CHAPTER 6

Effect of bees-carnauba wax (mixed wax) coating and phenyllactic acid on qualities and storage life of sweet orange fruit cv. Canh during low temperature storage

The impact of mixed wax (bees and carnauba wax - MW) combination with phenyllactic acid (PLA) on post-harvest qualities and storage life of Vietnamese sweet orange fruit cv. Canh was studied, by soaking fruit in 2.5% PLA before coating with 8% MW, and then storing at 5°C for 60 days. While untreated fruit and commercial wax (0.2% chitosan) coated fruit were used as control. Weight loss, total sugars, titrable acid, total soluble solids content (TSS), vitamin C, fruit decay, and sensory properties were monitored during the preservative time. The results showed that fruit dipping in 2.5% PLA and coating with 8% MW could reduce weight loss, decay, and increase ethanol. Moreover, after 60 days in storage, orange fruit maintained marketable properties expressed as titrable acid, TSS content, ascorbic acid, total sugars, ethanol and the sensory scores. In contrast, the shelf-life of control fruit at low temperature was only 40 days.

6.1 Introduction

Orange fruit (*Citrus sinensis* Osbeck) is one of the most popular fruit in Vietnam but the post-harvest life of fruit under ambient temperature is short due to fruit is decayed, lost weight and shed stalk. For other cultivars are available in Vietnam such as ‘Sanh’ and ‘Chanh’ orange fruit, recent published works showed that the shelf-life of fresh orange is increased from 30 days to 40 days by soaking fruit in 0.07% carbendazim solution and then coating with 2% chitosan (Hoan *et al*., 2002). Lam *et al.* (2011) reported that dipping in thiabendazol (150ppm for 150 second) for HamYen orange fruit inhibited the growth of blue, green mold *Penicilium digitatum* and *P. italicum*. ‘Valencia’ orange treated with imazalil and carnauba significantly reduced the development of fungus at pre-storage and post-storage (Ncumisa *et al.*, 2012). Carbendazim, thiabendazol, imazalil, benlate areinorganic fungicides, they are damaging the health of people and to the environment. Replacing these agents are needed to treat orange fruit before storing, one of methods is that the use of bio-fungicide in combination with MW coating to extend the shelf life and maintain qualities of fruit. Waxes reduce weight loss, prolong storage life, decreasing rate of transpiration and inhibit post-harvest disease of orange and maintaining attractiveness, keeping freshness, reducing ethylene production (Hagenmaier and Shaw, 1992; Thirupathi*et al*., 2006; Hung, 2008; Shahid and Abbasi, 2011; Ladaniya, 2008). Addition of postharvest fungicides to the wax, emulsion to control *Penicillium* rot in stored citrus fruitalso proved helpful (Thirupathi *et al*., 2006). Shahid and Abbasi (2011) concluded that coating 'Blood Red' orange fruit with a concentration of bees wax along with benlate performed better results in improving the overall quality and extending the shelf life of fruit. The 'Delta Valencia' orange fruit were coated with carnauba - based wax could store for 28 days at 5°C (Pereira *et al.,* 2013).

Lavermicocca *et al.* (2003) showed that the ability of phenyllactic acid to act as a fungicide provides new perspectives for the possibility of using this natural antimicrobial compound to control fungal contaminants (*Aspergillus ochraceus*, *Penicillium roqueforti, P. citrinu*, etc.) and extend the shelf-life of food and/or foodstuffs. 'Vangiang' orange fruit treated with 2% PLA followed by coating with wax (CP-01) maintained quality and appearance, while reducing the spoilage rate during an 8wk in storage at ambient condition (Thuy *et al.,* 2013). The purpose of this study was to evaluate effect of phenyllactic acid association with mixed wax on fruit qualities and storage life of Vietnamese sweet orange cv. Canh during low temperature storage.

6.2 Materials and methods

6.2.1 Materials

Orange fruit cv. Canh from a commercial orchard in ThanhOai district, Hanoi were harvested at 220-235 days after fruit set, and transported to a laboratory within 2-3 h. Fruit were selected for uniformity of shape, size and non-defected fruit.

Phenyllactic acid (PLA) is bio-fungicide and was produced by fermentation using *Lactobacillus plantarum* C2 (Thuy *et al.*, 2012).

The bees wax and carnauba wax in the ratio of 7:3 was prepared following process of Thinh, (2013). The bees wax and carnauba wax was melted by a magnetic stirrer at 80-85°C. After that oleic acid, palmitic, water was added to the mixture during stirring and blending for 8%concentrations of mixed wax (MW) for 25-30 minutes. The MW of various concentrations were cooled down to ambient temperature before coated to the fruit.

