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The Effect of Functional MA Film Packaging on Storage of Mature-Red Tomato

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Abstract The mature-red tomato fruits (cv. Pinky world) were packaged with functional modified atmosphere (MA) film (0.03, 0.06 mm) and stored at 0, 5, 15°C. The results showed that the concentrations of CO_2 and O_2 inside MA package were about 4.21~8.17% and 9.78%~14.45% under steady state during storage 29 days at 0, 5°C, respectively. The MA packaging(MAP) suppressed the fruits softening and the color change. The minimum lycopene content and maximum firmness were separately observed in fruits packaged with MA film (0.03 mm) at 5°C storage and film(0.06 mm) at 0°C, which the lycopene content 6.08 mg/100 g, and firmness was 0.49 Kgf at 29 th day storage. The optimal conditions to keep high quality of tomato fruits were obtained by MAP during storage at 0°C for 29 days, independently of the film thickness, in which the adequate gas composition was CO_2 at 4.2%~5.6%, O_2 at 14.3%~14.5%, respectively.

Key words MAP, Quality, Tomato, Gas composition

Introduction

The tomato is a popular fruit with its high nutrition, but it often soften and change color rapidly at higher ambient temperature. Modified atmosphere packaging (MAP) is common used to extend shelf-life and keep freshness for fruits and vegetables, its effect mainly based on the gas composition inside film package, which is closely related to respiration rate of fresh products and film gas permeability (Hertog *et al.*, 1998). Generally, the adequate high CO_2 and low O_2 made by MAP could reduce respiration and ethylene production of products, thus delay senescence, remain natural color and extend shelf life (Kadder *et al.*, 1989). It has been reported that MAP could delay the color change, and keep high quality for tomatoes (Park *et al.*, 1999). In this study, the mature-red fruits and the developed functional MAP film, a new kind of film with some addition of functional substances, were used to look for the optimal condition for keeping high quality of tomatoes.

Materials and Methods

1. Materials

The mature-red tomato fruits (cv. Pinky world) were selected according to same size and color at first, and then packaged with functional MA film (thickness: 0.03, 0.06 mm) followed by storage at different temperature (0, 5, 15°C), the non-packaging as control. 10 fruits packaged each bag (33 × 42 cm). The gas permeability of film was showed in Table 1. The gas permeability of film increased with the storage temperature, which showed the lower value in thicker film than that in thinner one. The gas composition inside MA package and fruit quality were determined at separate times.

2. Methods

1) Gas(CO_2, O_2) composition

The concentration of CO_2, O_2 inside MA package was determined by gas chromatograph(Shimadzu, GC 14-A, Kyoto, Japan).

2) Lycopene content

The color determination: it was measured by a color difference meter (Yasuda, Model 600-UC-IV, Tokyo, Japan) and expressed as Hunter L (lightness), a (redness-greeness), and b (yellow-blue) values. Two readings were made at the medial portion of fruit outside surface. The lycopene content was calculated according to Arias *et al.* (2000), i.e. lycopene, mg/100 g = 11.848(a/b) + 1.5471.

3) Firmness

The firmness was determined on three points around the

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Table 1. The gas permeability of MAP film at different temperature Units: ml·m^{-2}·h^{-1}·atm^{-1}

Temperature (°C)	CO_2		O_2	
	0.03 mm	0.06 mm	0.03 mm	0.06 mm
0	43.54 ± 1.42	30.38 ± 4.22	16.24 ± 1.10	9.52 ± 1.01
5	55.55 ± 3.15	36.21 ± 5.22	20.44 ± 3.72	11.35 ± 1.05
15	78.58 ± 4.20	45.05 ± 1.59	25.91 ± 1.99	16.52 ± 2.17

equator of each fruit using a Rheometer (SUN scientific, Model CR-10K, Tokyo, Japan) equipped with a cylinder probe of 8 mm diameter.

4) Soluble solids content, pH and titratable acidity

The soluble solids content (SSC), pH and titratable acidity (TA) were assessed in juice obtained from three replicate samples of 8 fruit per treatment. The SSC (°Brix) was determined on juice squeezed from fruit by a refractometer. Five milliliters of fruit juice were diluted in 50 ml distilled water, and pH of the solution was measured prior to determination of TA by titration with 0.1 N NaOH to pH 8.1. TA results are given as percentage of citric acid.

5) Vitamin C content

Vitamin C content was determined according to 2,6-dichloroindophenol method (Joo *et al.*, 1996).

