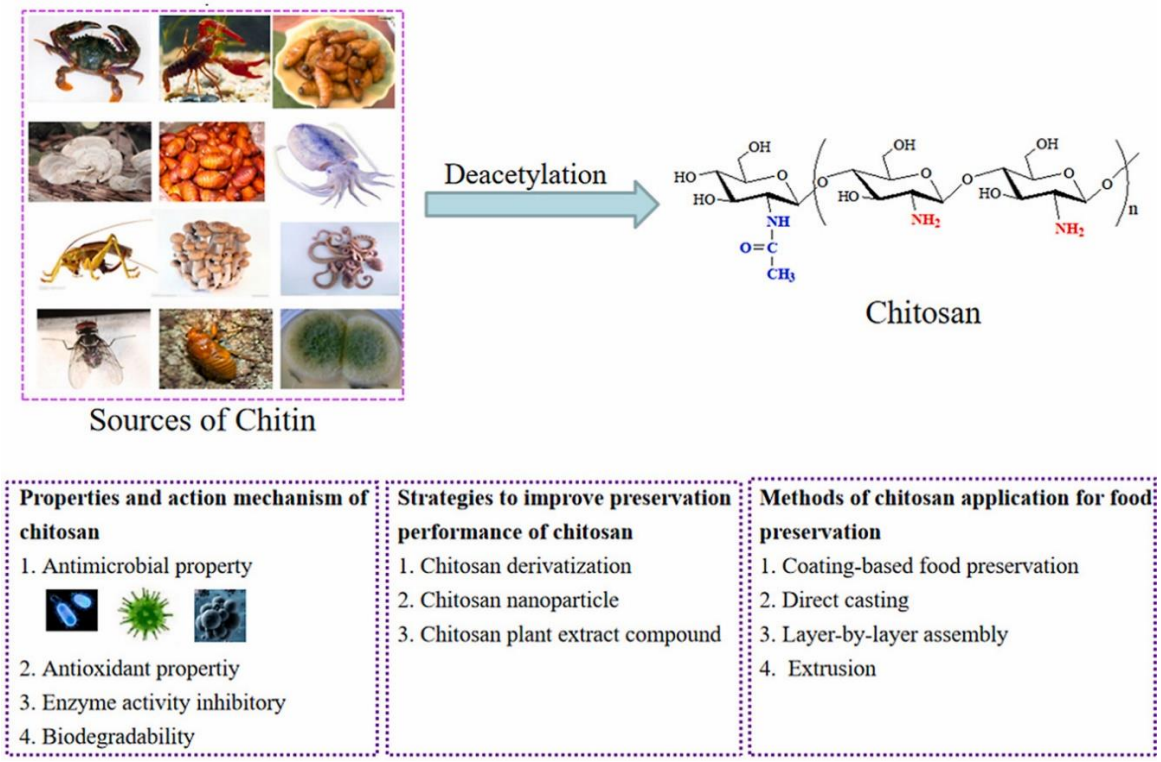

Figure 1. Chitin deacetylation process *(Xiaoli Liu, Wenying Liao et al., 2023)*

Due to its chemical, physical and biological properties, chitosan is widely used in various fields and to obtain certain products such as: cosmetics (toothpaste, shampoo, deodorant), food products (natural preservatives, food supplement, fiber), textile industry (underwear, sports equipment), pharmaceutical industry (detoxification, anticancer, treatment of psoriasis, skin cancer etc.), wastewater treatment, biomedicine (tissue engineering, artificial skin, ophthalmology, wound healing).

MATERIALS AND METHODS

To obtain chitosan it is necessary to obtain chitin first. Glucosamine, a prominent precursor of proteins and lipids in a biological system, is the building block of chitin. *(N.K. Kalutharage, et al. 2020)*

The process begins by obtaining the raw material, which is the exoskeleton of crustaceans, especially crabs and shrimps.

A washing treatment is performed to remove all impurities such as salt and mineral residues that may be embedded in the species' exoskeleton. The material is dried well and then ground to a flake form of about 1 mm.