Uniform sample of the orange cv. Canh were soaked in 2.5% PLA for 5 min, and then coated in 8% mixed wax (MW+PLA) for 1 min. On the other hand, 2.5% PLA soaked fruit for 5 min were coated in 0.2% chitosan (CW+PLA) for 1 min at room temperature. All treated fruit were dried in a room, after that the treated and untreated fruit were laid onto trays and stored at 5±1°C and RH 80±5% for 60 days and sampled/analyzed at 10 day intervals. A completely randomized design was used for the experiment. All measurements of each treatment were the average of the three replications.

6.2.2 Methods

The titrable acid (TA) was determined as citric acid by titrating against 0.1NaOH (AOAC, 2000).

Total sugars was analyzed by using the procedure of Lane and Eynonas described in AOAC (2000).

Vitamin C (ascorbic acid) was estimated using the detective dye 2.6 dichlorophenol-indophenol by standardizing 0.1% standard 2.6 dichlorophenolindophenol dye solution against 0.1% ascorbic acid solution (AOAC, 2000).

Total soluble solids (TSS) content was determined in filtered juice using a digital refractometer (RFM-80) (Atago, Tokyo, Japan).

Ethanol and acetaldehyde content in juice oforange fruit was estimated by using a Gas

Solid Chromatography (GSC) Agilent 7890A equipped with a 30 m × 0.25 mm × 0.25 µm HP-5 column, and coupled with a Mass spectrometry (MS) 5975C detector (Agilent, Palo Alto, USA), according to the method described by Perez *et al.* (2002). The concentrations of ethanol and acetaldehyde content were calculated base on (mg/L).

Fruit decay was assessed as the percentage of decay fruit as follows:

$$\text{Decay fruit (\%)} = \frac{\text{Number of decayed fruit}}{\text{Total fruit}} \times 100$$

Percentage of weight loss was calculated by weighing the whole fruit kept in a tray before and after storage, as follows:

$$\text{Percentage of weight loss} = \frac{\text{Weight}_{before} - \text{Weight}_{after}}{\text{Weight}_{before}} \times 100$$

Sensory score was evaluated by day 0, 10, 20, 30, 40, 50 and 60 days in storage. Fruit were peeled, separated into segments, and placed onto a disk. Each sensory experiment included a mixture of segments from five different fruit. Fruit taste was assessed by a committee consisting of five members. Each member evaluated the various samples, with anchor points of extremely liked and extremely disliked for each characteristic and sensory data were written on a point scale on the evaluation form. Panel discussions were performed in order to develop the sensory form. Each member was requested to rate peel color, odor, taste, and flavor on a hedonic scale from 1 to 9 points with 9 = extremely liked; 1= extremely disliked; and 5 = neither liked nor disliked (Hung, 2008).

Using the above indices, the storage life of orange cv. Canh was determined as unacceptable for marketable purposes as follows: when the percentage of fruit decay is above 10%, or/and when sensory score is ≤ 5.

Statistical analysis was carried out using Duncan’s multiple range test to analyze the significant differences ($P \leq 0.05$) between treatments and the control.

6.3 Results and Discussions

6.3.1 Change in quality of fruit: titrable acid, total sugars, vitamin C, total soluble solids, and ethanol

Changes in titrable acid (TA) of treated and control fruit during the storage period are presented in Figure 6.1. Maximum tritrable acid (0.119%) was observed in control. Least value (0.108%) was recorded in 8% MW combination with 2.5% PLA. The TA increased slightly in all treatments and the control, and did not significantly differ after 40 d in storage ($P \leq 0.05$). Titrable acid of the fruit treated with 8% MW+ 2.5% PLA were 0.108% after 60 d in storage. There were no significant differences in TA among the treated and control fruit ($P \leq 0.05$).

