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Review Article

Chitosan As A Natural Polymer: An Overview

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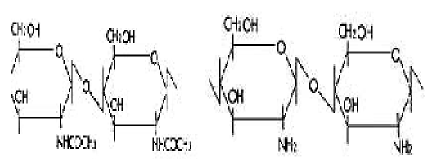
Chitosan is a natural product derived from chitin, a polysaccharide found in the exoskeleton of shellfish like shrimp or crabs. The high content of amino groups provide to chitosan very Interesting heavy metals chelating properties Chitosan is made from chitin by a chemical process involving demineralization (DM), deproteinization (DP), decolorization (DC), and deacetylation (DA). Very little work has been done to demonstrate the effects of altering or excluding any of the processing steps on chitosan characteristics. The present study was undertaken to evaluate the effects of process modification during chitosan production on the physiochemical and functional properties of crawfish chitosans. Chitosan and its oligosaccharides have received much interest for potential application in agriculture, biomedicine and biotechnology due to their biocompatibility, biodegradability and bioactivity. Synthetic bactericide treatment has been the main method for controlling diseases, there is a growing international concern over the indiscriminate use of synthetic compounds on crops because of the possible harmful effects on human health and the emergence of pathogen resistance to bactericides.They has a wide scope of application in the food, pharmaceutical, agricultural industries. Chitosan, which is soluble in acidic aqueous media, is used in many applications (food, cosmetics, biomedical and pharmaceutical applications). We briefly describe the chemical modifications of chitosan—an area in which a variety of syntheses have been proposed tentatively, but are not yet developed on an industrial scale. This review emphasizes recent papers on the high value-added applications of these materials in medicine and cosmetics.

Keywords: Chitosan , chitin, demineralization , biomedicine, bactericides. Mechanism, applications.

INTRODUCTION

Chitosan is a natural carbohydrate biopolymer derived by deacetylation (DA) of chitin an major component of the shells of crustacea such as crab, shrimp, and crawfish. After cellulose, chitin is the second most abundant natural biopolymer found in nature (Like cellulose, chitosan is a fiber. Chitosan is a non-toxic, biodegradable and biocompatible polymer. chitinous polymers, especially chitosan, have received increased attention as one of the promising renewable polymeric materials for their extensive applications in the pharmaceutical and biomedical industries for enzyme immobilization and purification, in chemical plants for wastewater treatment, and in food industries for food formulations as binding, gelling, thickening and stabilizing agent.[1]. Chitosan is a fiber-like substance derived from chitin, a homopolymer of ß-(1→4)-linked *N*-acetyl-D-glucosamine. Chitin is the second most abundant organic compound in nature after cellulose Chitin is made up of a linear chain of acetylglucosamine



Chitin **Chitosan**

groups while chitosan is obtained by removing enough acetyl groups (CH_3-CO) for the molecule to be soluble in most diluted acids. This process is called deacetylation. The actual difference between chitin and chitosan is the acetyl content of the polymer. Chitosan having a free amino group is the most useful derivative of chitin. [2]

Production of chitin and chitosan:

