Laboratory Report

Effect of polylactic acid (PLA) packaging on the preservation of Chinese bayberry

1 Experimental purpose

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

2 Materials and methods

2.1 Materials

Chinese bayberry (Biqi) were purchased from supermarket at Yinzhou District, Ningbo City on May 8, 2023. The bayberry fruits with consistent size and maturity were picked and the decayed, moldy and soft fruits were removed. The picked fruits were placed in plastic packages with single lattice.

2.2 Methods

The selected Chinese bayberry fruits were packaged as Table 1 and stored at temperature of 20-25 °C. The quality indexes were measured regularly.

Table 1 Experimental groups

Number	Group	Manner of packing	Experimental volume
1	CK	Single-layer storage without package	24/package×6 repeat
2	PE	Packed with PE	24/package×6 repeat
3	PLA	Packed with PLA	24/package×6 repeat

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 Chinese bayberry fruits were determined using PBI Dansensor (Denmark).

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

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

(5) TPA measurements

Six of Chinese bayberry 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 Chinese bayberry 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 bayberry 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 Chinese bayberry under different package

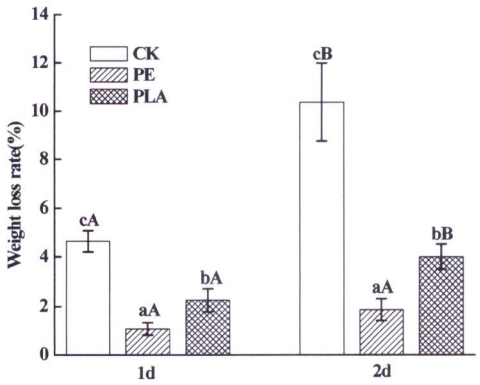


Figure 1 The effect of different package on the rate of weight loss of Chinese bayberry

The rate of weight loss is the external expression of the loss of water, and it is an important indicator to measure fruit quality. Fresh Chinese bayberry with high water content was strong. Loss of weight will lead to it becoming dry and wilt, which significantly affect its commercial and economic value. As can be seen from Figure 1, the bayberry (CK) without packaged losed water quickly at first day, which rate of weight loss reached to 4.6%. And the rate of weight loss for second day reached to 10.4%. It can be seen that the volume of bayberry was significantly reduced, and their surface was dry and cracked. The rate of weight loss of bayberry with PE package was 1.1% and 1.9% at first two days, while the PLA package was 2.3% and 4.0%, respectively. In terms of water conservation, PE plastic bag is little better than PLA

package, and PLA package is better than CK group. It can be seen that the PLA plastic bag could significantly inhibit the water loss of Chinese bayberry ($P < 0.05$).

3.2 Rate of mold of Chinese bayberry under different package

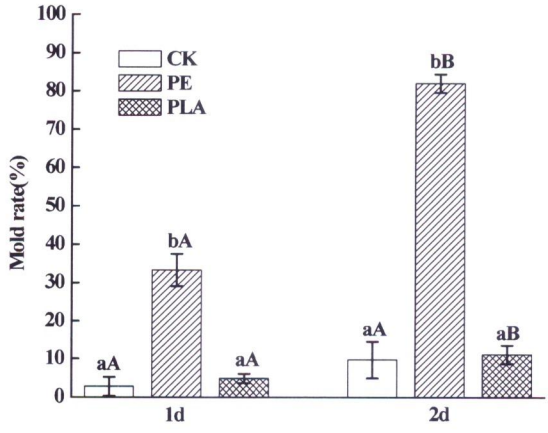


Figure 2 The effect of different package on the rate of mold of Chinese bayberry

Moldy is one of the main appearance of the decay of bayberry during storage, which is an important factor causing the loss of bayberry after harvest. The effect of different packages on the mold rate of Chinese bayberry was shown in Figure 2. For the group of PE package, it could effective control the loss of water, but its rate of mold rose rapidly, which was due to the condensation of moisture. On the second day of storage, the rate of mold for the group of PE package reached to 33.3%, and 81.9% for the third day. In compare with PE package, PLA package could significantly reduce the rate of mold ($P<0.05$), thereinto the rate of mold were only 4.9% and 11.1% at second and third day of storage. For the control group, its rate of mold is a little lower than the group of PLA package, but still determined the phenomenon of moldy. This result demonstrated that the increase of the rate of mold is not only due to the relative humidity, but also due to the mold species, which could still grow under low relative humidity.