The vitamin C was extracted from 50 gram of fruits by HPO_3 (5%), and determined as Joo *et al.* (1996) described by following the addition of 2 ml standard solution (1~5 mg/100 ml), 1 ml DCP (0.03%), 2 ml Thiourea (2%) and 1 ml DNP (2%) to the sample filtrate, and using 5 ml H_2SO_4 (85%) to stop reaction after 3 hrs at 37°C, the absorbance of the final reaction solution was recorded at 540 nm, the results were expressed as the content of L-ascorbic acid (mg) per 100 gram fruit.

6) Weight loss rate

Weight loss rate was calculated after determination of the fruits weight by electric balance, and expressed as the change amount of weight based on the storage time.

7) Decay rate

Fruit decay rate was calculated as the ratio of number of decayed fruits to that of total samples.

Results and Discussion

1. The gas composition inside MA package

The gas composition inside MA package was difference with different temperature and film thickness. The CO_2 accumulated and O_2 diminished gradually inside MA package during storage, no maximum or minimum value was observed in package stored at 15°C. While fruits stored at

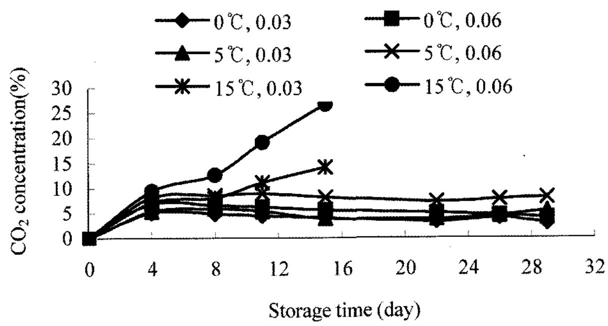

Fig. 1. Changes of the CO_2 gas composition within MAP bag during tomatoes storage.

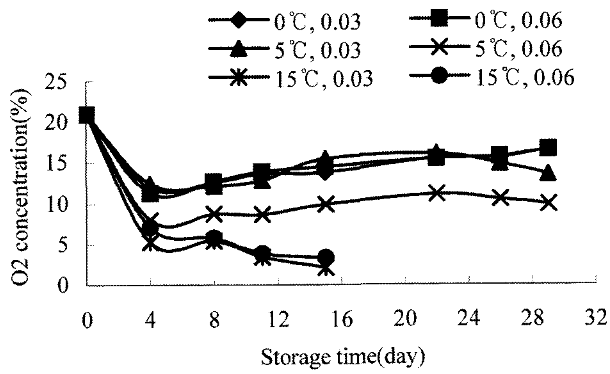

Fig. 2. Changes of the O_2 gas composition within MAP bag during tomatoes storage.

5°C, 0°C the concentration of CO_2 increased to maximum, or of O_2 decreased to minimum at first few days and followed by a relatively steady state (Fig. 1, 2, Table 2), at which the concen-trations of CO_2 and O_2 were about 4.21~8.17% and 9.78%~ 14.45% respectively (Table 2).

2. The quality

The tomato firmness decreased rapidly during fruits ripening, which was higher in packaged fruits than that non-packaged ones (Fig. 2). On the contrary, the change of lycopene content of fruits showed (Fig. 3, Fig. 4). And more, these effects were more obvious in fruits stored at higher temperature and packaged with thicker film. At 29th day after cold storage, no significant difference of firmness was found in both packaging films, but the minimum lycopene content was observed in fruits with MAP (0.06 mm)

Table 2. The concentration of CO_2, O_2 inside film bag at steady state

Temperature (°C)	Thickness (mm)	CO_2 concentration(%)		O_2 concentration(%)	
		Variation range	Average	Variation range	Average
0	0.03	4.11~4.91	4.21	12.61~16.58	14.26
	0.06	4.03~6.92	5.59	12.70~16.57	14.45
5	0.03	5.43~5.86	4.70	12.13~16.13	14.29
	0.06	7.31~8.98	8.17	8.66~11.08	9.78

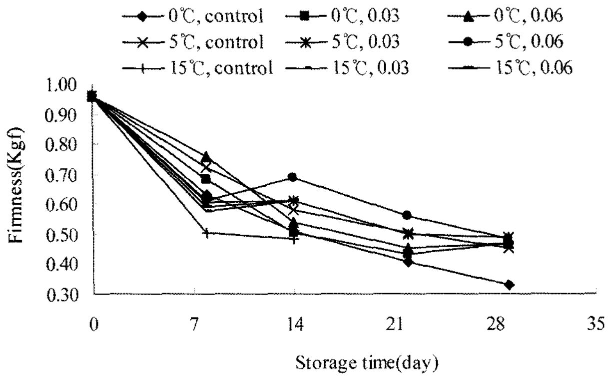

Fig. 3. The effect of MAP on the firmness of tomatoes.

