Study on the Preparation of High gas Permeable Film and its Application in Fruit Preservation

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Abstract: Fresh produces still maintain respiration after be harvested, they would be perishable if appropriate processes are not took in storage and transportation. The most common means of keeping fruits and vegetables fresh is Modified Atmosphere Packaging (MAP), which can extend the shelf life of fresh produces by way of controlling concentration levels of oxygen and carbon dioxide in-package to restraint respiration of the tissue cell. A kind of film with micropore structure was obtained by oriented extrusion stretching method. A series of films with five different filler concentrations were prepared in this paper, mechanical properties, barrier properties and application properties in fruit preservation of these films were also studied. One LDPE film without additive was used as control. Experiment results showed that Young's modulus of these films was moderately lower, and compared with the control, tensile strength of these films decreased by 40%~50% at most. Breaking strength and elongation at break decreased with increasing filler concentration. The OTR of films increased from 1358.52 cc/m^2·day to 1462.20 cc/m^2·day at mostWVTR of them had improved slightly. One with 2% filler concentration of these films was applied in fruit preservation as package of pear. After being stored at room temperature for 6 weeks, firmness dropped from 4.2×10^{5}Pa to 3.6×10^{5}Pa in sample film package in contrast to 3.0×10^{5}Pa in control package. Weight loss of pear stored in sample and control films was 1.45% and 2.24%. Gas contents (O_2,CO_2) in-package were determined every week, the results showed that a appropriate levels of oxygen and carbon dioxide in-package were obtained by using these kind of high gas permeable films. Fruits stored in these films package have better quality and longer shelf life.**Keywords:** Modified Atmosphere Packaging (MAP); high gas permeable film; diatomite; fruit preservation

1. Introduction

Worldwide postharvest produces losses are as high as 30 to 40%[1] and even much higher in some developing countries (especially in China). Because fresh fruits and vegetables still maintain respiration after harvest, they would be perishable if appropriate processes are not took in storage and transportation. The most common means of keeping fruits and vegetables fresh is Modified Atmosphere Packaging (MAP) technology[2], which can extend the shelf life by way of controlling levels of oxygen and carbon dioxide in-package to restraint respiration of the tissue cell. Therefore, the gas permeability of packaging materials must be compatible with respiratory performance of the packaged fruits and vegetables. For fruits and vegetables packaging, microporous film has a bright development prospect because of excellent gas permeability and lower processing cost.

According to the concept of 'Mixed Matrix Membranes', Some mircoporous films based on zeolite, calcium carbonate and molecular sieve were successively developed[3]. Diatomite is a kind of mineral rock with porous structure and the main ingredient of it is amorphous active silicon dioxide. Because of the special porous structure, it has been widely used as adsorbent, filter aid and decolorant in many industry fields. Diatomite, used as filler, was incorporated into polymer matrix. It can absorb the water produced by respiration of fruits and vegetables, and then delay corruption and finally achieve the purpose of preservation. In present study, a kind of high gas permeable films were obtained by oriented extrusion stretching method. Mechanical and barrier properties of them were studied compared with control. Furthermore, an application in pear preservation was evaluated.

2. Materials and methods

2.1. Materials and materials characterization

Low density polyethylene (LDPE, LD100-AC, MFI=2.0, China Petroleum & Chemical Corporation) was used as major component in matrix, and diatomite was incorporated as filler into polymer matrix. The studied diatomites have average particle sizes (D50) in the range of 20~50μm.

2.2. Film preparation

The polymer blended with the filler by using twin-screw extruder and the blend polymer was prepared, and the compounds was then fabricated by blow film extrusion process using single screw extruder. Five films with different filler concentration were obtained respectively:

1%, 2%, 3%, 5% and 8%. And one film without additive was used as control (0# film). The films obtained have a thickness of 45~50μm.

2.3. Mechanical properties test

Mechanical properties (Young's modulus, Ultimate tensile strength, Breaking strength and Elongation at break) of prepared films were measured by using an Universal Testing Machine (Model 5565A, Instron, USA) with a 100N load cell. The initial grip separation was set at 100mm and cross-head speed was set at 200mm/min. The specimens are 10×150mm film strips cut in both machine and transverse directions. Measurements represented an average of five samples.

2.4. Barrier properties test

Oxygen permeability of prepared films was measured, according to the ASTM standard D 3985-05 by using an Oxygen Permeability Tester (TOY-C2, Labthink Instruments, China), at 23℃ and 50%RH. The water vapor transmission rate (WVTR) was measured, according to the ASTM standard F 1249-01 by using an Water Vapor Permeability Analyzer (Model 3/33, Mocon, USA) at 37.8℃ and 100%RH. The OTR (oxygen transmission rate) and WVTR were determined three replicates per sample.