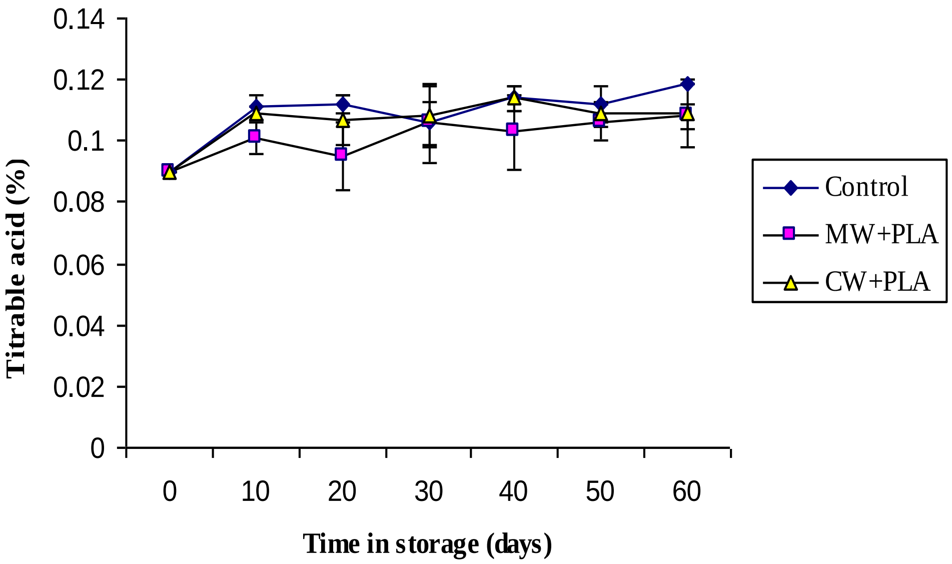


Figure 6.1 Effect of PLA combined with MW on titrable acid of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH

These results are in accordance with the finding of Thirupathi *et al*., (2006), who said that no significant change in constituentslike vitC, acidity, and sugar contents (In citrus fruit especially) were recordeddue to treatment waxing. Wilma *et al.*, (2009) reported that pH of ‘Valencia’ orange coating with Carnauba in combination with *Lippia* oil and stored 10°C for 5 weeks, followed by 1 week at 25°C were 3.45. TA of ‘Murcott tangor' when fruit were treated with 0.2% chitosan alone increased faster and higher than control when stored for 9 weeks at 15ºC (Po-Jung *et al.*, 2007). There did not observe effects of either the commercial wax or edible coating on acidity levels in citrus fruit after 4 weeks of cold storage followed by 5 days at 20ºC (Hadar *et al.* 2014).

Changes in total sugars are indicated in the figure 6.2. Total sugars content of control (4.65%) fruit decreased faster than other treatments at low temperature (5 ± 1°C) and 80 ±5%RH and long storage period. Minimum total sugars (4.65%) was recorded in control, maximum total sugars (5.53%) was recorded in 2.5% PLA association with 8% MW after 60 d in storage at 5 ± 1°C. There were no significant differences in total sugars among the treated fruit ($P \leq 0.05$), and which were significantly different from the control fruit ($P \leq 0.05$). After the first 60 d of storage, the total sugars content of treated fruit tended to decrease slightly (Fig. 6.2). Therfore, the changes in total sugars content tended to decrease with the long storage period at low temperature.

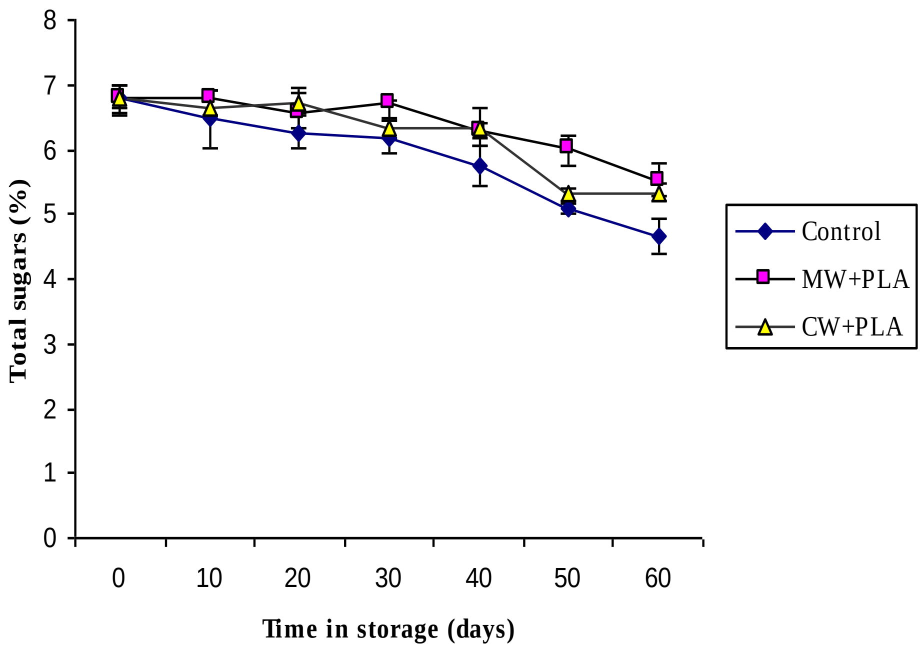


Figure 6.2 Effect of PLA combined with MW on total sugars of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH

Total sugars of orange cv. Canh fruit in our study was similar to the reported data of David *et al.* (2008) who found that 'Navel' orange fruit coated with shellac and imazalil and stored at 5ºC for 6 weeks have a sweet content it reduced slightly from 111.2 to

108.2mg/100ml. Babar (2007) and Pereira *et al.* (2013) concluded that 'Kinnows' mandarin and 'Delta Valencia' orange were treated with waxes andtotal sugars increased throughout the storage period at low temperature. Coating 'Mucott' mandarin with carnauba and imazalil reduced lightly sweetness for 6 weeks at cold storage and 1 week 20^{o}C (David *et al.*, 2011).

Figure 6.3 shows the changes in vitamin C content of treated and control fruit during the preservative period. After 20 d of storage, the vitamin C content of control reduced lightly but vitamin C content of MW combination with PLA and CW combination with PLA increased. Ascorbic acid is the major antioxidant compound found in citrus fruit. Dipping orange fruit in 2.5% PLA association with 8% MW coating showed the highest vitC content (23.52 mg/100g) and the highest preservative time at 5^{o}C.

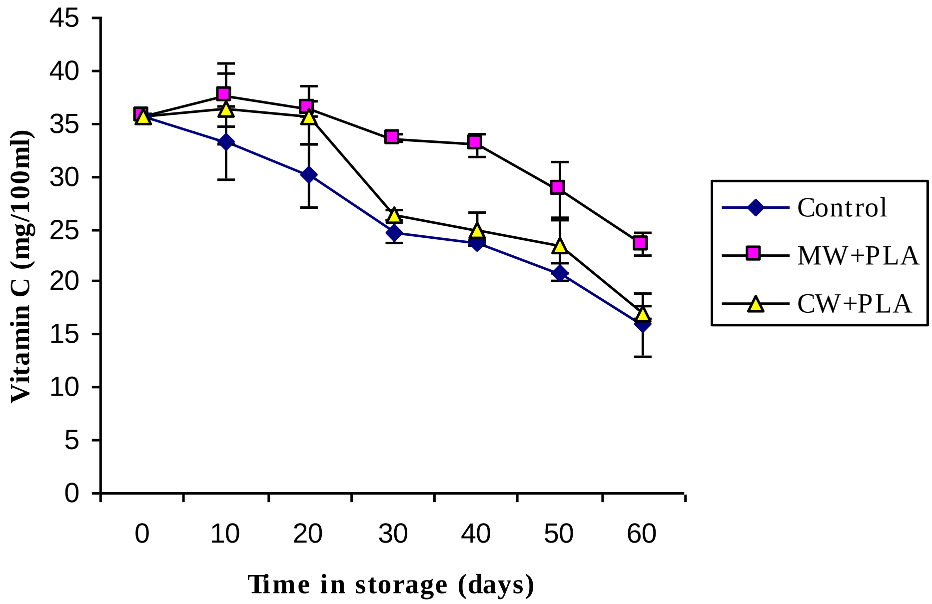


Figure 6.3 Effect of PLA combined with MW on vitamin C of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH

There were significant differences in ascorbic acid among the treatments and the control fruit ($P \leq 0.05$). This result explains that soaking in 2.5% PLA association with 8%MW prevented the reduction of vitamin C content. The results of our study are in contrast to the results of Po-Jung *et al.*, (2007) who reported that 0.1% low molecular weight chitosan coating maintained ascorbic acid in ‘Murcott tangor’ fruit higher than control after 56 days of storage at 15°C. The ‘Kinnows’ coated with polyethylene based wax and shellac based wax which showed maximum ascorbic acid content during 105 days storage at 5°C (Babar, 2007). ‘Kinnows’ orange fruit treated with coatings contain significantly higher ascorbic acid as compared to uncoated fruit and stored at low temperatures (7°C, 10°C), had significantly higher ascorbic acid as compared to fruit stored under ambient conditions (Thakur, 2002).

