Application of Functionally Integrated Modified Atmosphere Packaging Design in Preservation of Nanguo Pears at Room Temperature

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Abstract. In order to prolong the shelf life of Nanguo pears at room temperature (25 °C), we made two types of functionally integrated modified atmosphere packaging (MAP), OA and OB. OA integrated self-made high oxygen permeable film (film O) and high moisture permeable film (film A). OB integrated film O and another type of high moisture permeable film (film B). The headspace components in the packaging, and vitamin C (VC) contents, titratable acid (TA) contents and market value of Nanguo pears were monitored during the storage to evaluate the two types of MAP. Results show that OA and OB can effectively reduce the nutrient loss of Nanguo pears during storage, thus maintaining their good commercial value. OA and OB respectively extended the shelf life of Nanguo pears at room temperature from less than 8 days to less than 12 days and more than 14 days.

Keywords: Nanguo pears · Headspace · Titratable acid · Vitamin C · Commercial value

1 Introduction

Nanguo pears are specialty of Liaonan. They are known as the king of pears and rich in a variety of amino acids necessary for the human body and have a high nutritional value. Nanguo pears are perishable after ripening, and their shelf life are only 2–3 days at room temperature [1]. Therefore, Nanguo pears are generally picked during the stage of green mature to extend their shelf life. The effect of low temperature storage is good, but the cost is high, and it may cause cold damage to Nanguo pears and reduce their market value. Although 1-methylcyclopropene (1-MCP) can delay the ripening of Nanguo pears, the treatment will reduce the aroma of Nanguo pears [2]. Atmosphere storage is an economical and effective preservation method. It can reduce the activity of catalase and polyphenol oxidase in Nanguo pears and the browning index of the fruit [3]. So it has been widely used in the preservation of Nanguo pears.

The functions of film used in conventional MAP are relatively simple, and it is technically difficult to simultaneously achieve high oxygen permeability and high moisture permeability on a kind of film. In order to solve this problem, two types of MAP integrating high-oxygen permeability and high-moisture permeability functions

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were made. Our work is purpose to provide new ideas and technical references for the preservation of Nanguo pears and other fruits at room temperature.

2 Materials and Methods

2.1 Preparation of Modified Atmosphere Packaging and Nanguo Pears

We used a kind of high oxygen permeability film (film O) and two kinds of high moisture permeability film (film A and film B). O film is a kind of polyethylene modified film, its manufacturing process is referred to the patent of CN102863685A [4]. A film and B film are polypropylene modified film, and their manufacturing process is referred to the patent of CN104017243A [5]. The choice of film material and the determination of its dimensions were based on our previous research [6]. Three sides of the two pieces of the film (O and A, O and B) were bonded by hot melt adhesive to make bags (mark as OA, OB). The film parameters are shown in Table 1.

Table 1. Film parameters of OA and OB

Packaging	Film material	OTR [mL/(m^2 day atm)]	WVTR [g/(m^2 day)]	Size (m)	Area (m^2)
OA	O	1.2×10^5	<5	0.30 × 0.20	0.06
	A	<5	60	0.30 × 0.20	0.06
OB	O	1.2×10^5	<5	0.30 × 0.20	0.06
	B	1000	100	0.30 × 0.20	0.06

Nanguo pears of a mature degree of 70–80% were purchased from the Xinfadi fruit market in Beijing, without any chemical treatment. Nanguo pears were selected according to the same weight and appearance criteria. These pears were divided into three groups, OA, OB and control group (unpackaged). Each bag of the OA and OB group contains 6 Nanguo pears (0.5 kg) groups, and 6 Nanguo pears were randomly selected from the control group.

2.2 Measurement of the Headspace Component of the Packaging and Nutrient Analysis

CO_2 and O_2 concentrations in the headspace of each packaging were tested using an O_2/CO_2 handheld gas analyzer (Check Point). The determination of TA content was based on the method of Sivakumar and Korsten [7]. The VC content of pears was determined according to the method given by Li et al. [8].