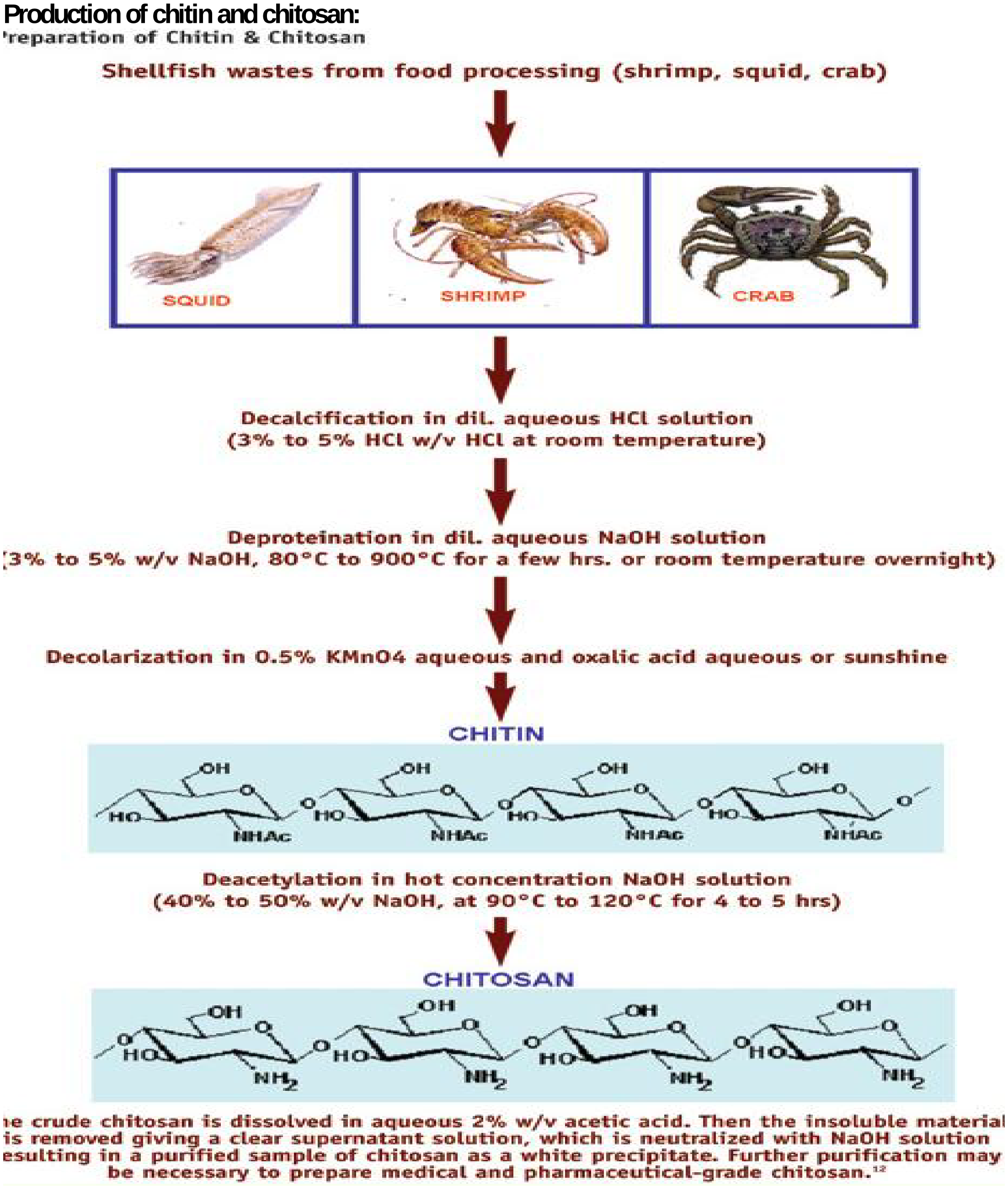


Fig. 1: Traditional Crawfish Chitosan Production Flow Scheme [3-5]

Chitin is the supporting material of crustaceans, insects, etc., and is well known to consist of 2-acetamido-2-deoxy-β-D glucose through a β(1→4)linkage. Chitin is highly insoluble like cellulose and has low chemical reactivity. Chitosan is the *N*-

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deacetylated derivative of chitin, although this *N*-deacetylation is almost never complete. Formation of chitosan from chitin is shown in Fig.2 and the structures of chitin and chitosan are shown above.

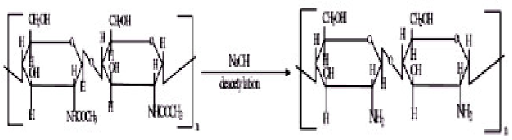

Fig. 2: Formation of chitosan from chitin

Objectives of chitosan:

The specific objectives, therefore, were to:

1. Develop an optimum chitosan production process for our particular intended application;

2. Study the physicochemical and functional properties of crawfish chitosan, prepared from modified process protocols, and compare these properties with those of commercial crab chitosans;

3. Evaluate how decoloration (DC) affects physicochemical and functional properties of crawfish chitosans;

4. Determine the effects of reversing the steps such as demineralization (DM) and deproteinization (DP) during the production of chitosan from crawfish shell on their physicochemical and functional properties.[6, 7]

Material &Method

Physical Properties

1. Molecular Weight

Chitosan is a biopolymer of high molecular weight. Like its composition, the molecular weight of chitosan varies with the raw material sources and the method of preparation. Molecular weight of native chitin is usually larger than one million Daltons while commercial chitosan products have the molecular weight range of 100,000 – 1,200,000 Daltons, depending on the process and grades of the product. [8]

2. Viscosity

Just as with other food matrices, viscosity is an important factor in the conventional determination of molecular weight of chitosan and in determining its commercial applications in complex biological environments such as in the food system. Some factors during processing such as the degree of deacetylation, molecular weight, concentration of solution, ionic strength, pH, and temperature affect the production of chitosan and its properties giving rise to the definition of 'Intrinsic Viscosity' of chitosan which is a n function of the degree of ionization as well as ion strength. Chitosan solution stored at 4oC is found to be relatively stable from a viscosity point of view.

