Biological Times

Volume No. 3 | Issue No. 9 | Pages 49-50

Chitosan and Bioactive Compounds: A review on developments in Biodegradable Coating for Extending Fruit Shelf Life

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ABSTRACT

Food packaging is essential to protect food, and petroleum-based materials are frequently employed because of their low cost, but lack of sustainability and eco-friendliness is a major threat to the environment. Edible packaging is a viable solution for this problem. This study focuses on how we can improve the shelf life of different fruits through chitosan edible packaging. It is evident from already present research that by incorporating bioactive compounds in chitosan films resulted in increased protection against microbes and oxidation of product. When chitosan applied on fruits it resulted in increased freshness and shelf life as well as protecting the attributes of fruits, thus preventing food loss. This is a sustainable substitute to conventional packaging.

Keywords: Chamomile daisy, origin, growth habit, growth requirements, propagation, and benefits

Introduction

Packaging is important in protecting the product, so it does perform the same function in food packaging. Card and board packaging material got replaced by easy and convenient petroleum based plastic material [1]. Due to their cheap prices and excellent strength these plastic packaging are currently the most used one in the food sector [2]. On the downside it has multiple drawbacks because of its non-biodegradable nature which can't be recycled and composted, thus results in harming the environment by staying forever [3]. Therefore, an upward trend can be seen in studies focusing on sustainable and biodegradable packaging to protect nature and the environment. The two hot materials in this regard are chitosan [4] and cellulose [5], which are excellent alternatives to plastic packaging and hold numerous benefits. After cellulose, chitosan is the second most common polysaccharide found in nature, it's a linear polymer and is derived from a deacetylated derivative of chitin. Given chitosan's exceptional qualities, it has been effectively used to a variety of postharvest fruits and vegetables [6].

In this review, we will focus on films and coatings that are edible using organic bio-material chitosan. However, to enhance the antioxidant qualities of chitosan films or coatings, it is a popular tactic to add bioactive substances that have proven their antioxidant properties. The study showed that incorporating bioactive compounds into films increased antioxidant activity, while vegetables and plant extracts from fruits, plants, and vegetables have resulted in prolonged life of different fruits as shown in Table 1.

Table 1: Studies of chitosan application to improve shelf life of Fruits.

Fruit	Incorporated Bioactive component (if any)	Effect	Method	Result	References
Apple	Liquorice extract	Antimicrobial activities	Dipped into solution for 5 minutes	Reduce water loss from 7.89% to 3.8%, maintain texture and firmness, retain moisture,	[7]
Mango	-	2% treatment outweigh others had better results	Dipped into solution for 5 minutes	Increase shelf life by 20,25 and 30 days respectively, Delayed ripening, maintain freshness for 3 weeks, 2% had better results than others.	[8]
Strawberry	Chlorophyllin	Antimicrobial activities	Soaked for 30 minutes	High anti-microbial activity against food pathogens and B. Cinerea, increase shelf life for 3 days without compromising color or visual quality in any way	[9]
Blueberries	BC-NT-TT	Antimicrobial activities	Dip for 2 minutes	Anti-microbial effects for mold, yeast, mesophilic aerobic bacteria, reduce microbial growth, maintain quality	[10]
Strawberry	Cellulose, nanofiber	Antifungal activity	Spraying	Anti-fungal activity against B.cinerea, preserve freshness, Delay colour change, enhance shelf life, decrease decay	[11]
Apricots	Gum Tragacanth	Natural thickener, high stability	Dipped into solution for 2 minutes	Increase firmness, lower weight loss, increase shelf life	[12]
Blackberry	Perillaldehyde. trans-2-hexenal	Antifungal activity	Packaging	Increase shelf life from 3 to 12 days	[13]
Fresh cut Guava	Citric Acid	Inhibit C.gloeosporioides	Immerse for 10 seconds	Reduce fungicidal action, maintain quality, preserve sensory characteristics	[14]
Barhi Dates	OPE, OCE	Antimicrobial, antioxidant	Dipped into solution for 5 minutes	Increase shelflife significantly, increase TSS, prevent moisture and firmness loss, prevent fungal growth	[15]
"Lady Finger" banana	1-MCP	Ethylene inhibitor	Dipped into solution for 1 minutes	Improve shelf life upto 3 days, prevent discoloration, maintain firmness, inhibit weight loss,	[16]
Mangoes	EPS	Antifungal activity	Brush paint the	Prolong shelf life to 3 times, inhibit fungal infection	[17]

