Laboratory Report

Effect of polylactic acid (PLA) packaging on the preservation of mangoe

1 Experimental purpose

The study of the preservation effects of polylactic acid (PLA, Zhejiang Aike Fans New Material Technology Co., LTD) packaging on mangoe stored at ambient temperature provided a convenient preservation method for mangoe stored at ambient temperature.

2 Materials and methods

2.1 Materials

Commercially available mangoes were purchased from supermarket at Yinzhou District, Ningbo City on May 8, 2023. The mangoe fruits with consistent size and maturity were picked and the decayed, moldy and soft fruits were removed. Then, the fruits were placed in the packages to conduct the experiment.

2.2 Methods

The selected mangoe fruits were packaged as Table 1. Each treatment was performed in triplicate and stored at temperature of 20-25℃ in the laboratory. The physicochemical indexes were regularly tested.

Table 1 Experimental groups

Number	Group	Manner of packing	Experimental volume
1	CK	storage without package	1/package×6 / triplicate
2	PE	Packed with PE	1/package×6 / triplicate
3	PLA	Packed with PLA	1/package×6 / triplicate

2.3 Quality indexes

(1) Rate of weight loss

The rate of weight loss was determined by the weighing method.

(2) Moldy rate measurements

Moldy rate (%) = number of moldy fruit / total number of fruit ×100%

(3) Gas concentration (O_2 / CO_2 content) measurements

Gas concentration of mangoe fruits were determined using PBI Dansensor (Denmark).

(4) Total soluble solid (TSS) and titratable acid (TA) measurements

The TSS and TA of mangoe fruits were measured by using PAL-BX / ACID F5 glucometer (ATAGO Co., Ltd, Japan).

(5) TPA measurements

Six of mangoe samples was used for TPA measurements using a texture analyser (TA.XT Plus texture analyser, Stable Micro Systems Co., Ltd, UK). The device and test parameters were a P/5 cylindrical probe, a pre-test velocity of 1 mm/s, a test velocity of 2 mm/s, a after-test velocity of 1 mm/s, a compression distance of 5 mm, and a trigger force of 5 g. The texture variables, including hardness and springiness were obtained from the Texture Expert software. Each fruit sample was measured in triplicate.

(6) Measurement of relative conductivity

A sample of 1 g mangoe fruit weighted from each treatment and control group was diluted and homogenized with 10 ml distilled water using a ZLD-300 homogeniser (Zonce Machinery Co., Ltd, Shanghai, China) at 8000 r/min for 1 min. The homogenate was used to determine the conductivity by using an DDSJ-308A conductivity meter (Shanghai INESA scientific instrument Co., Ltd, Shanghai, China) befor and after stewing for 10 min respectively, which seted as P_1 and P_2.

Relative conductivity (%)= $(P_1-P_0)/(P_2-P_0) \times 100\%$

where P_0 was the conductivity of distilled water

(7) Colour difference analysis

The colour difference of mangoe samples was evaluated by using a CI-60 colour difference meter (X-rite Pantone Co., Ltd, USA). The colour differences were analysed by L^*, a^*, and b^*, where L^* denotes lightness, a^* denotes from green to red, and b* denotes blue to yellow. All experiments were tested in triplicate.

2.4 Statistical analysis

All measurements were performed in triplicate and the results were reported as means ± standard deviations (SDs). Data were analyzed by one-way analysis of variance (ANOVA) and Tukey's pairwise comparisons tests by using SPSS v.20 (SPSS Inc., Chicago, IL, USA). Differences were considered significant at the level of $p < 0.05$. The figures were plotted with Origin v. 8.0 (OriginLab, Northampton, MA, USA) software.

3 Results and discussion

3.1 Rate of weight loss of mangoe under different package

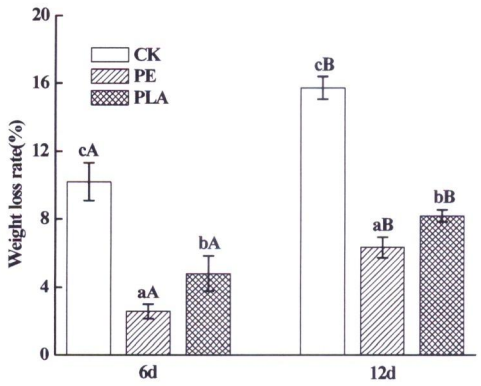

Figure 1 The effect of different package on the rate of weight loss of mangoe

The rate of weight loss is the external expression of the loss of water, and it is an important indicator to measure fruit quality. Freshly picked mangoes are full of moisture and exhibit a firm and plump state. Loss of weight will lead to it becoming dry and wilt, which significantly affect its commercial and economic value. As seen in Figure 1, mangoes without package (CK) losed water rapidly, with a weight loss rate of 10.2% after 6 days of room-temperature storage, and 15.7% after 12 days, showing a withered and wrinkled surface. The weight loss rates for PE package were 2.6% and 6.3%, while those for PLA package were 4.8% and 8.2%. PLA package exhibited lower water retention than PE but higher than CK. It is evident that packaging with PLA package could significantly suppress the water loss of mango ($P<0.05$).

