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Research Article

Chitosan and Shelf Life of Fruits: A Review

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Abstract

Fruits and vegetables are highly perishable commodities that require to be handled with much care to minimize losses. Losses during postharvest operations due to improper storage and handling are enormous. Edible coating is one of the methods of extending postharvest shelf-life. Chitosan is a modified natural carbohydrate polymer derived from chitin which has been found in a wide range of natural sources such as crustaceans, fungi, insects and some algae and is used in medical or industrial products as a bioactive material. It inhibits the growth of a wide variety of bacteria and fungi. Chitosan and its derivatives have been shown to inhibit the growth of awide range of fungi and trigger defensive mechanisms in plants and fruits against infections caused by several pathogens. Chitosan possesses excellent film-forming properties and can be applied as an edible surface coating to fruits and vegetables. After chitosan coating, the respiration rate and weight loss rate is restrained, and higher firmness is remained. Chitosan is a very promising edible coating material that is very effective and safer way in maintaining the overall quality of fruits. Chitosan coatings could prolong the shelf-life of fruits as chitosan coatings reduce physiological weight loss, spoilage, minimize the ripening processes including degradation of fruit cell wall maintain the firmness, maintain total soluble solids, titratable acidity, retard the growth of micro-organisms and overall keep all the characters attributing to quality in good condition. Therefore, the application of chitosan appears highly promising in the food industry for maintaining fresh-fruits during refrigerated storage.

Keywords: Chitosan, Fruits, Postharvest losses, Shelf life improvement

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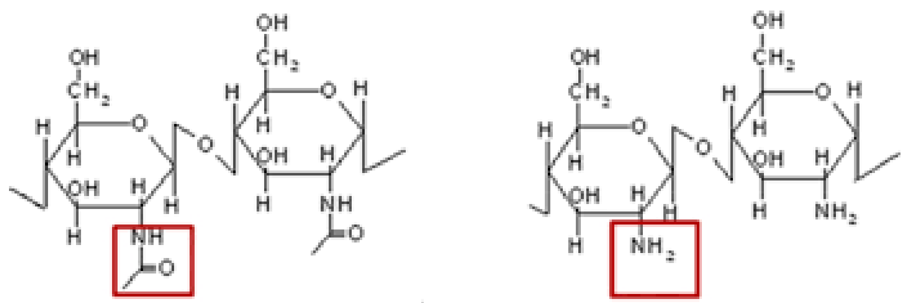
Introduction

Large post-harvest losses of fruits and vegetables are a matter of grave concern for any country whose economy is agriculture based. But this is a general phenomenon happening in almost every developing country. Fruits and vegetables are highly perishable commodities that require to be handled with much care to minimize losses. Because of their high moisture content horticultural crops are inherently more liable to deterioration. They are biologically active and carry out transpiration, respiration, ripening and other biochemical activities, which result in quality deterioration. Losses during postharvest operations due to improper storage and handling are enormous and can range from 20-50 percent in developing countries [1]. Recently, there have been many researches on edible coatings and films to diminish crop losses and maintain the quality of fresh fruit for a longer period. Edible coating is one of the methods of extending postharvest shelf-life. Many edible coating techniques to extend the shelf life and prolong freshness of fruits have been developed using polyethylene wax emulsion, bee wax, carnuba, candelilla, chitosan and paraffin3,4,5 [2-4].

The name 'chitin' is derived from the Greek word 'chitosan', meaning a coat of mail [5] and was apparently first used by Bradconnot in 1811 [6]. Chitosan is a modified natural carbohydrate polymer derived from chitin which has been found in a wide range of natural sources such as crustaceans, fungi, insects and some algae [7] and is used in medical or industrial products as a bioactive material [8, 9]. It inhibits the growth of a wide variety of bacteria [10, 11] and fungi [12-14]. Chitosan (poly b-1,4N-acetyl-D-glucosamine) polymer is industrially produced by chemical deacetylation of the chitin found in arthropod exoskeletons. This biopolymer can also be obtained directly from the cell wall of some plant-pathogenic fungi. Chitosan and its derivatives have been shown to inhibit the growth of awide range of fungi and trigger defensive mechanisms in plants and fruits against infections caused by several pathogens. Chitosan possesses excellent film-forming properties and can be applied as an edible surface coating to fruits and vegetables. Chitosan coatings have been reported to limit fungal decay and delay the ripening of several commodities, including strawberry. In addition, chitosan is an ideal preservative coating for fresh fruits because of its biochemical properties and its use in food is particularly promising because of it's ''biocompatibility'', non-toxicity and antimicrobial action [15].

Edible films and coatings from chitosan make considerable sense and interest in the food industry in the recent years as a new generation of food packaging material [16, 17]. There are several advantages of this technology in comparison with the traditional plastic packaging. They are: ecologically friendly, produces from renewable sources, nontoxic, biodegradable, made from by-products valuable materials, able to incorporate preservatives and other functional ingredients, like antioxidants, antimicrobial agents, vitamins, etc. The chitosan films are used as coating of fresh and fresh cut fruits and vegetables (apples, oranges, tomatoes, peppers, berries etc.) because they are flexible, offer valuable properties such as elasticity, selective permeability and act as microbial barrier against pathogens (*Candida, Escherichia coli, Staphylococcus aureus, Bacillus cereus, Proteus vulgaris, Botrytis cinerea*). As a result chitosan coatings are able to extend effectively the shelf-life [18-20]. So in this review an attempt was made for the use of chitosan on different fruits for their shelf life extension and also in maintaining better quality of fruits after harvest.