To cite this article: Murtaza G, M Abdullah & MM Habib. Chitosan and Bioactive Compounds: A review on developments in Biodegradable Coating for Extending Fruit Shelf Life. Biological Times. 2024. September 3(9): 49-50

			solution		
Mangoes	-	1000ppm had better result than others	Dipped in solution for 2 minutes	Inhibit decay, lower weight loss, reduce TBC and TMC in mango fruits, retain content of mangoes	[18]
Table grapes	Thymol	Antioxidant, antimicrobial	Dipped for 2 minutes	Increase firmness, anthocyanin, antioxidant activity and sensory attributes Lower weight loss	[19]
Fresh cut banana	WRE (watermelon rind extract), Guar Gum (GG)	Scavenging ability, naturally active substances	Wrap with CS-WRE film	Inhibit rotting and weight loss, CG-4%WRE have better result, inhibit food spoilage	[20]
Lychee	Pomelo extract (PE)	Inhibit fungal decay	Dipped in solution for 3 minutes	Increase shelf life to 2 days, reduce pericarp browning and weight loss, reduce disease severity	[21]
Apple	Banana peels extract	Antioxidant activity, CS-4% BPE showed better results	Dipped into solution for 2 minutes	Maintain quality during storage, when compared to the CS film, the CS-BPE composite film showed noticeably less water solubility, moisture content, and water vapor permeability.	[22]

Chitosan

Chitosan is a biodegradable, natural polysaccharide originating from chitin, a substance present in the exoskeletons of crustaceans like shrimp and crabs, as well as in fungal cell walls [24]. Chitosan is prepared from chitin by *N*-deacetylation [25]. Chitin's chemical structure [poly-β-(1 → 4)-N-acetylD-glucosamine] is comparable to that of cellulose, with the exception that acetylamine groups have replaced one hydroxyl group on each monomer in chitosan [26]. This biopolymer has garnered significant attention for its antimicrobial, antifungal, and film-forming properties, making it a highly suitable material for developing biodegradable food packaging solutions. Research shows that chitosan has inherent antibacterial action directed against a wide range of microbes, including bacteria, yeasts, and molds, which are the leading causes of food spoilage [27]. Additionally, it forms transparent films that act as effective barriers against moisture and oxygen, further enhancing its role in preserving perishable foods [28].

Properties of Chitosan:

The degree of acetylation (DA) is the mole fraction of the N-acetylated repeating units, whereas the degree of deacetylation (DD) is the percentage of the β-1,4-D-glucosamine repeating units in the polysaccharides [25]. Hence DA = 100% - DD as depicted in Fig.1.

Incorporation of Bioactive compounds:

In recent years, there has been an increasing amount of interest in creating edible films and coatings using natural biomaterials like chitosan. One approach involves incorporating bioactive compounds into biodegradable coating to enhance their antimicrobial properties. This approach is seen as an encouraging method for creating food packaging films, as natural extracts are believed safer and more favorable to the environment [30]. Edible chitosan films frequently include bacteriocins, plant extracts, or essential oils as antimicrobial agents, which enhance the molecule's antibacterial and antifungal activity, despite its inherent antibacterial and antifungal properties. Because of their ability to combat a wide variety of microbes, natural antimicrobial substances like essential oils have become one of the most promising solutions in this regard [31]. Plants and vegetal raw materials offer numerous phytochemical compounds with potential uses in the food sector. Recent research aims to incorporate plant extracts in food packaging films, particularly biodegradable polysaccharide films like chitosan films.

Conclusion

Numerous investigations have exhibited the efficacy of chitosan-derived films in rising the fruit's shelf life through the improvement of their mechanical, barrier, and functional attributes. Active ingredients like fruit extracts, essential oils, and phenolic compounds greatly enhanced the films' antibacterial and antioxidant properties. These improvements helped to prolong the freshness of fruits like berries, grapes, and apples by reducing oxidative damage and microbial growth. Even though these bioactive chemicals clearly have a good effect on chitosan films, more research is necessary to maximize their benefits, including ethylene scavenging and oxygen and CO2 regulation. Further research is also necessary to examine the interactions of chitosan packaging with various food kinds and any possible hazards related to their use. Chitosan-based films will become more competitive with traditional packaging materials and more successful in real-world applications with more research and development

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