The depigmentation process follows. This procedure is optional and is done with acetone (an organic solvent in which chitosan is insoluble), xylene, ethanol or hydrogen peroxide.

The previous process is followed by the decarbonization process, in which HCl is used. Once this process is finished, deproteinization is continued, which is done in a basic medium using NaOH. Wash with plenty of water and finally filter. The compound obtained is chitin. It is treated with 50% NaOH at a temperature of about 110 °C for 3 hours.

This process allows the removal of the acetyl group from the chitin structure so that chitosan can be obtained. To be packaged, dehydration and grinding are carried out until the particle size is 250 μm. Chitosan is an insoluble compound in water, having its approximate molar weight of $1.26x10^5$ g/mol of polymer, obtained by the viscometer method.

As a natural biopolymer, chitosan has been developed as a sustainable alternative to traditional chemicals such as food preservation, food processing, food packaging, and food additives due to its abundant functional groups and excellent biological functions. (*Yu C., Yong L., et al. 2023*)

RESULTS AND DISCUSSIONS

With over 30 years of research on chitin and chitosan, the researchers have found that the biopolymer possesses some unique characteristics and properties, which have made it a versatile material to be used in numerous applications. In Table no. 1 are presented summary of major applications of chitin and chitosan in the different fields.

Table 1 *Summary of major applications of chitin and chitosan in the different fields*

Field of Application	**Applications**
Biomedical and Pharmaceutical applications	Antioxidant: free radical scavenger/quencher Antimicrobial agent: positively charged chitosan-NH_2 groups interact with negatively charged microbial cell membrane creating pores. Drug delivery: mucoadhesive properties increase drug permeation of intestinal, nasal, and buccal epithelial cells, Gene therapy: Delivering various genes and siRNA Chitosan based drugs. For example, lowering effect of cholesterol for obesity treatment. Regenerative technology/tissue engineering: bone, neural, cornea, cardiac and skin regenerative technology. Provides a three-dimensional tissue growth matrix, activate macrophage activity and stimulate cell proliferation. Wound management: homeostatic agent, participate in repair, replacement, activation of humor immunity, complement system, and CD4+ cells, enhances granulation as well as the organization of the repaired tissues. It slowly degrades into *N*-acetyl-β-d-glucosamine that stimulates fibroblast proliferation, regular collagen deposition in addition to stimulating hyaluronic acid synthesis at the wound site.
Health care products	Cosmetics formulations: Antimicrobial, antifungal, UV absorbing abilities exploited in various cosmetics formulations including in shampoos, rinses, colorants, hair lotions, spray, toothpaste formulations and tonics. Sunscreens, moisturizer foundation, eyeshadow, lipstick, cleansing materials, and bath agent, toothpaste, mouthwashes, and chewing gum as a dental filler.
Food Industry	Packaging, edible coatings, body filling, emulsifying agent, natural flavor extender, texture controlling, thickening and stabilizing agent, food preservation (antimicrobial agent), antioxidant agent. Flocculation/Clarification and deacilification of fruits and beverages
Agriculture	Antimicrobial activities against various plant pathogens. Fruit preservative. controlled delivery of fertilizers, pesticides, and insecticides. Increase in the auxin concentration and urea release in the soil, germination capacity, root length and activity, and seedling height
Industrial application	Functional materials: Graphitic carbon nanocapsules/composites, tungsten carbide chitin whiskers, etc. are used in the production of micro-electrochemical systems and 3D networks.

	Electrolyte: Sulfuric acid and chitosan combination has the ability to discharge high voltage. Chitosan provides ionic conductivity and can be used in the production of solid-state batteries. Photography: fixing agent for color prints. Paper manufacture: Production of filter papers, water-resistant papers, biodegrading packages, water-resistant papers Enzyme carrier: immobilizing enzymes on solid materials
Construction industry	wood adhesive, fungicide, wood quality enhancer, and preservative
Waste treatment	Flocculating, and negative charge (chelating agent), for dye, heavy metal ions removal and decontamination. Used for various processing plants such as whey, dairy, poultry, and seafood processing plants

CONCLUSIONS

Chitosan is a versatile and promising natural food additive that can improve the quality and safety of food products. Its multiple functions can meet the diverse requirements of the food industry, such as preservation, processing and nutrition.