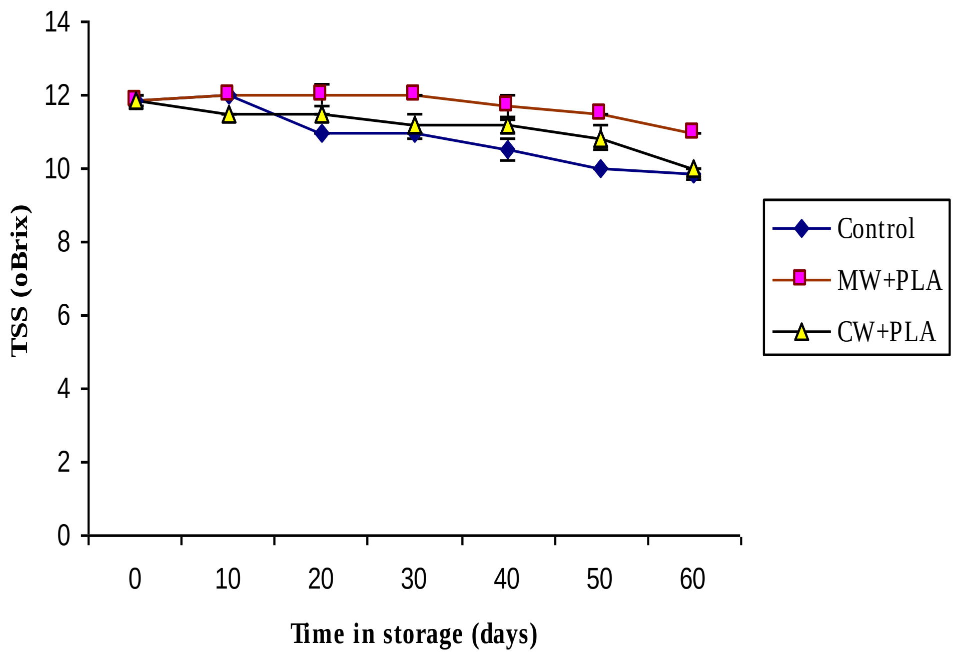


Figure 6.4 Effect of PLA combined with MW on TSS of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH

Changes in total soluble solids (TSS) content are illustrated in figure 6.4. The TSS content of control reduced lightly throughout the preservative time. After 40days 8%MW combination with 2.5% PLA had the highest TSS content (11.67°brix). There was significant difference in TSS content of MW - treated fruit and the control fruit at low temperature ($P \leq 0.05$). While, maximum TSS content (11.00°brix) was recorded in fruit coated in 8% MW and dipping 2.5% PLA, minimum TSS content (9.83°brix) was measured in control fruit. There was significant difference in TSS content of treatments and the control fruit during the storage period ($P \leq 0.05$). In this research, TSS contents of fruit in all treatments and the control decreased after 60 d in storage perhaps due to respiration and metabolism sugars into alcohol.

Our results are consistent with the reported data on TSS content of oranges fruit of David *et al*. (2013) and Shahid and Abbasi (2011) who concluded that the possible reason in reduction of TSS content in 'Blood Red' orange in 5% bee wax + 0.5% benlate was due to these retarding the hydrolysis of starch into sugars and also the conversion of polysaccharides in to disaccharides and monosaccharide by changing the bio-chemical activities. The TSS content of 'W. Murcott Afourer' mandarins that were stored for 4 weeks at 5◦C and then moved to 20◦C for 2 weeks maintained better than stored fruit at 20◦C for 2 weeks (David *et al*., 2013). 'Tomango' citrus fruit treated with carnauba and *lippia*, *limonene*, sprearmint oil could be extremely valuable to prevent shrivelling, TSS, pH, extend shelf-life during prolonged storage period (Wilma *et al*. 2009).