2.5. Packing test

One with 2% filler concentration of these prepared films was selected as the representative of high gas permeable films. Crystal pear were used as experiment object for studying the application effect of high gas permeable film in fruit preservation, 0# film used as a control. Selected pears must be uniform in size, color, shape, and free of damage. Sample packed with these films stored at room temperature for 6 weeks.

The quality evaluation (firmness and weight) of each sample and gas contents in-package were measured each week. Firstly, firmness of pear was determined by fruit hardness tester (GY-2, Hangzhou top instruments, China), and the firmness of sample was expressed in 10^5Pa. The weight loss was calculated according to the weight of each sample before and after storage, and expressed as a percentage of the initial sample weight. Gas contents (O_2,CO_2) in-package were measured by using an Headspace Analyzer (Model 650, Mocon, USA).

3. Results and discussion

3.1. Mechanical properties

Mechanical property of material would decline when adding inorganic filler. Because there is no chemical bond between two phases of polymer matrix and inorganic filler, and the rigid diatomite is incompatible with polymer[4]. Some flaws appear between two phases and lead to decreasing mechanical property. Mechanical properties of six films were presented in Table 1, the average value were compared in machine and transverse directions respectively. Young's modulus of films first increased and then declined. The ultimate tensile strength and breaking strength showed a gradually decreasing trend. The ultimate tensile strength sharply decreased when adding inorganic filler, even the proportion is only 1%. Elongation at break of prepared films are less than control group, but there are significant differences between machine and transverse directions, it dramatically declined from 2#, 3# respectively. That is because the prepared film was obtained by oriented extrusion method and the machine direction of films has been stretched

Table 1. Mechanical properties of prepared films

Film		*Young's Modulus (MPa)*	*Tensile Strength (MPa)*	*Breaking Strength (MPa)*	*Elongation at Break (%)*
0#	MD	124.24	21.03	17.74	619.74
	TD	138.79	21.27	16.94	803.93
1#	MD	133.39	16.07	15.35	563.82
	TD	122.16	15.89	15.04	729.25
2#	MD	135.86	15.33	14.42	382.73
	TD	137.79	14.10	13.03	601.76
3#	MD	108.08	12.50	11.71	330.77
	TD	98.89	10.37	9.87	430.55
4#	MD	115.72	12.48	11.71	326.64
	TD	112.27	10.74	9.94	340.16
5#	MD	111.11	12.10	11.52	334.49
	TD	115.46	10.60	9.77	290.71

3.2. Barrier properties

Barrier properties of prepared films is refected by oxy-

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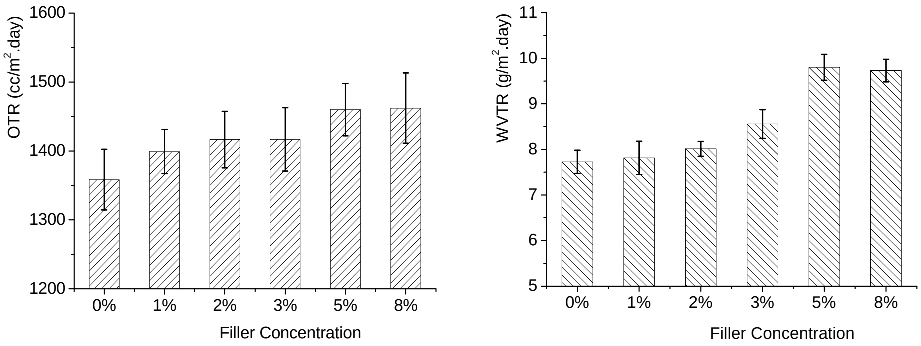
gen transmission rate and water vapor transmission rate. As showed in Figure.1, the OTR and WVTR of films increased with increasing filler concentration. The OTR increased steadily with the increase of filler concentration, compared to the control group, it had rised from 1358.52 cc/m^2·day to 1462.20 cc/m^2·day at mostWVTR of them has improved slightly from 1% to 3%, when adding to 5%, it has greatly increased. Cavity or bubble emerged between two phases because that the inorganic filler is incompatible with polymer matrix. Gas molecules can permeate through these flaws, and diatomite itself own porous structure[5]. Gas permeability of prepared films increased correspondingly compared with the control group.



