PRESERVATION EFFECTS OF ACTIVE PACKAGING MEMBRANE FROM ALLYL ISOTHIOCYANATE MOLECULARLY IMPRINTED POLYMERS COOPERATING CHITOSAN ON CHILLED MEAT

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Abstract – Active food packaging membrane with slow-release function was produced by allyl isothiocyanate moleculatly imprinted polymer (AITC-MIPs) cooperating chitosan (AITC-MIPs-co-CS). The preservation effects of the membrane were investigated according to the physicochemical indexes on chilling meat stored at 4 ℃. At the same time, unpackaged group, pure chitosan coated membrane group and chitosan membrane including AITC group were set as the controlled samples. Preservation effects of AITC-MIPs-co-CS on chilled meat is superior to the other control groups, which can effectively inhibit the growth of bacteria and delay the rise of volatile base nitrogen (TVB - N) and pH. After 11 d storage, pH is 6.48, TVB-N 15.12 mg/100g, and total number of bacteria 4.52 lg CUF/g. The storage period is 3.67 times for the group 3 as long as the CK group. It can significantly prolong the shelf life of chilled meat by a packaging membrane of AITC-MIPs-co-CS.

Key Words – Action packaging membrane, Allyl isothiocyanate, Chitosan, Moleculatly imprinted polymer

I. INTRODUCTION

Allyl isothiocyanate (AITC), the major component of mustard oil [1] can be used as an antimicrobial to kill common spoilage bacteria and pathogenesis [2, 3]. It can not only reduce the unpleasant smell of AITC, but also delay the release of the AITC by embedding AITC in β-cyclodextrin (β-CD) cavity. It is reported that the release time of AITC from AITC-β-CD complex is 120 h under different environmental relative humidity [4].

AITC molecularly imprinted polymers (AITC-MIPs) was prepared to further improve release time of AITC on the basis of the AITC inclusion complex. Then the combination of AITC-MIPs and chitosan (CS) with excellent film-forming properties were applied in packaging materials. Further, the preservation effect of the packaging materials was studied on chilled fresh pork. It can provide experimental data for application of AITC inclusion compound used in food packaging.

II. MATERIALS AND METHODS

Prepararion of AITC inclusion complex [4]

The preparation of AITC (*99% purity, Xiya Chemical Technology Co., Ltd., Chengdu, China*) inclusion complex was composed of β-CD (*99% purity, Sigma-Aldrich Company, USA*) dissolved in distilled water and mixture of AITC and ethanol (v/v, 1:1). Then, it was kept on stirring at 45 °C for 4 hours, followed by filtration for AITC inclusion complex. Subsequently, it was put into an oven for 12h.

Preparation of AITC-MIPs

β-CD dissolved in DMSO (*Xiya Chemical Technology Co., Ltd., Chengdu, China*), AITC was added to Erlenmeyer flask. Then, β-CD and AITC were in full reaction at 45 °C for 24 h. TDI (*Xiya Chemical Technology Co., Ltd., Chengdu, China*) was added to the reaction system under the protection of nitrogen to conduct the reaction with vigorous stirring at 65 °C for 24 h. The reaction solution was added into excessive acetone to get a milky white flocculent precipitate. Subsequently, it was dried in oven for 12 h and was ground and stored in a desiccator to reserve.

Preparation of packaging film

CS (*Beijing Solarbio Science & Technology Co., Ltd., Beijing, China*) was dissolved in 1% (v/v) acetic acid to get coating solution and was coated on fresh paper (*Yufeng Paper Products Co., Ltd., Xiong County, Hebei province, China*), dried and used as the group 1. AITC inclusion complex was added to the coating solution. It was evenly coated on fresh paper, dried and used as the group 2. Similarly, the coating solution containing AITC-MIPs was coated on fresh paper, dried and used as the group 3.

Chilled fresh pork processing

Chilled meat 100 g was packaged into the groups 1 to 3; the CK group was not with wrap. They stored in a 4 °C refrigerator. Indexes of chilled meat were measured from one sample of each group every day.