3.2 Rate of mold of mangoe under different package

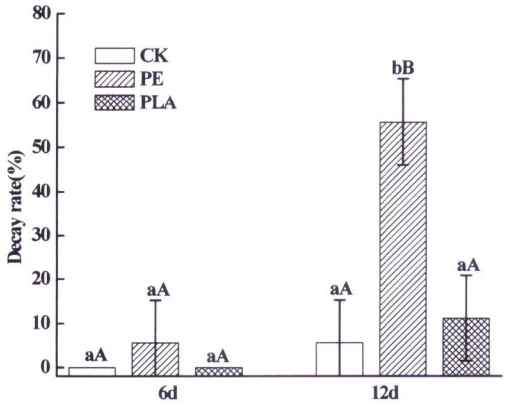

Figure 2 The effect of different package on the rate of mold of mangoe

Black rot (anthracnose) is one of the main appearance of the decay of mangoe during storage, which is an important factor causing the loss of mangoe after harvest. The effect of different packages on the decaye rate of mangoe was shown in Figure 2. Although the PE package groups were effective in controlling water loss and weight loss, the decay rate is as high as 55.5% after 12 days of storage, which significantly higher than that of PLA and CK groups. Although no significant decay occurred after 6 days of storage for all packaging treatments, the mango stems in the PE package showed obvious molds, while those in the PLA and CK package did not show any signs of molds. Based on the results in Figure 1, PLA package could significantly reduce the weight loss rate while effectively reducing the occurrence of decay during 12 days of storage.

3.3 Changes of gas concentration of mangoe under different package

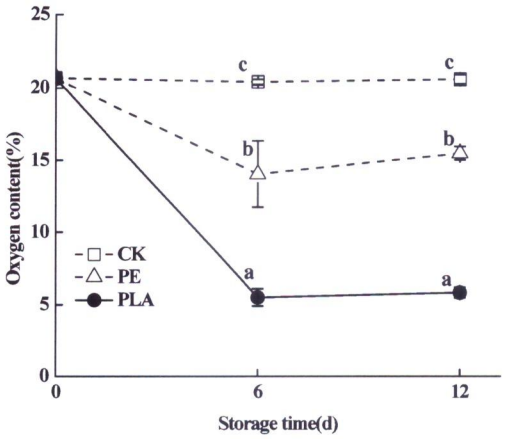

Figure 3 Effect of different packaging treatments on the oxygen concentration in the package

Suitable gas concentration can reduce the phenomenon of mold and decay, otherwise will affect the respiratory metabolism of the fruit, and produce the flavor of alcohol flavor under anaerobic respiration. The change of gas concentration in different packaging treatments was shown in Figure 3-4. Figure 3 showed the effect of different packaging treatments on the oxygen concentration in the package. For the control group, its gas concentration is the same to the air. For PLA and PE package, their oxygen concentration decreased rapidly and its rate of decrease for PLA package was faster. On the six day of storage, the oxygen concentration for PE package was 14.0% and for PLA package was 5.5%.

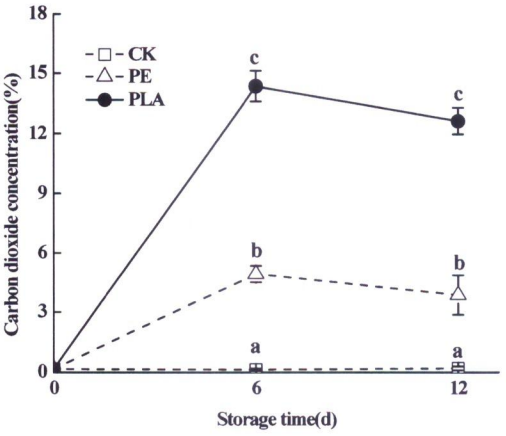

Figure 4 Effect of different packaging treatments on the carbon dioxide concentration

in the package

Because the mangoe is live, it could consume O_2 and release CO_2 in the package. The oxygen concentration descreases while the concentration of carbon dioxide increases in the package. Among the groups, the concentration of carbon dioxide in the PLA package increased faster, which have bacteriostasic activity. However, it should pay an attention to the change of gas composition, and prevent the alcohol metabolism induced by anaerobic respiration.