Chitin Chitosan

Effect of chitosan coating on physico-chemical parameters

Physiological Loss in Weight

Physiological loss in weight after harvesting may be attributed to post- harvest physiological processes such as respiratory degradation of reserve carbohydrates with the production of water and carbon dioxide as end products and transpiration of water through peel tissue during storage [21]. Chitosan coatings serves as a semi-permeable barrier against oxygen, carbon dioxide and moisture, thus reducing respiration, water loss and oxidation reactions [22].

Spoilage

The spoilage in fruits after harvesting is mainly brought about by rotting caused by pathogens. After chitosan coating, the chance for microbes to contact fruits and vegetables has been reduced, thus making fruits free from microbe's invasions [23]. Meanwhile, the amino of chitosan has bacteriostatic effect and can reduce the number of microbes [24]. Coating with chitosan reduce spoilage due to the anti-microbial activity of chitosan which induces chitinase, a defense enzyme and catalyze the hydrolysis of chitin, a common component of fungal cell-walls thus preventing the growth of fungi on the fruits [25, 26].

Firmness

Crisp, related with firmness, is an important sensory characteristic of fresh fruit and vegetable. Once post-harvest fruits become soft during storage time, their crisp characteristic gradually decreases and then disappears. During the storage period of fresh fruits and vegetables, their firmness will decrease owing to water evaporation, pectin degradation, nutrient consumption, and so on. Chitosan coating can restrain the transpiration, and then more water is reserved [27]. Thus, the cell of fruit and vegetable maintains the larger swelling pressure and shows higher firmness. So chitosan coating could reduce the firmness decrease of post-harvest fruit and vegetable to some extent [28]. Fruit firmness is related to softening due to the activity of cell wall-degrading enzymes during ripening. Since, chitosan film on fruit surface is reported to act as a barrier for O_2 uptake thereby slowing the metabolic activity, and consequently the ripening process [29]. Chitosan is a negatively charged polysaccharide and is likely to bind directly to the pectins which form the chitosan-pectin and thereby effectively prevent the access of pectinolytic enzymes such as PG to the substrate of the cell wall and thus help maintain fruit firmness [30].

Cell Membrane

The cell membrane plays an important role in maintaining cell structure and function of the post-harvest fruits and vegetables. Two key indicators of cell membrane integrity are permeability and malonaldehyde (MDA) content. During the storage time, much free radical in the cell accumulates and harms to cell membrane owning to the destruction of equilibrium mechanism between production and elimination of the radical [31]. Lipid per-oxidation is an oxidation process of unsaturated fatty acid through free radical action. The reaction produces lipid peroxide that is poisonous to cell. MDA, one of final products in lipid per-oxidation reaction, can severely harm cell membrane. MDA content reflects the active status of free radical of post-harvest fruit and vegetable. The more the MDA content is, the higher the level of free radical such as ·OH and O2- [32]. The cell membrane permeability increases once being damaged, causing the electrolyte leakage rate to increase [33]. After coating with chitosan, the increase of the cell membrane permeability and MDA content can be restrained, and the cell membrane of post-harvest fruit and vegetable may maximally execute normal physiological function.

Nutrients

There are many factors leading the nutrients of post-harvest fruit and vegetable to decrease. Saccharide, fat and soluble protein may degrade because of respiration; polyphenol, vitamin c and flavones may serve as antioxidant and participate to eliminate all kinds of free radicals during preservation; some of nutrients decrease owing to pathogenic bacteria activity [34]. After coating with chitosan on the surface of fruit and vegetable, respiration rate decreased, free radicals reduce, and the disease resistance increases. Thus, many nutrients are preserved in maximum [35].

Conclusion

Chitosan coating has wide application value in fresh fruit, vegetable or their fresh-cut materials. After chitosan coating, the respiration rate and weight loss rate is restrained, and higher firmness is remained. Meanwhile, the activities of protective enzymes are maintained higher level, and the cell membrane can keep relatively intact. Furthermore, chitosan coating had certain preventive effect against microbes and may reduce decay. Since the storage condition of fruit and vegetable is improved, more nutrients are also reserved. Chitosan coating would probably have wide prospect in the preservation of post-harvest fruits and vegetables in the future. From the above review of chitosan it can be concluded that chitosan is a very promising edible coating material that is very effective and safer way in maintaining the overall quality of fruits. Chitosan coatings could prolong the shelf-life of fruits as chitosan coatings reduce physiological weight loss, spoilage, minimize the ripening processes including degradation of fruit cell wall maintain the firmness, maintain total soluble solids, titratable acidity, retard the growth of micro-organisms and overall keep all the characters attributing to quality in good condition. Therefore, the application of chitosan appears highly promising in the food industry for maintaining fresh-fruits during refrigerated storage.

Future Thrusts

From the point of view of the possibilities in the fortified food market, there is a wide range of opportunities to develop new products using chitosan treatments, due to the high and increasing demand of fresh and healthy food. When using impregnation techniques, the behaviour of the vegetable or fruit matrices is highly produce-specific, increasing the amount of research needed. Also, some issues regarding impregnation techniques, especially vacuum impregnation need further research. Differences in density of the solution and the commodity (usually lower) makes keeping in contact sample and solution more difficult. Approaches to solve the problem are the use of stirring, compressing or sinking rods. These methods can cause damage to the product and increase the cost of the process. More research might be necessary in this area to obtain acceptable levels of quality for fresh-like minimally processed products. Also, the antimicrobial effect of the treatments based on chitosan on fruits and vegetables has been relatively little studied, compared with the amount of reports showing the effects of these treatments on the quality. The markets for convenient, fresh and fortified foods are continuously growing. This extensive knowledge gathered and the further research proposed can be exploited for the development of novel fresh-like minimally processed fruits and vegetables enriched with chitosan.

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