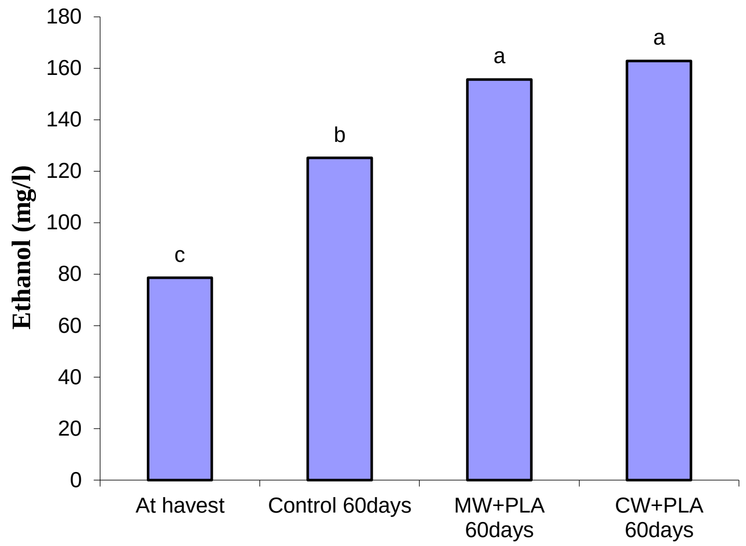


Figure 6.5Effect of PLA combined with MW on ethanol of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH

Figure 6.5 presents ethanol in juice of treated and control fruit during the storage period at 5ºC. After 60 d in storage, 2.5% PLA+8% MW the ethanol was 155.7mg/L. For control fruit, ethanol in juice was 125.2mg/L. There were no significant differences in ethanol content among the treated fruit ($P \leq 0.05$), which were all significantly different from the control fruit ($P \leq 0.05$). Results from this study demonstrate influence of the soaking PLA and mixed waxing orange fruit increased lightly ethanol during low temperature. In contrast, acetaldehyde did not find in both coated and control fruit. The chilling temperature also increased the production of ethylene and volatile components (ethanol and acetaldehyde) in fruit after a return to normal temperature (Eaks, 1980).

These results are in accordance with the finding of Obenland and Arpaia, (2012) who reported that ‘Gold Nugget’, mandarin varieties, produced relatively low levels of ethanol following waxing and storage in comparison to the other varieties tested. Ethanol concentrations in ‘W. Murcott Afourer’ mandarins following 4 weeks at 5◦C and 2 weeks at 20◦C increased significant (561.8 to 1629.5µg/l) (David *et al*., 2013). Effects of storage time (0, 3, 6 weeks cold storage for a week at 20◦C) on ethanol of ‘Owari’ mandarins increased statistically significant changes by the packinghouses using carnauba-based coatings and fungicides (David *et al*., 2011). David *et al*. (2008) assayed ‘navel’ orange in California after 4 weeks in storage, very high levels of ethanol in oranges would be expected to impart a fermented taste and strongly reduce the organoleptic properties of the orange.

6.3.2 Change in physical properties: decay, weight loss, and sensory score

The percentage of fruit decay of treated and control fruit during the storage time were determined and results are presented in figure 6.6. The rate of fruit decay increased rapidly when fruit was stored for long time. After 40 days in storage, the control had 8.58% decay and the minimum decaywas found in all treatments. For coated fruit, the highest fruit decay rate incidencewas found (6.75%) in the CW combination with PLA treatment and lowest decay rate was found (5.69%) in 8% MW + 2.5% PLA treatment after 60 days in storage. Postharvest decay of oranges was also reduced by the use of appropriate pre-postharvest and postharvest fungicides, proper sanitation of the wash water and appropriate storage temperature and RH condition (Postharvest Handling Technical Bulletin, 2003). There was not significant variation in decay of orange cv. Canh fruit between treatments ($P \leq 0.05$) but were all significantly different from the control fruit ($P \leq 0.05$).