3.4 Changes of TSS and TA of mangoe under different package

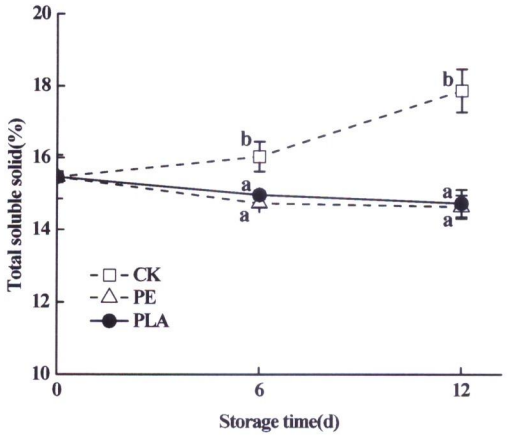

Figure 5 Effect of different packaging treatments on the total soluble solid of mangoe

Total soluble solid (TSS) is an important evaluation index to measuring the sweetness of mangoe. As shown in Figure 5, the TSS of mango in the CK group increased significantly during the storage period. However, the TSS of mango in PLA and PE packages did not show remarkably change and were significantly lower than that in the CK group. Hence, the PLA and PE packages maintained the TSS at a relatively stable level by preventing the water loss.

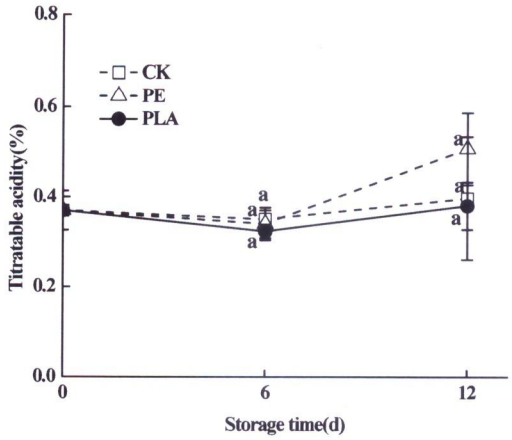

Figure 6 Effect of different packaging treatments on the titratable acid of mangoe

Titrateable acidity, also known as acidity, is an important evaluation index for measuring the acidity of mango. As shown in Figure 6, there was no significant difference in the effect of different packaging treatments on the TA of mango within 12 days of storage ($P>0.05$). Overall, there was no significant difference among the groups ($P>0.05$).

3.5 Changes of TPA of mangoe under different package

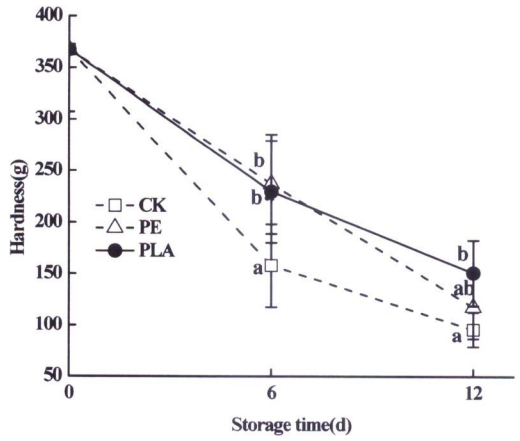

Figure 7 Effect of different packaging treatments on the hardness of mangoe

TPA intuitively reflects the fruit edible quality, and hardness is one of the indexes of TPA. Figure 7 showed the change of the hardness of mangoe in different packages. As can be seen from the figure, the hardness of different groups decreased during the storage period, with the CK group showing the fastest decrease rate. The hardness of

fresh mango was 367.7g and then decreased to 158.0g and 95.80g after 6 and 12 days of storage, respectively. The hardness of mango for PLA and PE packages decreased, but at a significantly slower rate than CK group. The hardness decrease of mangoes was related to the post-harvest ripening and water loss. As CK group experienced significantly higher water loss than PLA and PE groups, its decrease rate of hardness was higher. There was no significant difference for the hardness changes in mangoes packaged with PLA and PE ($P>0.05$), but both were significantly higher than CK group, which indicating that PLA and PE packages have similar effects in maintaining mango hardness and delaying fruit softening and water loss.

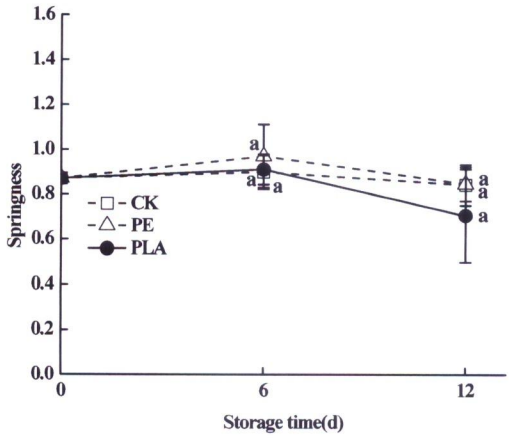

Figure 8 Effect of different packaging treatments on the springness of mangoe

Springness is one of texture feature parameters, which demonstrated the ratio of the height that can be recovered between the end of the first bite and the beginning of the second bite. Figure 8 showed the effect of different packaging treatments on the springness of mangoe. Results showed that there is no significant difference among the groups ($P>0.05$)