3.3 Changes of gas concentration of Chinese bayberry under different package

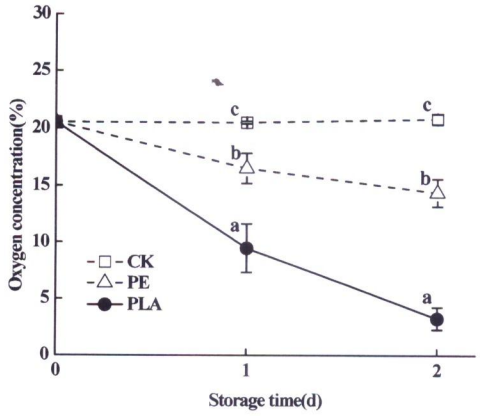


Figure 3 Effect of different packaging treatments on the oxygen concentration in the package

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 second day of storage, the oxygen concentration for PLA package was 3.3% and for PE package was 14.4%.

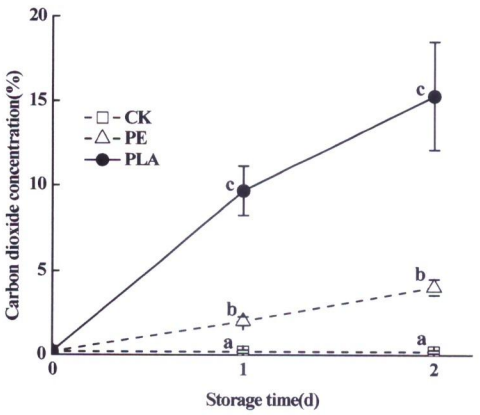


Figure 4 Effect of different packaging treatments on the carbon dioxide concentration in the package

Because the bayberry is live, it could consume O_2 and release CO_2 in the package.

So the gas concentration changes in the PE and PLA 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 Chinese bayberry under different package

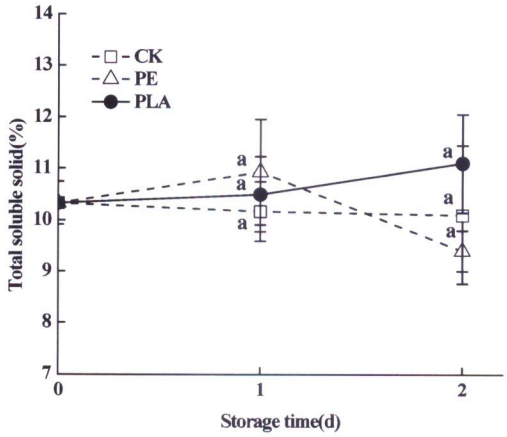


Figure 5 Effect of different packaging treatments on the total soluble solid of Chinese bayberry

Total soluble solid (TSS) is an important evaluation index to measuring the sweetness of Chinese bayberry. As shown in Figure 5, there was no significant difference in the effect of different packaging treatments on the total soluble solid of Chinese bayberry ($P>0.05$). However, during storage for 2 day under PE package, the TSS of bayberry decreased, which may be related to its mildew, corruption and consumption of nutrients.