2.3 Commercial Value Evaluation and Data Processing and Analysis

The commercial value of Nanguo pears fruit was evaluated by examining its exterior and taste. This evaluation was conducted by 10 trained people, adopting a 10-point

evaluation method. The evaluation criteria are shown in Table 2. When the score is less than 5 points, it can be considered that the shelf life of Nanguo pears is reached.

Table 2. Commercial value evaluation standards of Nanguo pears

Score	Exterior quality	Taste
$8 < X \leq 10$	Peels don't shrink, the color is bright yellow	The flesh is delicate, sour and sweet, without softening
$6 < X \leq 8$	Peels don't shrink, the color of bright yellow fade	The flesh is delicate, sour and sweet, without softening
$5 < X \leq 6$	Peels shrink slightly, turn black	The flesh soften slightly and its sweetness is reduced
$X \leq 5$	Peels shrink obviously, individual rot	The flesh is obviously soft and its sweetness is very light

Using SPSS9.0 for experimental data analysis and drawing with Origin 8.5.

3 Results and Discussion

3.1 Changes in Composition of the Headspace

Nanguo pears belong to climacteric fruit, their respiratory intensity will suddenly rise during the maturation process and then enter the aging stage. In order to meet the needs of Nanguo pear's breathing, we used a piece of high oxygen permeability film, film O, to provide sufficient oxygen in the packaging. It can be seen from Fig. 1a, the oxygen content in the packaging had been maintained at more than 20%, which avoided the anaerobic respiration of Nanguo pears and the production of any toxic effects. We used two kinds of high moisture permeable films, film A and B, to eliminate the water vapor produced by Nanguo pears in a timely manner. No water vapor condensation occurred in the packaging during the entire experiment, which verified the rationality of the packaging design. It can be seen from Fig. 1a that the OA group reached the peak of respiration on the 7th day, while the OB reached the peak of respiration on the 9th day. The result shows that the OB can delay the maturation of Nanguo pears. This is because the moisture permeability of the A film was lower than that of the B film, resulting in the excessive relative humidity in the OA. The position of the CO_2 concentration peak in Fig. 1b corresponds exactly to the position of the respiratory peak in Fig. 1a. Thus validating the previous inference.

3.2 Loss of Nutrients

Titratable acid is an important nutrient in Nanguo pears, and it is also an important factor affecting Nanguo pears's flavor. From Fig. 2a, it can be seen that the total acidity of the three groups of Nanguo pears showed a downward trend during the storage period. The total acid reduction in the OA and OB groups was significantly lower than in the control group. The TA content of the control group decreased to 0.284% on the

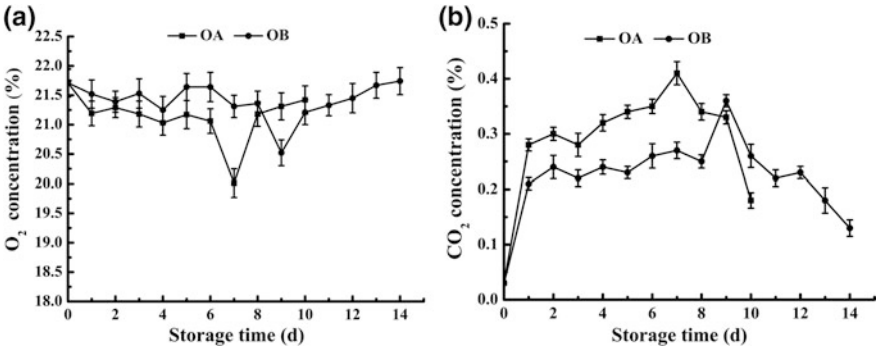

Fig. 1. **a** Changes of O_2 concentration in the headspace of packaging. **b** Changes of CO_2 concentration in the headspace of packaging

sixth day, which was only 51% of the initial value. However, the TA content of the OA and OB groups were always higher than this value throughout the storage period. This is because the higher relative humidity environment in the two sets of packaging, which weakened the transpiration of Nanguo pears. It reduced the metabolism of the acid substances.

