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EFFECTS OF CHITOSAN APPLICATION ON THE GROWTH OF SEVERAL CROPS AND IMPROVEMENT OF QUALITY AND SHELF-LIFE OF FOODS

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Chitosan has a wide range of potential applications in different fields of chemical sciences, biological systems, food sciences and agricultural, pharmaceutical and medical industries. Recently, considerable research has been conducted to develop and apply bio-based polymers made from a variety of agricultural commodities and/or of food waste products. This increased interest was intensified due to concerns about limited natural resources of the fossil fuel reserve and the environmental impact caused by the use of nonbiodegradable plastic-based packaging materials. Such biopolymers include starches, cellulose derivatives, chitosan / chitin, gums, proteins (animal or plant-based) and lipids. These materials offer the possibility of obtaining thin films and coatings to cover fresh or processed foods to extend their shelf life.

Keywords: Chitosan, Plant growth regulators, biological systems, food sciences

ЭФФЕКТИВНОСТЬ ПРИМЕНЕНИЯ ХИТОЗАНА В ОТНОШЕНИИ РОСТА НЕСКОЛЬКИХ РАСТЕНИЙ, УЛУЧШЕНИЕ КАЧЕСТВА И СРОКА ГОДНОСТИ ПРОДУКТОВ

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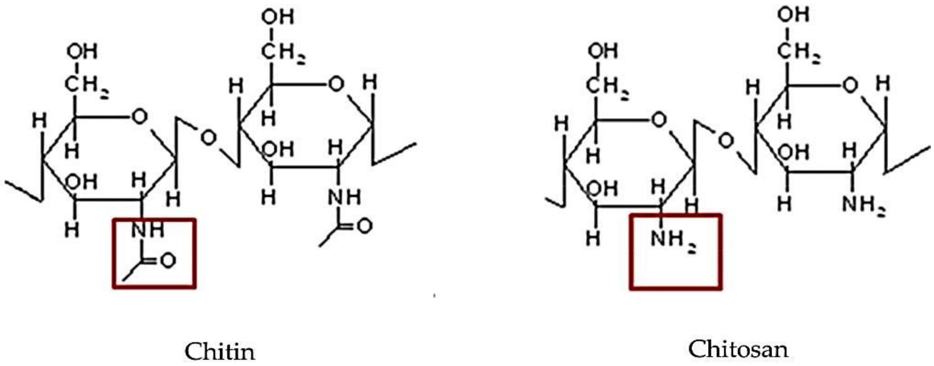
Хитозан имеет широкий диапазон возможных применений в различных областях химических наук, биологических систем, науки продовольствия и сельского хозяйства, фармацевтической и медицинской промышленности. В последнее время значительное исследование было проведено с целью разработки и применения биологических полимеров на основе сделанных из различных сельскохозяйственных товаров и продуктов пищевых отходов. Этот повышенный интерес усиливались из-за беспокойства по поводу ограниченных природных ресурсов запаса ископаемого топлива и воздействия на окружающую среду, вызванным использованием биодеградации упаковочных материалов синтетической основы. Такие биополимеры включают крахмалы, производные целлюлозы, хитозан, хитин, камеди, белки (животного или растительного происхождения) и на основе липидов. Эти материалы предлагают возможность получения тонких пленок и покрытий для покрытия свежих и обработанных пищевых продуктов, чтобы продлить их срок хранения.

Ключевые слова: хитозан, регуляторы роста растений, биологические системы, пищевые науки

1. Chemical structure of chitin and chitosan

Chitin is an abundant naturally occurring bio-polymer and is found in the exoskeleton of crustaceans, in fungal cell walls and in other biological materials. It is mainly poly (β-(1–4)-2-Acetoamido-D-Glucose) which is structurally identical to cellulose, except that a secondary hydroxyl on the second carbon atom of the hexose repeat unit is replaced by an acetamide group. Chitosan is derived from chitin by deacetylation in an alkaline media [12].

Actually, chitosan is a co-polymer consisting of β-(1–4)-2-Acetamido- D-glucose and β-(1–4)-2-amino-D-glucose units with the latter usually exceeding 60 %. Chitosan is described in terms of degree of deacetylation and average molecular weight and its importance resides in its antimicrobial properties in conjunction with its cationicity and film-forming properties (Fig. 1).