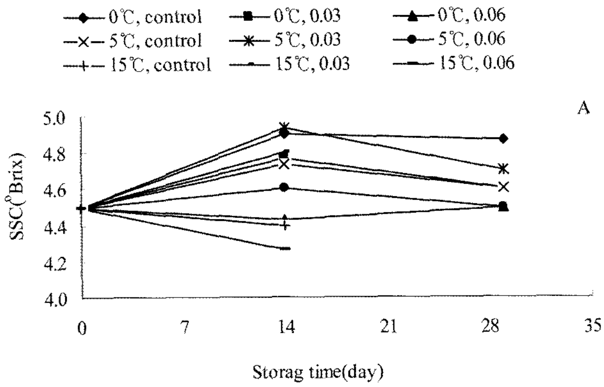

Fig. 5. Effects of MAP on the SSC content of tomatoes.

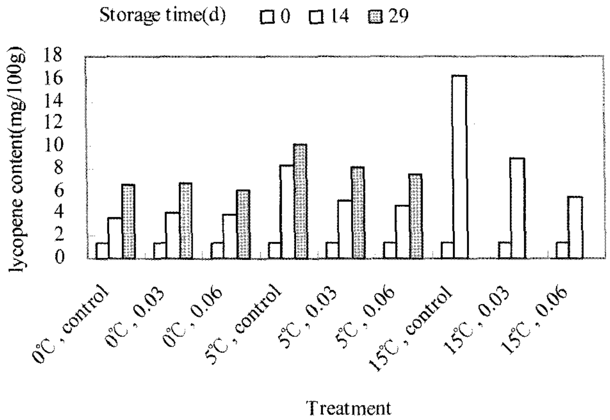

Fig. 4. The effect of MAP on the lycopene content of tomatoes.

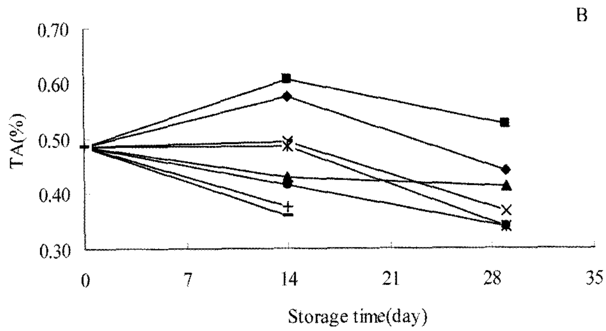

Fig. 6. Effects of MAP on the acidity of tomatoes.

at 0°C storage. Thus it showed that MAP suppressed the fruit softening during cold storage, independent of film thickness, although the thicker film had the more effective inhibition on the development of lycopene.

The tomato SSC had a slight change during storage, showing the lower value in fruits packaged with the thicker film (0.06 mm), independent of the storage temperature (Fig. 5). Thus, it was also shown that MAP suppressed the sugar transferring into soluble sugar during ripening (Kadder *et al.*, 1989; Park *et al.*, 1999).

The tomato TA content trended to decrease at last, and remained the higher value during storage at lower temperature (Fig. 6). The thicker film (0.06 mm) reduced the TA content during storage at lower temperature (0°C, 5°C) and the film (0.03 mm) packaging kept the highest value of TA at 0°C storage, besides that there were no obvious difference in fruits packaged with film (0.03 mm) from control at 5°C storage.

The tomato pH trended to increase in fruits stored at 15°C, but the cold storage trended to decrease, besides that the thicker film (0.06 mm) had no marked effect, the MAP declined the pH value, although there were no significant difference in both film packages (Fig. 7).

Changes of vitamin C content were difference with storage temperature and MAP film thickness. It trended to decrease during storage, and more markedly at 15°C, which had little difference between packaged and non-packaged ones at lower temperature (0°C, 5°C), but the packaging decreased the vitamin C content at 15°C storage, especially within packaging film (0.06 mm) (Fig. 8).