3.6 Changes of colour of mangoe under different package

Table 2 Effect of different packaging treatments on the colour of mangoe

	L^*	a*	b^*	$\triangle E$
0 d	63.66±2.30^b	11.00±1.47^a	40.03±3.90^a	/
CK 6d	63.23±0.71^b	16.74±0.89^b	40.43±1.69^{ab}	5.770
PE 6d	63.22±0.66^b	16.34±0.44^b	41.82±2.98^{ab}	5.646
PLA 6d	64.15±0.91^b	17.15±1.35^b	44.37±2.83^b	7.543

CK 12d	60.52±2.11[a]	16.29±1.32[b]	40.78±2.15[ab]	6.198
PE 12d	60.15±1.92[a]	17.79±0.36[b]	43.06±2.96[ab]	8.220
PLA 12d	62.17±0.91[ab]	16.79±1.40[b]	44.26±2.60[b]	7.326

Color is an important evaluation index of fruit commodity. At present, Lab method is a commonly used method. This method uses the lightness L^* and chromatism coordinates a^* and b^* to represent the position of the color in the color space, where L^* indicates the lightness of the color. a^* positive value indicates red and negative value indicates green. Table 2 showed the effect of different packaging treatments on the color parameters of L^*, a^* and b^* of mangoe. Along with the extention of storage time, the L^* value decreased significantly, mainly occurring during 6-12 days of storage, and the a^* value increased significantly, mainly occurring during 0-6 days of storage. The effect of different packages on L^* and a^* was not significant, but the b^* value of mangoes packaged with PLA was significantly higher than those packaged with PE or without package. This indicated that mangoes tended to become darker and more reddish or yellowish, and that the color of PLA package tended to be more yellow. The change in color difference occurred mainly within 0-6 days of storage. With storage for 6-12 days, the ΔE value of mangoes packaged with PE increased significantly, while that of PLA package was relatively stable. This may be related to the fact that PE packaging was more prone to rot and become black, resulting in a darker color. Therefore, PLA package is more beneficial for maintaining color stability.

3.7 Effect of different packaging treatments on the relative conductivity of mangoe

Relative conductivity is an important physiological and biochemical index to reflect the condition of plant membrane system. In aging or adversity, the cell membrane is easy to rupture and membrane proteins are damaged, which lead to the infiltration of the cytosol, so that the relative conductivity increase.

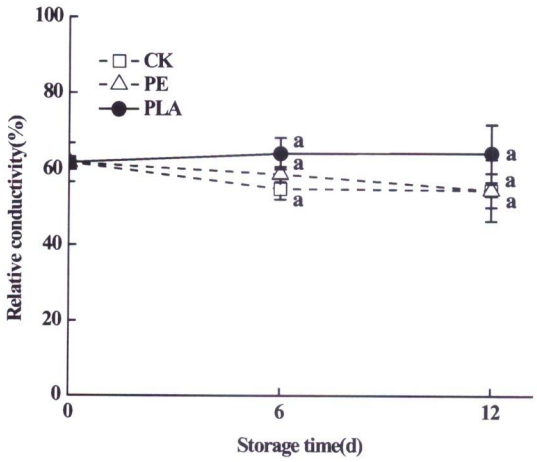

Figure 9 Effect of different packaging treatments on the relative conductivity of mangoe

Figure 9 showed the changes of relative conductivity of mangoe in different package. It can be seen from the figure that there was no significant difference in relative conductivity among mangoes with different treatments during storage. This may be due to the fact that the measurement of relative conductivity is determined by using mango pulp that has not decay, while the water loss and wilting for mangoe during storage mainly occured on the peel, with relatively minor impact on the pulp.

4 Conclusion

(1) Through this experiment, it was found that the main storage problems for mangoes are water loss and wilting, as well as decay and blackening (anthracnose disease).

(2) Although the PE package could effectively inhibits the wilting and drying caused by water loss, it remarkably aggravated the mildew, decay and lead to blackening of the fruit stem.

(3) For the PLA package from Zhejiang Aike Fans New Material Technology Co., LTD, results showed that PLA package is better than PE package in the aspects of preventing the water loss. Also it could effectively reduced the decay of mango fruits, delayed the decrease of the hardness, and extended the shelf life. The commodity of mangoe was still good when storage for 12 days.

Agricultural Product Processing Research Institute

Ningbo Academy of Agricultural Sciences

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Attached: experimental pictures of the preservation effect of mangoe

Overall figure of mangoe stored for 1 day

Overall figure of mangoe stored for 7 days

Figure of root of the mango stored for 7 days

Overall figure of mangoe stored for 11 days