2016 Joint International Conference on Social Science and Environmental Science (SSES 2016) and
International Conference on Food Science and Engineering (ICFSE 2016)
ISBN: 978-1-60595-390-8

Advances of Chitosan-based Active Films in Food Packaging

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Keywords: Chitosan, Active Film, Food Packaging, Advances.

Abstract. With the increased awareness of environmental and improvement of food safety, bio-based biodegradable films become a new trend in food packaging. Chitosan is a natural biodegradable polysaccharide, derived from chitin. It is used for preparing biodegradable films with great film-forming property, antibacterial activity, biodegradable and nontoxic. Microbial growth and lipid oxidation and other factors can lead to food spoilage. There has a potential to develop active films to improve food safety and shelf life. This review is to summarize the development and function of chitosan-based active films in food packaging.

Introduction

In recent years, with the continuous economic development, the demand for plastic packaging has been increasing [1]. It has brought the oil resource scarcity and environmental pollution. Thus, biodegradable materials have been widely studied, to replace (partially substitute) petroleum-based plastics [2], such as, chitosan, gelatin, starch, cellulose and so on. As it is well known, chitosan is macromolecule polysaccharide. Chitosan has some advantages of non-toxic, antibacterial, biodegradable, renewable *et al.* Although chitosan is a promising biopolymer for active films, it does not have significant antioxidant activity and antibacterial activity. So, the antibacterial agents and antioxidants are added into chitosan to improve the performance of antibacterial and antioxidant properties, in order to achieve the purpose of extending shelf life. The composite film not only can improve the shortcomings of single film, but also can better play their functional properties, consisting of antioxidant properties and inhibit microbial growth and many more.

In 1811, the French scholar first extracted chitin from mushrooms [5]. In 1859, chitosan was extracted from chitin [5]. Since then, researchers have began to study on chitosan. Chitosan is rich in nature reserves, after cellulose [4]. According to reports that the first films and coatings appear in twelfth or thirteenth centuries in China [8].

Nowadays, people pay more attention to the food of health and safety, so natural and safety food packaging have a widespread concern [3]. Food with adequate nutrition, vulnerable to the invasion of microorganisms and oxygen, leading to spoilage [6-7]. Numerous studies show that chitosan based active film has been used in meat, fruits and vegetables packaging, could extend the shelf life of food. This review is to summarize the application of chitosan based active films in storage of the meat, seafood, fruit and vegetable, it provides a theoretical basis about advances of bio-based activity packaging for food.

Chitosan- based Active Films in Food Packaging

Composite Films in Meat Packaging

Dehnad *et al*. studied the chitosan and nano-cellulose composite film to extend the shelf life of ground meat [9]. The results showed that after the composite film packaging of meat reduce the lactic acid bacteria group significantly, contrast with nylon packaged samples up to 1.3 and 3.1 logarithmic cycles at 3, separately, which due to the composite film can suppress both gram-negative (*E. coli* and *S. enteritidis*) and gram-positive (*S. aureus*) bacteria via the contact surface effectively. Thus, the composite film could extend the shelf life of ground meat.

Cardoso *et al.* examined the effect of chitosan gelatin-based edible coating for color care of beef in retail display period [10]. The results of the present study indicated that the beef can reduce lipid oxidation, discoloration and weight loss of the steaks after 5 days of storage.

It was studied that the effect of chitosan incorporated with Low-Density Polyethylene (LDPE) film to sliced fresh red meats for fresh preservation [11]. Authors found that film with 8% chitosan could to maintain the redness for 5 days, meanwhile single Poly Ethylene (PE) films kept fresh red color on the meat surface for only 3 days. Chitosan with LDPE films of sliced flesh red meats, red color shelf life was extended.

Chitosan (CH) film enriched with tea polyphenol (TP) could extend shelf life of pork meat patties [12]. The result showed that CH -TP composite film served as a good antioxidant and antibacterial properties for pork meat patties, and the pork meat patties always saved an excellent appearance, compared with the control samples.

Gilani *et al.* effect of chitosan together with pomegranate juice dipping blend coatings incorporated with Zataria multiflora essential oil (ZEO) on the shelf-life of chicken meat [13]. The results showed that total number of bacteria, peroxide value and protein oxidation obviously were reduced in all of experiments than control, during refrigerated storage for 20 days at 4°C. Therefore, pomegranate juice dipping and chitosan coating are new preservation methods for food.

Latou E. *et al.* Discussed the combine effect that chitosan and modified atmosphere packaging of chicken breast fillets for shelf life extension [14]. Grounded on the sensory data and microbiological, chitosan/MAP treated chicken breast fillets was two weeks of shelf life, this is significantly expand longer (9, 7, 3 and 2 days) than control samples. Chitosan and common use of modified atmosphere packaging to extend shelf life can be better.