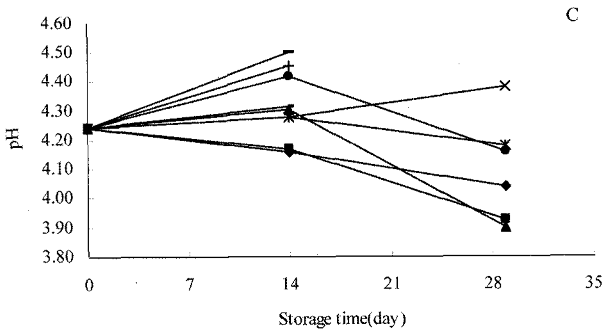

Fig. 7. Effects of MAP on the pH of tomatoes.

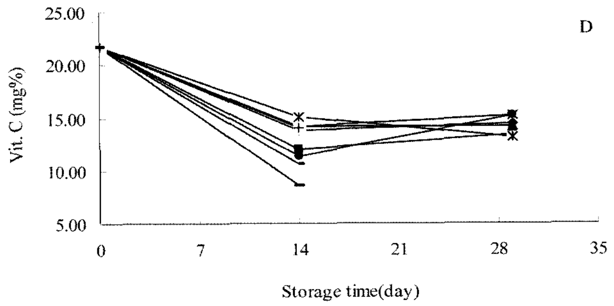

Fig. 8. Effects of MAP on the Vitamin C contents of tomatoes.

3. The ratios of decay and weight loss

There were 60%, 66% of fruits to decay within 0.03, 0.06 mm packaging film treatment as fruits stored at 15°C for 14 day, while 40%, 25% to decay in 0.03, 0.06 mm film package at 5°C for 29 days, respectively. No decay was found in fruits without packaging stored at 0°C. The packaged fruits showed off-flavor and apparent rot for 14 days storage at 15°C. It might be resulted from inadequate gas composition within package, in which there were excessive accumulation of CO_2 and/or depletion of O_2 to lead fermentation and metabolic disorder (Beaudry *et al.*, 1992; Brackett, 1987; Exma *et al.*, 1993), and the higher humidity might promote the development of decay (Joles *et al.*, 1994).

Weight loss of fruits increased with increasing storage temperature, which could be significantly reduced by MAP, independent of the film thickness at the same storage temperature (Fig. 9).

In conclusion, above all results showed that the optimal storage conditions to keep high quality of tomato were obtained at 0°C within package up to 29 days storage, independently of the film thickness, in which the optimal gas composition inside film bag was about 4.2%~5.6% CO_2, 14.3%~14.5% O_2, respectively.

요 약

토마토(Pinky 종)를 기능성 MA 필름(두께 0.03, 0.06 mm)으로 포장하여 0, 5, 15°C에 저장하면서 품질 변화를 조사하였다. 저장 29일에 MA 포장재 내의 CO_2, O_2농도는 각각 4.21~8.17%, 9.78~14.45%였고, 전반적으로 MA 포장구에서 연화와 색택의 변화가 억제되었다. 저장 29일에 MA 포장(0.03두께)을 한 후 5°C에 저장한 토마토의 경도(0.49 kgf)가 가장 높았고, MA 포장(0.06두께)을 한 후 0°C에 저장한 토마토가 최소 라이코펜 함량(6.08 mg/100 g)을 보였다. 토마토의 품질 유지를 위한 최적 조건은 MA 포장을 하여 0°C에 저장하는 것이 바람직한 것으로 나타났으며 필름 두께 간에는 유의적인 차이가 나타나지 않았다. 또한 MA 포장재 내의 최적 가스 조성은 CO_2는 4.2%~5.6%, O_2는 14.3%~14.5%로 나타났다.

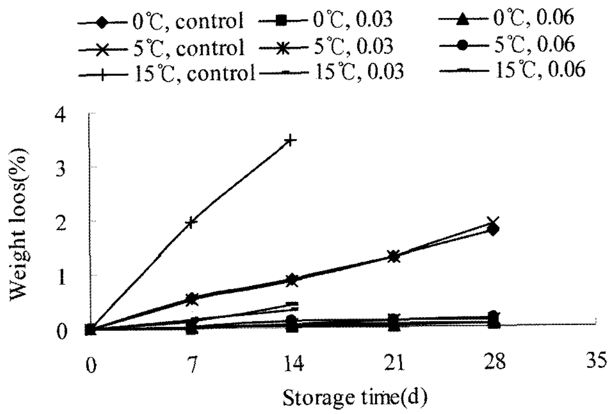

Fig. 9. The MAP on the weight loss of tomatoes during storage.

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