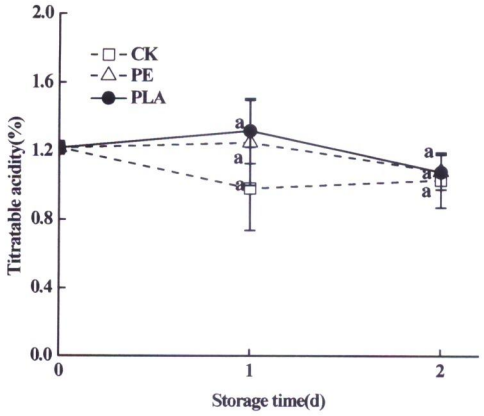


Figure 6 Effect of different packaging treatments on the titratable acid of Chinese bayberry

Titratable acid (TA) is an important evaluation index to measuring the acidity of Chinese bayberry. As shown in Figure 6, the decrease of acidity was determined in the CK group for storage one day, while the decreases of TA were seen in the PLA package and PE package for storage two days. Overall, there was no significant difference among the groups ($P>0.05$).

3.5 Changes of TPA of Chinese bayberry under different package

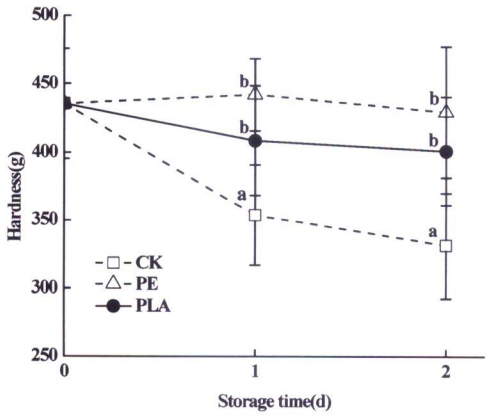


Figure 7 Effect of different packaging treatments on the hardness of Chinese bayberry

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 bayberry in different packages. As can be seen from the figure, the hardness of different groups decreased during the storage period. Among them, the hardness of CK group decreased fastest, from 435.7

g for 0 d, to 354.0 g for 1d, then to 331.7 g for 2d. For PE package, the hardness of Chinese bayberry increased slightly and then decreased to 429.8 g for storage for 2 d. For PLA package, the hardness of Chinese bayberry decreased to 408.7 g and 401.2 g for storage for 1 d and 2 d, respectively. There was no significant difference between PLA package and PE package ($P>0.05$), but both ere significantly higher than CK group ($P<0.05$), which indicated that PLA and PE package could maintain the hardness of bayberry, and delay the water loss and softening of the fruit.

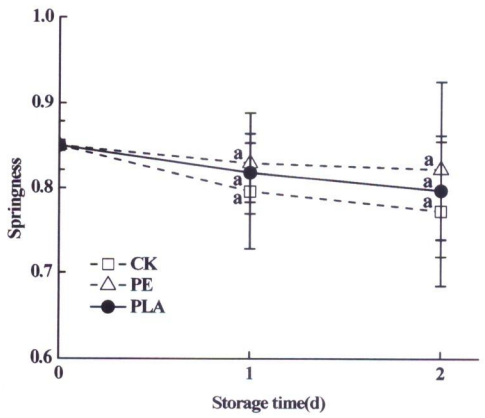


Figure 8 Effect of different packaging treatments on the springness of Chinese bayberry

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 Chinese bayberry. Results showed that there is no significant difference among the groups ($P>0.05$) and the changes showed similar to the results of hardness. Along with the extension of storage, the springness of bayberry gradually decreased, thereinto the springness of PE group was highest, then the PLA group, and then the CK group. Therefore, PLA package showed some effect on maintaining the springness of Chinese bayberry.

3.6 Changes of colour of Chinese bayberry under different package

Table 2 Effect of different packaging treatments on the colour of Chinese bayberry

	L^*	a^*	b^*	$\triangle E$
0 d	18.99±0.47[a]	4.17±0.59[a]	1.77±0.35[a]	/
CK 1d	18.76±0.85[a]	4.12±0.64[a]	1.59±0.43[a]	0.299