Determination of pH

The pH was measured according to a national standard of GB/T 9695.5–2008. Evaluation criteria were as followed: $5.6 \leq pH \leq 6.2$ was for primary fresh meat, $6.3 \leq pH \leq 6.6$ for secondary fresh meat; and pH> 6.7 for the deterioration of meat.

Determination of volatile basic nitrogen (TVB-N)

TVB-N was measured according to GB/T 5099.44-2003, semi-micro diffusion method. Evaluation standard was as followed: TVB-N ≤ 15 mg/100 g for primary fresh meat; TVB-N ≤ 20 mg/100 g for secondary fresh meat; TVB-N> 20 mg/100 g for deterioration meat.

Determination of the total number of bacteria

The total number of bacteria was measured according to GB/T 4789.2-2010. Evaluation criteria were as followed: logarithm total number of colonies of (lg CUF) <4 was for primary chilled meat, 4 <lg CUF-<6 for secondary fresh meat, and lg CUF> 6 for deterioration meat.

Shear force

Chilled meat sample was cut along the vertical direction of the muscle fibers with a diameter of 1.27 cm. Muscle tenderness was measured along the vertical direction of the muscle fibers by C-LM3 digital muscle tenderness instrument.

Colour value

L (brightness value), a (red) and b (yellowness) was measured by WSD-III portable whiteness

colorimeter, respectively.

The end of the experiment was determined by primary criteria for each experimental indicator.

III. RESULTS AND DISCUSSION

pH of cold meat of different group

As shown in Figure 1, with the increase of storage time, pH generally decreased and then increased. As for the group 1, its pH was up to the critical point (5.74) on the first day. As for groups 2 and 3, their pH reached the critical point on the second day. On the third day, The pH of the CK group was 6.66 close to the pH of the deterioration of meat (pH> 6.7). As for groups 1 to 3, their pH reached the secondary chilled standard on the fifth day, eighth day and eleventh day, respectively. When the group 3 was stored for 11 d, its pH reached 6.48. There were no significant difference for the shelf life between the group 1 and 2 (P>0.05) while there were significant difference (P<0.05) between the CK group and group 3.

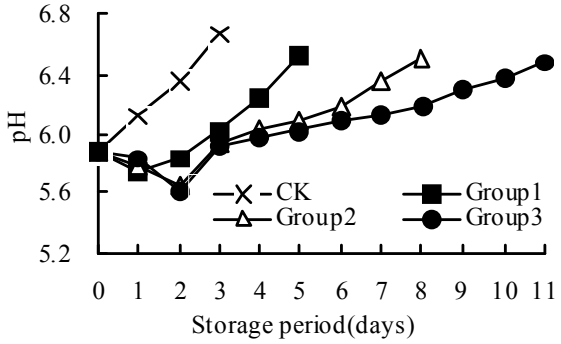

Figure 1. Effects of different packing conditions on pH of chilled fresh meat.

TVB-N content in chilled meat in different groups

As shown in Figure 2, initial TVB-N content in chilled meat was 8.4mg/100g. TVB-N content in each treatment group displayed an upward trend with the increasing storage time. There was significantly different (P <0.05) for TVB-N content between the treatment groups. On the third day, TVB-N content in the CK group was up to 17.36mg/100g, while TVB-N content in the group 1, 2 and 3 was respectively 12.88 mg/100g, 10.08 mg/100g and 10.08 mg/100g. On the fifth day, TVB-N content in group 1 was 15.68 mg/100g.

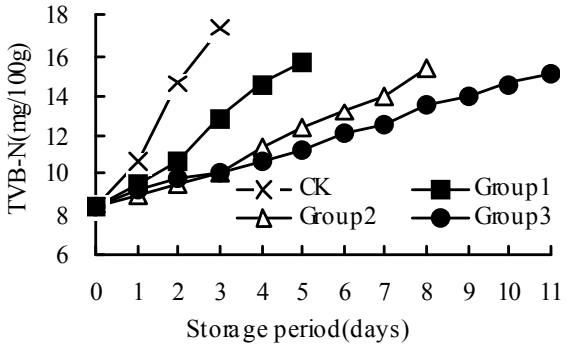

Figure 2. Effects of different packing conditions on the TVB-N conten in chilled fresh meat.