Composite Films in Seafood Packaging

The effect of chitosan - gelatin composite film for minced trout fillet with ethanolic red grape seed extract and *Ziziphora clinopodioides* essential oil (ZEO) by Kakaei and Shahbazi [15]. The test was evaluated over 11 days storage at 4±1°C with *Listeria monocytogenes*. The article reported that compared with the control group, the fish wrapped in chitosan - gelatin film had an obvious phenomenon that spoilage was delayed. It showed the chitosan - gelatin film can be combined with GSE and ZEO, lead to increased the antibacterial properties and enhanced the shelf life of fish fillet.

It has been reported that the silver carp (*Hypophthalmichthys molitrix*) skin gelatin - chitosan films with oregano essential oil (OEO), it had a good role in preservation for fish by Wu [16]. The present work demonstrated that OEO had the best antimicrobial activity for *Escherichia coli, Staphylococcus aureus, Bacillus subtilis* and many more. Compared with the control group, the OEO content of 4% when the composite film has good storage indicator. The results show that incorporated gelatin - chitosan films has effective antimicrobial activity, and it can extend the shelf-life of fish muscle. Therefore, the gelatin chitosan film incorporated with OEO have a great potential for applicability in fish preservation.

Granda et al. studied effect of chitosan with 0.5% of oregano and thyme oil coated ready-to-eat peeled shrimps (Penaeus vannamei) on the microbiological quality [17]. The experiment, estimate the nature of spoilage organisms for shrimps during refrigerated storage. The comparison showed

that Chitosan edible coatings could inhibit bacterial growth, maintain the microbiological quality of RTE peeled shrimps for 12 days storage at 4°C.

Reesha et al. preparation and Study of LDPE/chitosan (CS) composite antimicrobial film[18]. The experiment showed that the film inhibition of E.coli was 85-100%, and had good oxygen barrier properties. Then, all samples as pack-aging films for chill stored tilapia. The study found tilapia packed in 1%, 3% LDPE/CS films were remained acceptable stay 15 days, compared with virgin LDPE and 1% LDPE/CS films. But, 3% film had a more antibacterial properties than others. Thus, the film extended the shelf life of tilapia effectively.

Composite Films in Fruit and Vegetable Packaging

Study on the preservation effect of gelatin - chitosan edible composite films for fresh-cut grapes by Li [19]. The results indicated that the performance of the composite films have been improved after compounded. At the same time, due to the addition of the chitosan, preservation of edible film was enhanced. Coating on fresh-cut grapes played a good preservation effect, the fresh-cut grapes can still maintain a fresh, state for the 10 days at room temperature (30°C, in summer).

The effect of cassava starch/chitosan composite film packaged fresh-cut pineapple [20]. Determination of the freshness indicators what sensory evaluation, physiological and biochemical indexes and microorganism, during storage. As a result, the composite film extended the shelf-life of pineapple by 6~9 days, storage at (3 ± 1) °C.

Duran et al. researched the effect of chitosan packaging with antibacterial agents (containing natamycin, nisin, pomegranate and grape seed) of fresh strawberry on shelf life [21]. Study showed that chitosan packaging with antibacterial agents have improvements of quality and shelf life of fresh strawberry.

Jovanovi et al. studied the antimicrobial activity of chitosan coatings and films against Listeria monocytogenes [22]. The result outstanding that antibacterial effect and preservation performance, it can extend shelf life of black carrot.

In terms of preservation, Zhu et al. have a study on the effect of chitosan composite film with soy protein of straw mushroom [23]. The experiment was carried out at 15°C. Studies have shown that chitosan composite film can effectively prevent moisture dispersion loss, reduced weight loss, and to some extent suppress soluble solids, titratable acidity and Vitamin c content of nutrient loss, play a good role in preservation.

Kong et al. studied effect of chitosan blend film coating on preservation of *pleurotus eryngii* [24]. The results show that the package can effectively reduce the degree of browning and moisture, soluble protein content, delaying the change range of free amino acid content, total soluble sugar and other indicators of mushroom, compared with the control. Meanwhile, the package postponed aging rate after picking, keep the nutritional value and flavor processing. From this, the preservation effect was recognized.

Summary

The use of chitosan as packaging materials is very important in food manufacturing. Chitosan based active films have been used in meat, fruits and vegetables packaging, played an important role in food preservation, antibacterial, extend shelf life, etc. However, the mechanical properties and water barrier properties of chitosan-based film is poor, further studies will concentrate on improvement them. Although chitosan-based active films can not replace the status of plastic packaging materials, but the advantage of its anti-bacterial, biodegradable and film-forming property, it still has some potential for development in the food packaging for future.

Acknowledgements

This research was supported by the Project of Scientific research start-up fund of Jilin Agricultural University of China (2015019) and Project of Science and Technology Development of Jilin Province of China (No. 20110246).

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