PE 1d	18.10±0.39^{ab}	4.02±0.77^{a}	2.24±0.68^{a}	1.105
PLA 1d	17.67±0.64^{c}	3.69±0.55^{a}	1.95±0.62^{a}	1.414
CK 2d	18.49±0.40^{ab}	4.37±0.55^{a}	2.10±0.57^{a}	0.632
PE 2d	18.60±0.92^{ab}	4.12±0.99^{a}	2.19±0.66^{a}	0.577
PLA 2d	18.56±0.65^{ab}	4.63±0.82^{a}	2.05±0.20^{a}	0.690

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 bayberry. There is no significant difference of a^* and b^* for different packaging treatment and storage time ($P>0.05$). Although there were differences of L^* value for different packaging treatments, it is still difficult to clarify its influence law. As can be seen from the color difference value ($\triangle E$), all the results showed lower than 1.5, which is lower the color difference value that distinguished by the human's eyes. Therefore, the package maerial showed a little influence on the color of bayberry.

3.7 Effect of different packaging treatments on the relative conductivity of Chinese bayberry

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.

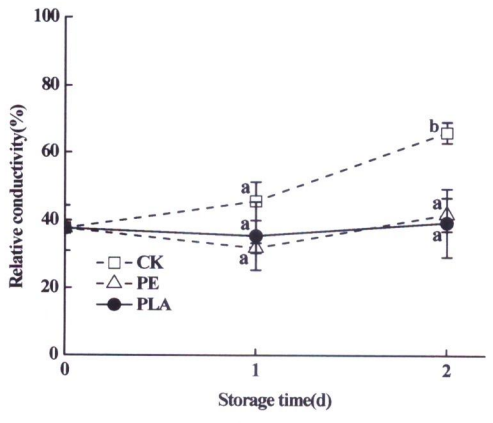


Figure 9 Effect of different packaging treatments on the relative conductivity of Chinese bayberry

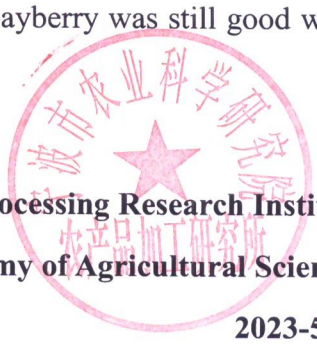
Figure 9 showed the changes of relative conductivity of bayberry in different package. As can be seen from the figure, the relative conductivity of bayberry with different treatments increased during the storage period, thereinto the rising rate of CK group was fastest, which rose from 37.6% to 45.6% and 65.9% at first and second day. For PE and PLA group, their relative conductivity showed slight decreased at first day and then rose to 41.7% and 39.3% at second day, respectively, which showed no significant difference ($P>0.05$). The relative conductivity for both of PE and PLA groups were significantly lower than that of CK group ($P<0.05$). It showed that PLA package has a similar effect to PE package in avoiding the cell membrane damage, and has a good regulation effect on the inhibition of bayberry aging.

4 Conclusion

(1) Through these experiments, we found that the water loss, mildew and corruption of Chinese bayberry are mainly responsible for the quality change during storage.

(2) Although the PE package could effectively inhibits the wilting and drying caused by water loss, it remarkably aggravated the mildew of bayberry.

(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 knot dew and water loss. Also it could effectively reduced the mildew rate of bayberry fruit, delayed the decrease of the hardness, inhibited the aging process, and extended the shelf life. The commodity of bayberry was still good when stored for three days.