On the eighth day, TVB-N content in group 2 was 15.44mg/100g and in the group 3 was 13.44

mg/100g. It increased slowest in the group 3, and was slightly more than 15mg/kg (15.12 mg/100g) at storage time of 11 days.

Total number of bacteria in chilled meat in different groups

As can be seen in Figure 3, the initial total number of bacteria in chilled meat was 2.35 lg CUF/g. There was significantly different (P <0.05) for total number of colonies between the treatment groups. The trend line of microbial growth is steep for the CK group. On the third day, the total number of bacteria in the CK group was 5.11 lg CUF/g, while that in the group 1, 2 and 3 was respectively 2.76 lg CUF / g of of 2.05 lg CUF / g of 1.55 lg CUF / g. The chilled meat in the group 1, 2 and 3 all became secondary fresh one, when the storage time was respectively 5 d, 8 d and 11d. Correspondingly, the total number of colonies was respectively 4.1 lg CUF / g, 4.43, lg CUF / g and 4.52 lg CUF / g. On the whole, the microbial grown slowest in the group 3, its shelf life was 3.67 times as long as the CK group.

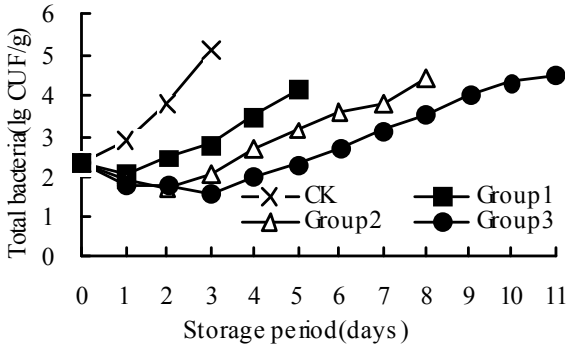

Figure 3. Effects of different packing conditions on the total bacteria of chilled fresh meat.

Shear force of chilled meat

Figure 4 shows that the shear force reached the maximum (15.53 N) on the first day for the group 1. For the groups 2 and 3, their shear forces respectively reached the maximum 17.54 N and 17.88 N on the second day. On the third day, the shear force of CK group decreased 9.21 N. During storage, the shear force of group 1 decreased faster, relative to groups 2 and 3. On the fifth day, the shear force of the group 1 was 5.39 N while the shear forces of the group 2 and 3 were 6.49 N and 8.68 N, respectively. By significant analysis, during storage, the shear force between treatment groups change was significantly different (P <0.05). After storage of 5 days, the shear force of group 3 was no significant difference (P> 0.05).

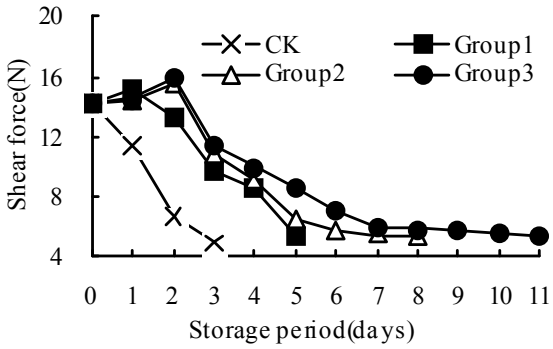

Figure 4. Effects of different packing conditions on the shear force of chilled fresh meat.

Chilled meat color value of different groups

As shown in Figure 5, the L value of the groups 1 to 3 all initially increased and then decreased. The L value of the group 1, 2 and 3 reached peak on the first day, the second day and the third day, and the peak value of which was 51.91, 54.04 and 55.39, respectively. On the third day, the L value of CK group decreased 15.64. During storage, the L value of the group 1 decreased faster, relative to group 2 and 3. On the eight day, the L value of group 2 was 35.55, while on the eleventh day that of the group 3 was 34.77. During storage, there was significantly different ($P < 0.05$) for the L value between the treatment groups. Moreover, on the fourth day later, the L value of group 3 was kept no significant difference ($P > 0.05$).