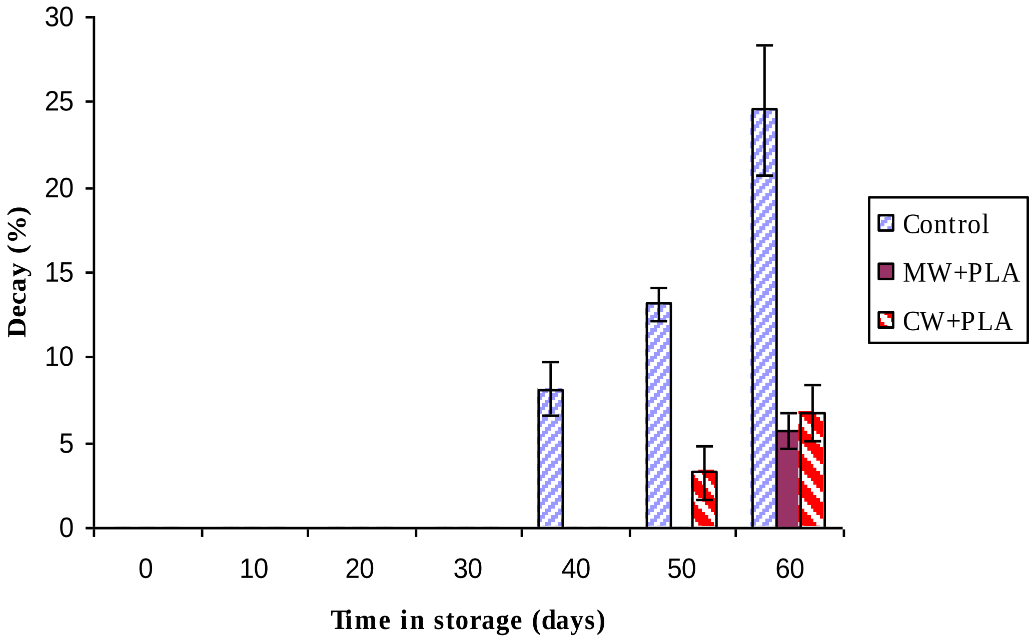


Figure 6.6 Effect of PLA combined with MW on decay of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH

A 2% concentration of PLA completely inhibited the growth of the green mold *Penicillium digitatum* in 'Vangiang' orange (Thuy *et al.*, 2013). The application of L.enzymogenes 3.1 T8 in association with chitosan reduced the number of diseased plants by 50-100% relative to the *Pythium* control of stored cucumber (Jianglian and Shaoying, 2013). Henik *et al.* (2013) illustrated that a combination *Eugenia caryophylata* crude extract and *Candida utilis* TITR 5001 reduced natural development of green mold rot of 'SainamPung' tangerine. Potassium sorbate incorporated in wax orange significantly reduced the incidence of postharvest decay in all tested cultivars, stored for 1 month at 4 °C (Khamis *et al.*, 2012).

Figure 6.7 indicates the percentage of weight loss in treated and control orange cv. Canh fruit during the storage period at 5ºC. For coated fruit, the control had the highest weight loss (29.15%) after 60 days in storage, and the lowest weight loss was found in 8% MW+2.5% PLA (10.06%). Generally, percentage of weight loss of MW association with PLA coated fruit and the control fruit increased with increasing of storage times and temperature storage. There was significant difference in percentage of weight loss of treatments and the control fruit during the preservative time ($P \leq 0.05$). This result demonstrates that 8% MWcoating in combination with 2.5% PLA soaking had the best effectiveness on reducing the weight loss in orange cv. Canh during storage at low temperature (Figure 6.6 and 6.7). Fruits andvegetable are waxed for propose to inhibit weight loss (Thirupathi *et al*. 2006).

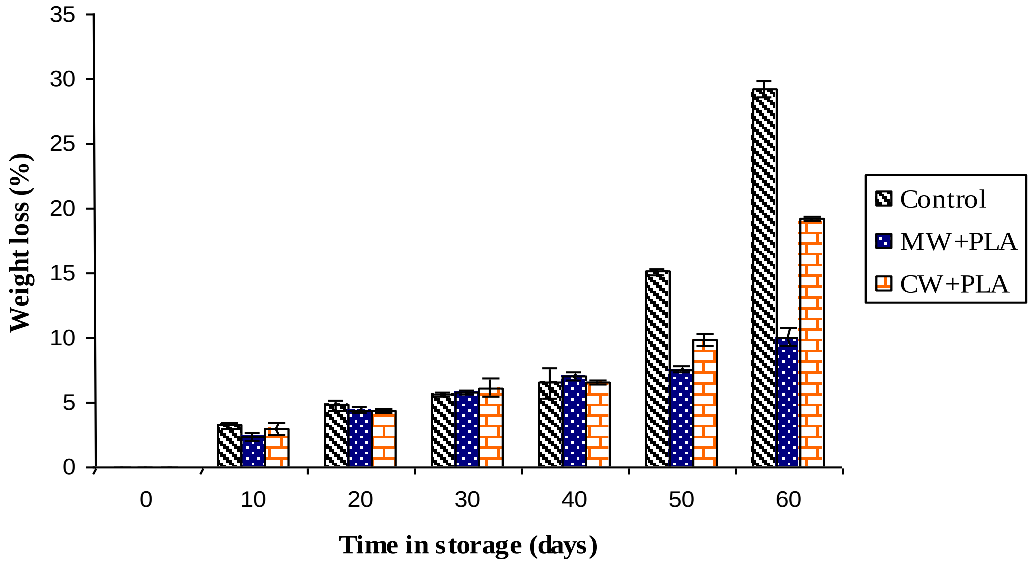


Figure 6.7 Effect of PLA combined with MW on weight loss of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH