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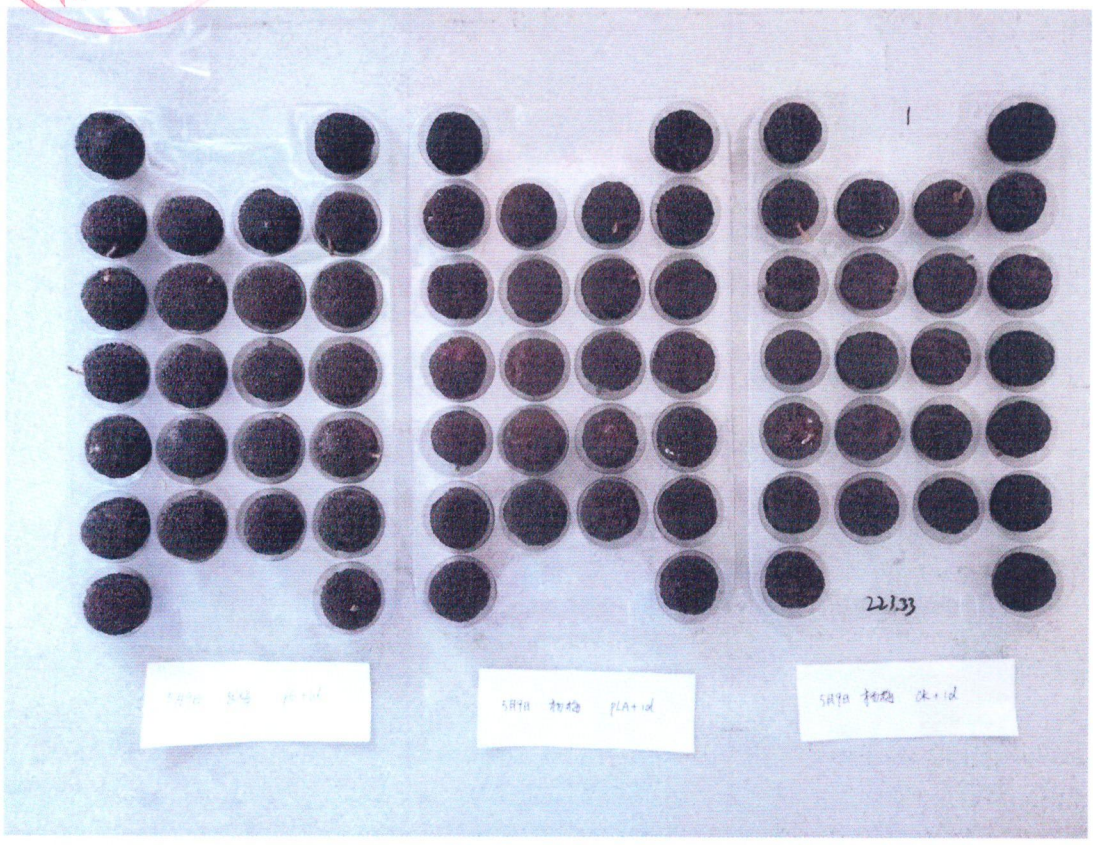
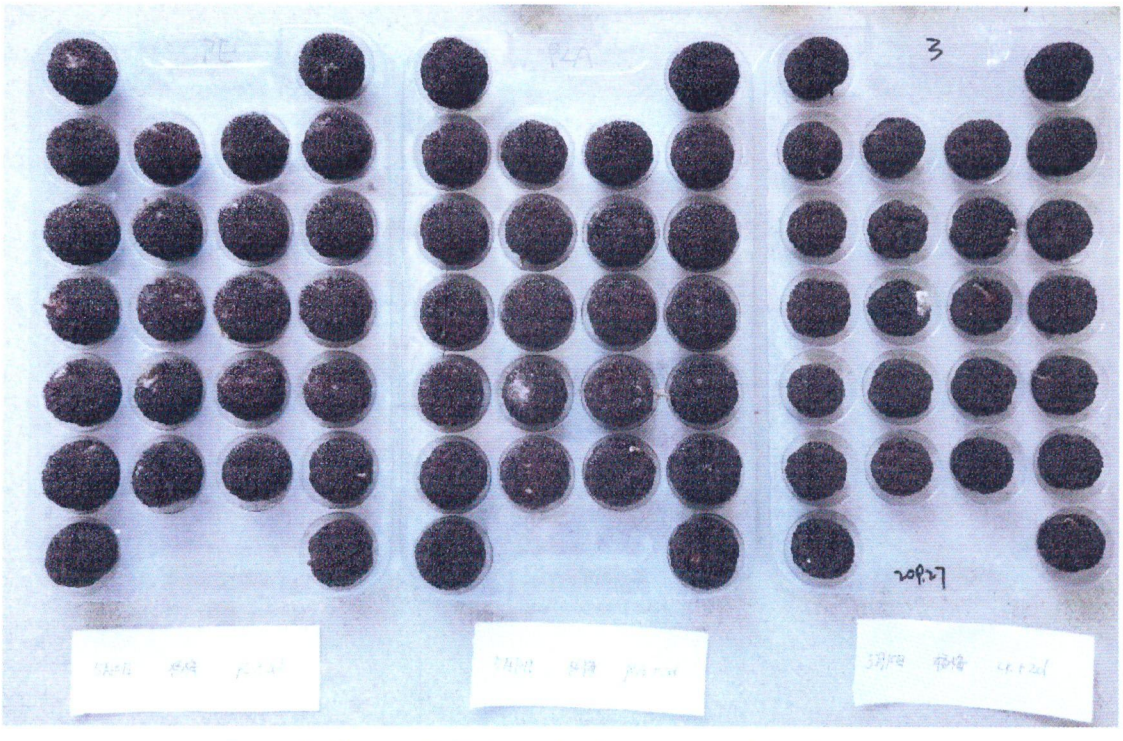
Attached: experimental pictures of the preservation effect of Chinese bayberry