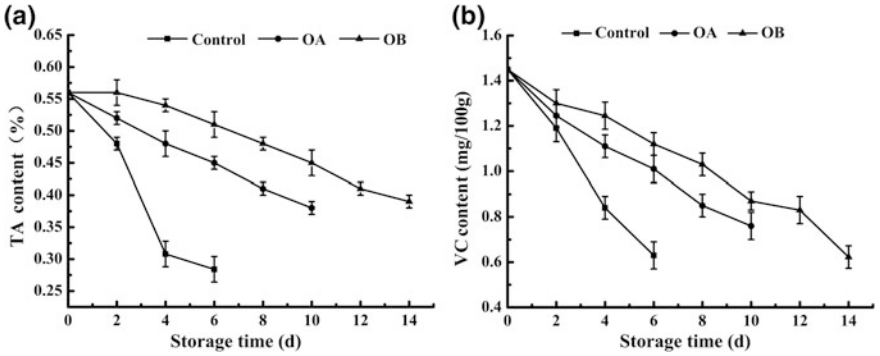

Fig. 2. **a** Changes of titratable acid content in Nanguo pears. **b** Changes of VC content in Nanguo pears

Vitamin C is the essential nutrient needed by the human body, and it protects cell tissue from damage and delays spoilage. Our test found that VC content in Nanguo pears was relatively small, and the initial test value was 1.45 mg/100 g. It can be seen from the Fig. 2b that the decrease in the content of the control group during storage was significantly higher than that of OA and OB. On the one hand, the oxygen concentration in the atmosphere of the control group was higher, their respiratory intensity was higher. On the other hand, Nanguo pears in the control group matured

faster than the OA and OB groups. These resulted in a higher oxidation rate of VC in the control group than in the OA and OB groups.

3.3 Commercial Value

From Fig. 3, it can be seen that the commercial score of the control group during the storage period was significantly lower than that of the OA and OB groups. Its commercial score was less than 5 on the 8th day, indicating that the shelf life was less than 8 days. The OA group had a commercial score of less than 5 on the 12th day, indicating that the shelf life of the OA group was less than 12 days. The overall score of the OB group on the 14th day was still higher than 5, indicating that its shelf life was more than 14 days. Compared with the control group, the Nanguo pears in the OA and OB groups showed less change in appearance and less nutrient loss, which resulted in a higher commercial value score.

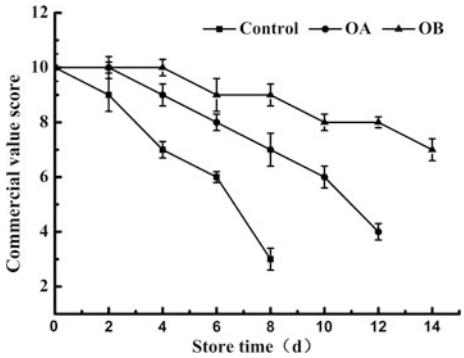

Fig. 3. Changes of commercial value score of Nanguo pears during storage

4 Conclusions

In order to adjust the oxygen and humidity inside the MAP at the same time, this experiment proposes two kinds of functional integrated MAP design. The high oxygen permeable film provides the packaging with sufficient oxygen. The high moisture permeable films, A and B, promptly eliminated the water vapor generated by Nanguo pear's respiration. Compared with the control group, both modified atmosphere packaging designs can significantly reduce the loss of VC contents, TA contents and commercial value of Nanguo pears during the storage period. OA and OB respectively extended the shelf life of Nanguo pears from less than 8 days to less than 12 days and more than 14 days at room temperature. This integrated modified atmosphere packaging can also be further expanded to add other functions. Compared with the traditional MAP using single film, it has more features and better flexibility.

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