OTR WVTR

Figure.1 OTR and WVTR of prepared films

4. Packing test

4.1. Firmness

Pulp firmness is one of the most important quality indexes, it reflects maturity of fruit. Nutrient depletion, degradation of pectin substances and water loss are considered as the three main factors causing the decline of pulp firmness. Pulp firmness in sample films is obviously higher than it in control film after stored for 6 weeks. It can be seen from Figure.2, firmness value in sample films remained stable in the first 3 weeks. And noticeable decline occurred in control film after the first week. After stored for 6 weeks at room temperature, firmness dropped from 4.2×10^5Pa to 3.6×10^5Pa in sample film package in contrast to 3.0×10^5Pa in control package. Experiment results indicated that the prepared films can maintain water and nutrition in pulp tissue.

4.2. Weight loss rate

Weight loss is caused by a loss of cellular sap as a result of biochemical alterations. Large weight loss accelerated decay in fresh fruit as well as result in consumer unacceptability[6]. Figure.3 showed weight loss rate of experiment pears in different packages, which increased significantly during storage and the final percentages weight loss is respectively 1.45% and 2.24% of initial experimental pear weight in sample and control packages. The results showed that the prepared films are beneficial to fruit preservation.

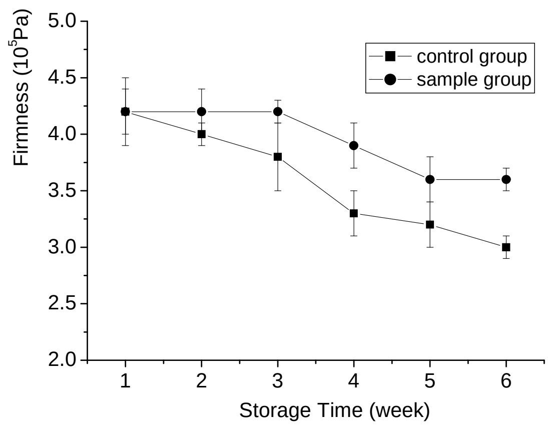


Figure.2 Firmness of experimental pears during storage

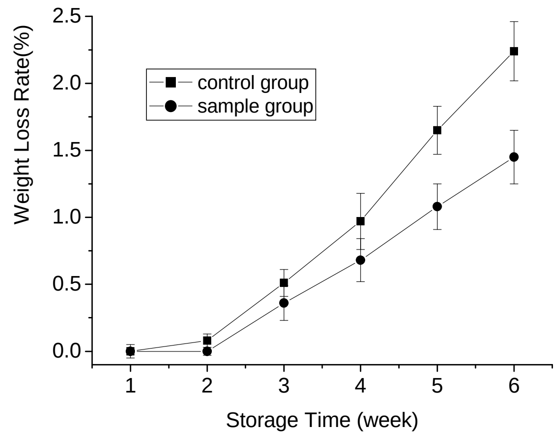


Figure.3 Weight loss rate of experimental pears during storage

4.3. Gas contents (O_2,CO_2)

O_2 and CO_2 concentrations in different packages were presented in figure. 4. Gas concents within packages of different films were not significantly different. The O_2 level of sample group slightly higher than the control group and maintain at 15%~18% from the second week. Research suggest that high O_2 level is helpful to keep fruit fresh. It can inhibit the respiration of fruit tissue because the tissue is in a 'full-oxygen' state. Experimental results showed that a appropriate levels of oxygen and carbon dioxide in-package were obtained by using these kind of high gas permeable films.

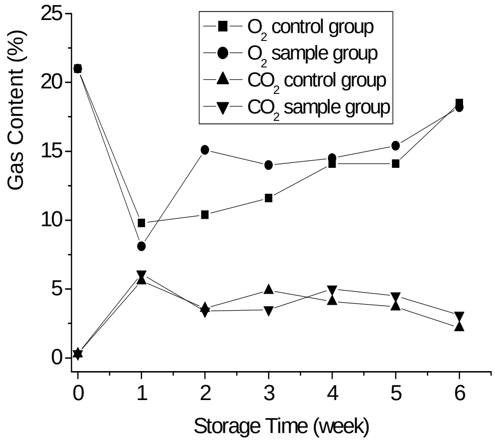


Figure.4 Gas contents in different packages of experimental pears during storage

5. Conclusion

According to the concept of 'Mixed Matrix Membranes', a kind of high gas permeable film with micropore structure was obtained by oriented extrusion stretching method. Mechanical properties of these films declined when adding inorganic diatomite. The OTR and WVTR of these films increased with increasing filler concentration. When applied them in pear preservation, results showed that these films can maintain fruit firmness and a lower weight loss, and a appropriate concentration levels of oxygen and carbon dioxide in-package can obtained by these films. But, further research on a higher gas and water vapor permeability is needed before it can be commercialized.

6. Acknowledgements

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