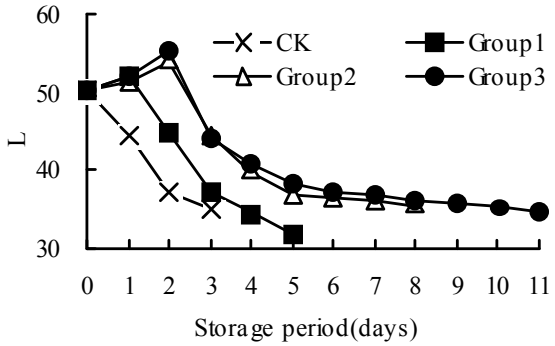

Figure 5. Effects of different packing conditions on the L value of chilled fresh meat.

As can be seen in Figure 6, during the storage, the red value of the CK group, the group 1, 2 and 3 were all initially increased and then decreased ($P < 0.05$).On the third day, a value of the group 1 and 2 reached a peak, 17.66 and 17.40, respectively. On the fourth day, a value of the group 3 reached a peak of 17.30. After that, a value of each treatment group showed a downward trend.

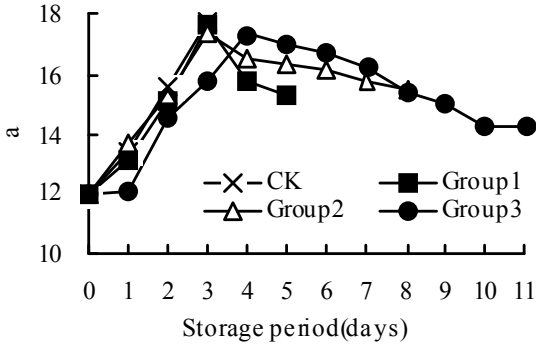

Figure 6. Effects of different packing conditions on the a value of chilled fresh meat.

As shown in Figure 7, during storage, the b value of each treatment group showed an overall upward trend ($P < 0.05$). On the third day, the b value of the CK group was 8.98, which was respectively 1.19 times, 1.95 times and 2.91 times as much as the group 1,2 and 3. On the fifth day, b value of the group 1 increased 1.49. On the eighth day, b value of the group 2 increased 1.63 and that of the group 3 increased 1.82 on the eleventh day. It suggested that AITC-MIPs-co-CS caused better antibacterial effect and antioxidant capacity.

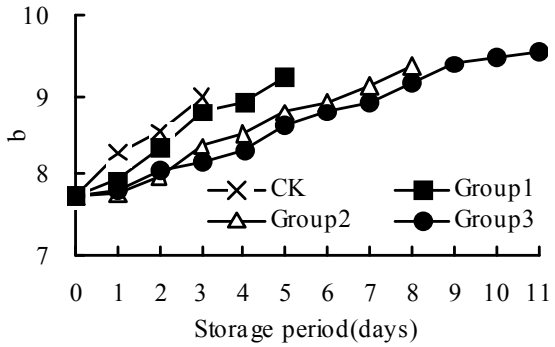

Figure 7. Effects of different packing conditions on the b value of chilled fresh meat

4 CONCLUSION

These results indicated that the preservation effect of the group 3 was optimal. After storage 11d, the pH of the group 3 was 6.48, TVB-N was 15.12 mg/100g, the total number of colonies was 4.52 lg CUF/g. The storage time was 3.67 times for the group 3 as long as the CK group. The indicator values for the group 3 were just over primary fresh meat standards, indicating that the release of AITC by AITC-MIPs could be better delayed than by AITC inclusion complex. It can can effectively suppress the rise of the pH, decrease of TVB-N, inhibit the propagation of microorganisms by the packaging membrane of AITC-MIPs-co-CS.

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