Overall figure of Chinese bayberry stored for 1 day



Overall figure of Chinese bayberry stored for 2 days

Figure of Chinese bayberry in PE package stored for 1 day

Figure of Chinese bayberry in PLA package stored for 1 day

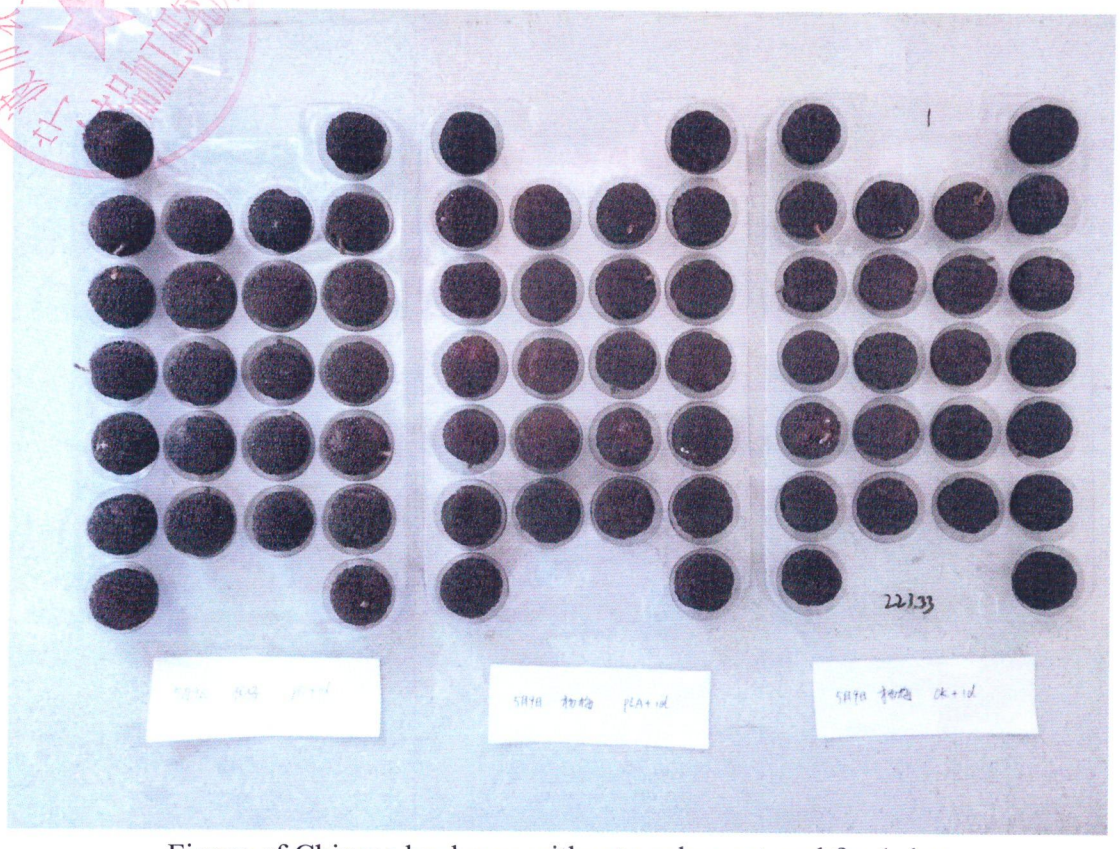


Figure of Chinese bayberry without package stored for 1 day

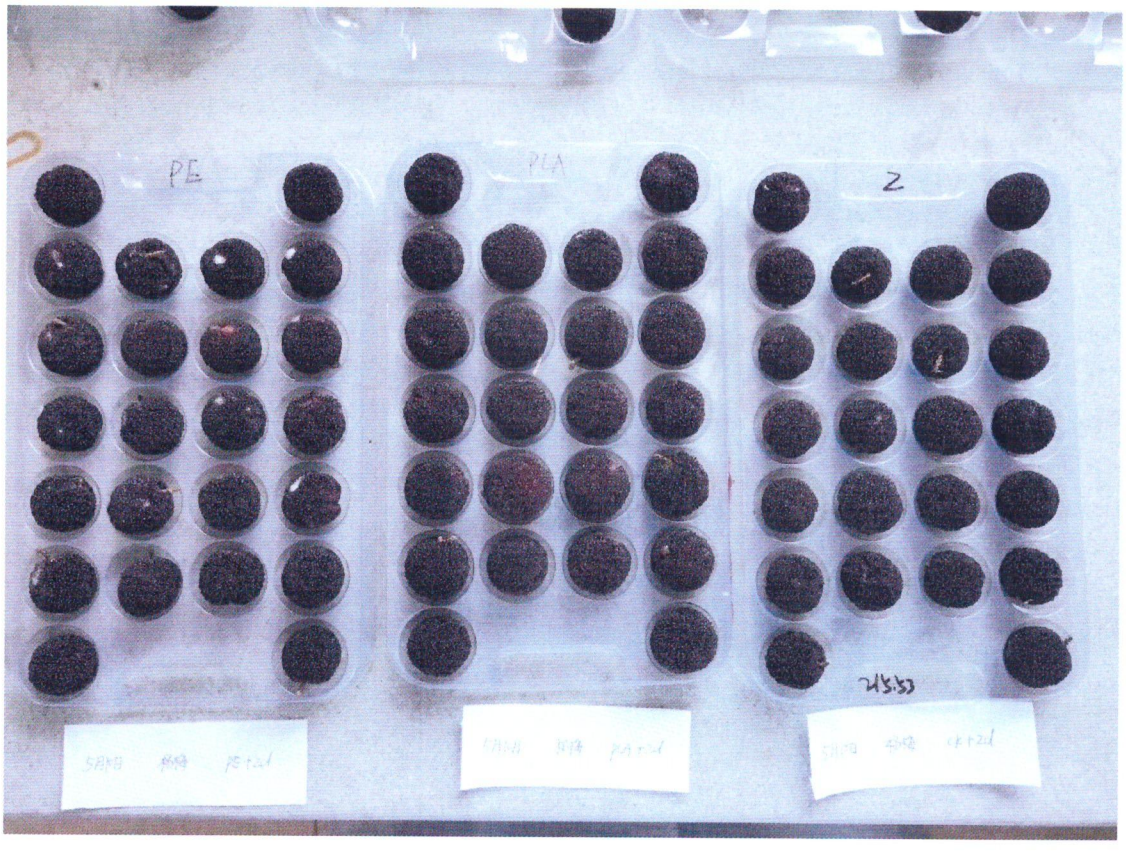


Figure of Chinese bayberry without package stored for 2 day