Fig, 1. Chemical structure of chitin and chitosan

2. Applications of Chitin and Chitosan

Chitosan refers to the whole family of acidic soluble linear hetero-polysaccharides. Chitosan is a natural, non-toxic biopolymer derived by deacetylation of chitin, a major component of the shells of crustaceans such as crab, shrimp, and crawfish, it also occurs naturally in some fungi but its occurrence is much less widespread than that of chitin. A sharp nomenclature border has not been defined between chitin and chitosan based on the degree of *N*-deacetylation. Chitosan is of great interest because of their all-around properties and applications in almost every field with great potential in diverse industries (Fig. 2).

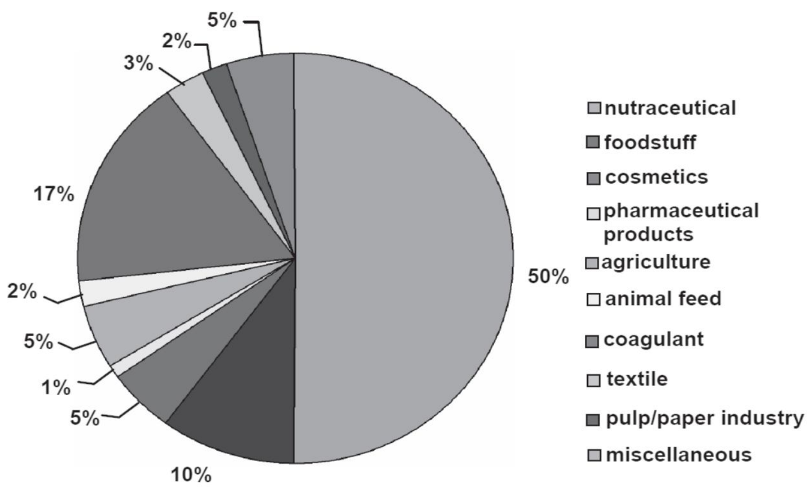


Fig. 2. Chitosan utilization in various fields of application

2.1. Chitosan as a plant growth regulator

Application of plant growth regulator (PGR) seems to be one of the important practices in view of convenience, cost and labor efficiency. Recently, there has been global realization of the important role of PGRs in agriculture for better growth and yield of crops [16].

Chitosan is derived from chitin, a polysaccharide found in exoskeleton of shellfish such as shrimp, lobster or crabs and cell wall of fungi [20]. Very few efforts were done to study the effect of chitosan on plant growth, development and productivity, which is mainly attributed to stimulation of plants immunity against microorganisms (bacteria and fungi) [4; 6; 17–19]. Recently, some researchers reported that chitosan enhanced plant growth and development [3; 6; 8]. They reported that application of chitosan increased key enzymes activities of nitrogen metabolism (nitrate reductase, glutamine synthetase and protease) and improved the transportation of nitrogen in the functional leaves which enhanced plant growth and development. Research works of chitosan on growth, yield attributes and fruit yield of okra is almost rare.

Considering the above facts, the present research work was undertaken to overview the effect of chitosan as a plant growth regulator.

Mondal *et al.* (2012) investigate the effect of foliar application of chitosan, a growth promoter, on morphological, growth, biochemical, yield attributes and fruit yield of okra. Results revealed that most of the morphological, growth, biochemical parameters and yield attributes were increased with increasing concentration of chitosan until 25 ppm, resulted in the highest fruit yield in okra (27.9 % yield increased over the control). However, the increment of plant parameters as well as fruit yield was not significant from 100 ppm of chitosan. Therefore, foliar application of chitosan at 100 or 125 ppm may be used at early growth stage to achieve a maximum fruit yield in okra.

Research study was conducted mainly to analyze the influence of chitosan on wheat seedling growth and physiological mechanisms under drought stress. The results showed that the group coated with chitosan significantly improved the growth index such as germination rate, wet weight, root length, root active, and impacted physiological indices such as superoxide dismutase (SOD), peroxidase (POD) and catalase (CAT)), the content of malondialdehyde (MDA) and chlorophyll compared with control under drought stress. Activities of POD, CAT and SOD increased and then decreased, the content of MDA increased under drought stress. But variation rates of the group coated with chitosan were slower than that of control, which indicates that chitosan can significantly improve antioxidant enzymes activity to clear timely active oxygen and reduce the content of MDA so as to alleviate the degree of damage in the drought stress and make seedlings grow better.