3. Solubility

While chitin is insoluble in most organic solvents, chitosan is readily soluble in dilute acidic solutions below pH 6.0. Organic acids such as acetic, formic, and lactic acids are used for dissolving chitosan. The most commonly used is 1% acetic acid solution at about pH 4.0 as a reference. Chitosan is also soluble in 1% hydrochloric acid but insoluble in sulfuric and phosphoric acids. Solubility of chitosan in inorganic acids is quite limited[8]

4. Bulk Density

The bulk density of chitin from shrimp and crab is normally between 0.06 and 0.17 g/ml, respectively indicating that shrimp chitin is more porous than crab chitin. Krill chitin was found to be 2.6 times more porous than crab chitin. In a study conducted by the bulk density of chitin and chitosan from crawfish shell, is very high (0.39 g/cm3. [8, 9]

5. Colour

The pigment in the crustacean shells forms complexes with chitin (4-keto and three 4, 4'- diketo-ß-carotene derivatives). Chitosan powder is quite flabby in nature and its14 colour varies from pale yellow to white whereas starch and cellulose powder have smooth texture and white colour. [10].

6. Formation of Film

Chitosan has an ability to form film which makes it suitable for use as food preservation for control of psychotropic pathogen in fresh/ processed meat and fish products packaged under modified atmosphere. According to the most potential application of chitosan is as a coating agent in the area of fruit preservation. [11]

Biological Properties

1. Antimicrobial Properties

Antibacterial activities of chitosan have revealed that chitosan is effective in inhibiting growth of bacteria. The antimicrobial properties of chitosan depend on its molecular weight and the type of bacterium. For gram-positive bacteria, and gram-negative bacteria, chitosan with was effective. Chitosan generally showed stronger bactericidal effects for gram-positive bacteria (Listeria monocytogenes, Bacillus megaterium, B. cereus, Staphylococcusaureus, Lactobacillus plantarum, L. brevis, and L. bulgaris) than for gram-negative bacteria (E.coli, Pseudomonas fluorescens, Salmonella typhymurium, and Vibrio parahaemolyticus) in the presence of 0.1% chitosan, reported that chitin and chitosan in *vitro* show antibacterial and anti-yeast activities. [12]

Higher antibacterial activity of chitosan at lower pH suggests that addition of chitosan to acidic foods will enhance its effectiveness as a natural preservative including biodegradability, biocompatibility and non-toxicity;properties which render natural polymers superior over present-day synthetic polymers, making them valuable materials for pharmaceutical, biomedical as well as industrial applications.

2. Biodegradation

Whereas chitosan solutions are highly stable over a long period, there is sometimes a need for degrading chitosan to a level suitable for a particular application, or as a means of conferring solubility to chitosan at neutral pH. Several methods for producing chitosan oligomers ("chitosanolysis") have been described in literature, including radiation, chemical (acid hydrolysis or oxidative-reductive degradation) and enzymatic methods, of which enzymatic degradation is preferred, since reaction and thus product formation could be controlled by means of pH, temperature and reaction time .[12, 13]

3. Biocompatibility

One of the most important biological properties of any implantable biomaterial is biocompatibility chitosan is well tolerated by living tissues, including the skin, ocular membranes, as well as the nasal epithelium, and has thus been proven valuable for a wide range of biomedical applications.[14]

- Complexation ability
- Metal ions
- Anionic polymers
- Amino acids, proteins, DNA, cells
- Dyes
- Fats and cholesterol

Application & Uses of Chitosan

The poor solubility of chitin is the major limiting factor in its utilization. Chitosan is considered as a potential polysaccharide because of its free amino groups that contribute polycationic, chelating, and dispersion forming properties along with ready solubility in dilute acetic acid. Chitosan possesses exceptional chemical and biological qualities that can be used in a wide

Table 1: Applications and Uses of Chitosan

Application	Uses
Wastewater Treatment	Removal of metal ions, flocculants/coagulant, protein, dye, amino acids dye
Food Industry	Removal of dye, suspended solids, preservative, colour stabilization, food stabilizer, thickener and gelling agent, animal feed additive, etc.
Medical	Wound and bone healing, blood cholesterol control, skin burn, contact lens, surgical sutures, dental plaque inhibition, clotting agent, etc.
Agriculture	Seed coating, fertilizer, controlled agrochemical release
Cosmetics	Moisturizer, face, hand, and body creams, bath lotion, etc
Biotechnology	Chromatography