The exoskeleton of some marine organisms, a by-product of the fishing industry, remains the principal source of chitin and chitosan.

Chitosan has many desirable attributes e.g. antimicrobial properties and promoting wound healing, and is used in various applications.

Chitosan offers real potential for applications in the food industry due to its particular physico-chemical properties, short time biodegradability, biocompatibility with human tissues, antimicrobial and antifungal activities, and non-toxicity.

Due to its chemical, physical and biological properties, chitosan is widely used in various fields and to obtain certain products such as: cosmetics, food products, textile industry, pharmaceutical industry, wastewater treatment, biomedicine.

REFERENCES

Alessandro P., Georg M G., Gibson S. N., (2022). *Review: Chitosan: Sources, Processing and Modification Techniques*, National Library of Medicine (NIH), Editor: Mazeyar Parvinzadeh Gashti, Gels. 2022 Jun 21;8(7):393. doi: 10.3390/gels8070393.

Gisoo Maleki A., Ernst J. Woltering b, M.R. Mozafari (2022). *Applications of chitosan-based carrier as an encapsulating agent in food industry*, Trends in Food Science & Technology, Volume 120, Pages 88-99;

Inmaculada A., Andrés R A., Maria C. C., Concepción A., Begoña E., Angeles H. C, Niuris A., (2021). *Chitosan: An Overview of Its Properties and Applications*, National Library of Medicine (NIH), Polymers (Basel). 2021 Sep 24;13(19):3256. doi: 10.3390/polym13193256.

Mohammed A. (2010). *Chitosan application for active bio-based films production and potential in the food industry: Review*, LWT - Food Science and Technology, Volume 43, Issue 6, July, Pages 837-842.

Mohamed E. Abd El-Hack, Mohamed T. El-Saadony, Manal E. Shafi, Nidal M. Zabermawi, Muhammad Arif, Gaber Elsaber Batiha, Asmaa F. Khafaga, Yasmina M. Abd El-Hakim, Adham A. Al-Sagheer (2020). *Antimicrobial and antioxidant properties of chitosan and its derivatives and their applications: A review*, International Journal of Biological Macromolecules, Volume 164, 1 December 2020, Pages 2726-2744.

N.K. Kalutharage, D.L. Rathnasinghe, (2020). *A study of chitosan and glucosamine isolated from Sri Lankan local mushroom Schizophyllum commune and oyster*

mushroom (Pleurotus ostreatus), Materials today: Proceedings, Volume 23, Part 1, 2020, Pages 119-122.

Ruchir P., Jong-Whan R. (2020). *Chitosan-based biodegradable functional films for food packaging applications*, Innovative Food Science & Emerging Technologies, Volume 62, June 2020, 102346.

K. Shijie (Gabriel), Peters L., Mucalo M., (2022). *Chitosan: A review of molecular structure, bioactivities and interactions with the human body and micro-organisms*, Carbohydrate Polymers, Volume 282, 15 April 2022, 119132.

Venkatesan M., Ramachandran K., Saravanan R., Senthilkumar R. (2018). *Chapter 15 - Chitosan Applications in Food Industry*, Biopolymers for Food Design, Handbook of Food Bioengineering, Pages 469-491.

Xiaoli Liu, Wenying Liao, Wenshui Xia (2023). *Recent advances in chitosan based bioactive materials for food preservation*, Food Hydrocolloids, Volume 140, July, 108612.

Yu Chen, Yong Liu, Qingfeng Dong, Changhua Xu, Shanggui Deng, Yongfeng Kang, Min Fan, Li Li (2023). *Application of functionalized chitosan in food: A review*, International Journal of Biological Macromolecules, Volume 235, 30 April 2023, 123716.

https://pdfcoffee.com/aplicatii-biomedicale-ale-chitosanului-pdf-free.html.

https://ro.tnnchemical.com/info/application-of-chitosan-84258294.html.

https://ro.tnnchemical.com/.