The results also showed that chitosan improved chlorophyll content than that of control, which demonstrated that chlorophyll content significantly influenced the photosynthetic efficiency of the mutant and added wheat above ground biomass and the field experiment results showed that chitosan increased yield 13.6 % than that of control [5].

Asghari et al. (2009) investigate the effects of chitosan on plantlets growth in vitro and enhance of mini tuber yield in potato micropropagation, plantlets of Agria cultivar were treated in vitro with soluble chitosan at different concentrations including 0, 5, 15, 50, 150, 500, 750 and 1000 mg/l added to the MS tissue culture medium. Plantlets were subsequently transferred to the greenhouse and mini tuber yield parameters were evaluated. At the concentrations of 750 and 1000 mg/l of chitosan the culture medium failed to solidify. Application of 500 mg/l of soluble chitosan increased the shoot fresh weight.

The 5 and 15 mg/l of soluble chitosan led to a significant increase in root fresh and dry weight of in vitro plantlets, whereas, higher concentrations, especially 500 mg/l, significantly decreased root fresh weight of in vitro plantlets. Application of 500 mg/l chitosan in vitro resulted in improved acclimatization of plantlets in the greenhouse increase in mini tuber number and yield, compared to the control. The tested lower concentrations had no effect on yield parameters. The results indicate that soluble chitosan can be successfully incorporated into potato seed production from in vitro plantlets.

The effect of chitosan on the growth and development of orchid plant meristemic tissue in culture was investigated in liquid and on solid medium. The growth of meristem explants into protocorm-like bodies in liquid medium was accelerated up to 15 times in the presence of chitosan oligomer. The data are consistent with preliminary results from field experiments and confirm unequivocally that a minor amount of chitosan has a profound effect on the growth and development of orchid plant tissue [9].

2.2. Chitosan-based edible films and coatings

Consumers usually judge the quality of fresh fruits on the basis of freshness and appearance at the time of purchase. However, minimal processing operations alter the integrity of fruits and vegetables, bringing about negative effects on product quality such as off-flavour development, texture breakdown and browning. In addition, the presence of microorganisms on the fruit surface may compromise the safety of fresh-cut fruit [1].

The search for methods that aim to retard these negative effects is of great interest to all the stakeholders involved in the production and distribution of fresh fruits. Traditionally, edible coatings have been used in the fresh fruit industry as a strategy to reduce the deleterious effects that minimal processing imposes on intact vegetable tissues.

Edible films and coatings offer extra advantages such as edibility, bio-compatibility, esthetic appearance, a barrier to gas properties, non-toxicity, non-polluting and its low cost. In addition, bio-films and coatings, by themselves or acting as carriers of food additives (i.e.: antioxidants, antimicrobials), have been particularly considered in food preservation due to their ability to extend the shelf life. Edible coatings have the potential to improve the quality and to extend the shelf life of lightly processed produce. Chitosan has been successfully used as a food wrap because of its film-forming properties. It has thus been used to maintain the quality of post-harvest fruits and vegetables, as examined by Yang et al. (2010).

Edible coatings may contribute to extending the shelf-life of fresh-cut fruits by reducing moisture and solute migration, gas exchange, respiration and oxidative reaction rates, as well as by reducing or even suppressing physiological disorders. Edible coatings have a high potential to carry active ingredients such as antibrowning agents, colorants, flavours, nutrients, spices and antimicrobial compounds that can extend product shelf life and reduce the risk of pathogen growth on food surfaces.

Use of natural compounds to prohibit microbial growth has notably increased in response to consumer awareness and consciousness of the use of chemically synthesized additives in foods. Chitin and chitosan are biopolymers having immense structural possibilities for chemical and mechanical modifications to generate novel properties, functions, and applications [13–15].

The main goal of this article is to review and update the information available on the use of edible coatings as carriers of food ingredients (texture, antimicrobials, nutraceuticals and enhancers,) to improve the quality, safety, and functionality of fresh fruits.

However, specific studies on fresh fruits are rather limited and their industrial implementation is still incipient [7; 10].

Much research is still to be done in order to develop safe, fresh fruit products with high sensory quality and nutritional value. The development and evalution of new processing techniques for preserving fresh cut fruit needs to overcome some of the hurdles to a successful commercial distribution of such products and outputs. Interest in the possible.

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