Table 2: Applications – Pharmaceuticals and Cosmetics

Applications	Benefits / advantages
Conventional formulations • Tablet manufacture	Binder; disintegrant; coating; lubricant; diluents
• Gels	Sustained drug release; enhanced absorption
• Films and membranes • Emulsions	Controlled drug release stabilizer
Microspheres, microcapsules	Mucoadhesive; sustained delivery of drugs; penetration enhancement; increased bioavailability
Ophthalmic formulations	Ocular tolerance; mucoadhesive; wetting and penetration-enhancing properties; antibacterial; prolonged precorneal drug residence
Transdermal delivery systems	Enhancement of penetration across epithelia; controlled drug release
Colon-specific drug delivery	Delivery biodegradable by colonic bacteria
Vaccine delivery Mucosal vaccination Oral vaccination	Induction of mucosal and systemic immune response; penetration into intestinal and respiratory mucosal protection of antigens from gastric juice, bile acids and salts and from proteolytic enzymes of the gastrointestinal tract
Peptide drug delivery	Delivery improving oral bioavailability of peptides and protein
Gene and nucleic acid delivery Deodorant formulations	Safe, non-viral system Dermatological compatibility; nonirritating; enhancing fragrance adhesion; deodorizing
Hair and skin care products	Preservative; emulgator; thickener; moisturizer; soothing effect on skin

Table 3:Applications – Medical And Biomedical

Applications	Benefits / Advantages
Antacid and anti-ulcerogenic	demulcent and protective effect on stomach mucosa
Antidiabetic (hypoglycemic)	lowering of blood glucose level; increasing glucose tolerance and insulin secretion
Antihypertensive —	
Antioxidant	Scavenging of radicals and chelating of divalent metals
Antitumor	Induction of apoptosis in tumor cells
Haemostatic	Hemostatic biological adhesive for soft tissues strong binding to mammalian cells
Hypocholesterolaemic; nutritional aid for weight loss	Prevention of fat absorption reduction of blood lipid levels
Wound dressings	Products for wound treatment, Inhibition of fibroplasias ; promotion of tissue regeneration; acceleration of wound-healing with minimal scar formation
	Optical clarity; wound-healing; mechanical stability; sufficient optical correction; Dentistry and oral medicine bioadhesive; viscosity-enhancer; permeabilizer; antimicrobial; antiadhesive; prolonged drug release in buccal cavity; anti-dental caries; treatment of periodontal diseases, oral candidiasis and tooth mobility; reduction of plaque formation
Contact and bandage lenses	Compatibility; gas permeability; wettability; antimicrobial stimulation of immune system; augmenting immunogenicity of administered
Immunopotentiator	antigens; promoting resistance to systemic infections biodegradable
Surgical sutures and implants Hemodialysis membranes —	—

variety of industrial and medical applications.[15-19]

Conclusion

Chitosan, a polysaccharide biopolymer, has a unique chemical structure as a linear polycation with a high charge density, reactive hydroxyl- and amino-groups as well as extensive hydrogen bonding. It combines a group of physicochemical and biological characteristics, which allow for a wide range of applications. Chitin and chitosan are natural amino polysaccharides with unique structures, multidimensional properties and highly sophisticated functions that are widely used in biomedical applications. Their microstructure and biomedical activity are strongly dependent on the source of chitin and the conditions of chitosan preparation. Knowledge of the structural differences among chitin/chitosan products is very important in determining the properties of these biopolymers and is essential for the structure-activity analysis of biological systems. For medical applications, various forms of chitosan-based products are available, like finely-divided powders, films, membranes, nanoparticles or hydrogel biomedical applications, and will help to accelerate their future applications. So far, only the influence of the most important factors, such as the weight-averaged molecular weight (MW) and degree of *N*-acetylation (DA) on the biomedical activity of chitin/chitosan products, have been investigated in detail and summarized in some papers. .

Throughout the literature on chitosan, the main emphasis is on its quality and physicochemical properties which vary widely with crustacean species and preparation methods Upon this emphasis, this research study was attempted to prove or dispute these views by conducting similar studies and monitoring the modification of processing protocols of the chitosan production using crawfish shell waste, and to determine whether such modifications had any effect on the various physicochemical and functional properties of chitosans. From our results, we found that specific physicochemical and functional properties of chitosan have affected by process protocol alteration/modification

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