Our results are in similarity with the reported data on weight loss of orange fruit (Babar, 2007, Po-jung*et al.*, 2007, Hadar *et al.*, 2014). Weight loss of commercial polyethylene wax and CMC/chitosan bilayer edible coatings of ‘Or’ mandarin slightly reduced 4 weeks of cold storage followed by 5 daysunder shelf-life conditions at 20◦C (Hadar, 2014). According to Wilma *et al.*, (2009), Valencia orange fruit treated with carnauba wax and *Lippia*, spearmint oil exhibited lower weight loss than the control treated with synthetic fungicides and coatings at 10^{o}C for 5 weeks, followed by 1 week 25^{o}C. Low molecular weight chitosan (0.2%) coating improved the water content for ‘Murcott’ tangor stored at 15^{o}C for 56 days (Po-Jung *et al.*, 2007). Khamis *et al.*, (2012) showed that salt (ammonium bicarbonate) interfered with the action of the wax to retard weight loss of Tarocco orange for 1 month at 4^{o}C. The weight loss of Valencia orange treated with imazalil and carnauba significantly were reduced at pre-storage and post-storage of 26 days at low temperature and 7 days of shelf life at 20^{o}C (Ncumisa, 2012).

The changes in sensory score of treated and the control orange cv. Canh fruit are presented in Table 6.1. Citrus are very sensitive to chilling, excessive cold storage or chilling in the field has an important effect on citrus not only on the external appearance but also internally (Enrique and Jose, 2008). After 40 days, it was 5.5 in for the control, and it ranged from 6.0 for MW+PLA, and they were no significant difference in alltreatments (P≤0.05). Sensory score decreased slightly 5.2 in fruit were coated with 8% MW combination with 2.5% PLA, and that was significant difference with CW + PLA treatment and control after 60d (P ≤ 0.05). Orange cv. Canh fruit coated with 8% MW in association with 2.5% PLA soaking to have sensory score value that was accepted for marketable during 60d at low temperatures. This result has been reported similar previously of orange, mandarins of Ron *et al*., 2005; Hagenmaier, 2000; David *et al*. 2011; David *et al*., 2013.

Table 6.1 Effect of PLA combined with MW on sensory of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH

Treatments	Time in storage (days)						
	0	10	20	30	40	50	60
T0	8.5a	7.5a	7.0a	6.0a	5.5a	3.5a	2.5c
MW+PLA	8.5a	8.0a	7.5a	6.5a	6.0a	5.5b	5.2a
CW+PLA	8.5a	7.5a	7.0a	6.2a	5.5a	5.0b	4.5b

Note: *Means followed by the same letter(s) within a column are not significant different as determined by Duncan's multiple-range test P< 0.05.*

9 = extremely liked; 1= extremely disliked; and 5 = neither liked nor disliked

David *et al*. (2011) concluded that storage was deleterious to the flavor of both cultivars, with an increase in off-flavor of 'Owari' fruit and a decrease in overall hedonic score of 'W. Murcott' fruit being indicative of the loss in flavor quality. After 4 weeks of storage (3 weeks at 5◦C and a week at 20◦C) three of the six varieties of mandarins ('Frost Owari', 'OkitsuWase' and 'Fairchild') had high hedonic scores that were significantly lower for the fruit that included at 20˚C storage period in the storage regime in comparison to that which was stored at a continuous 5˚C (David *et al*., 2013). Hagenmaier, 2000 reported that the flavor scores of stored 'Valencia' orange fruit were markedly affected by the coating and storage temperature.

6.3.3 Change in storage life

Table 6.2 presents the shelf life of treated and control orange cv. Canh fruit at 5 ± 1°C, 80 ± 5%RH. The treatment of 2.5% PLA + 8% MW could keep fruit with good quality for 60 days when compared to 40 days in the control fruit, and similar to 2.5% PLA in association with 0.2% chitosan. Fruit and vegetable harvested without wax, the water quickly begins to evaporate,resulting in poor product shelf life to maintain freshness and appearance (Thirupathi *et al.*, 2006). Although storage life of fruit coated with 8% MW in combination with 2.5% PLA could extend to 60 days but sensory score were 5.2, the percentage of fruit decay were low (5.69%). Therefore, orange cv. Canh stored at low temperature with waxing coupled with anti-fungus storage extended shelf life.

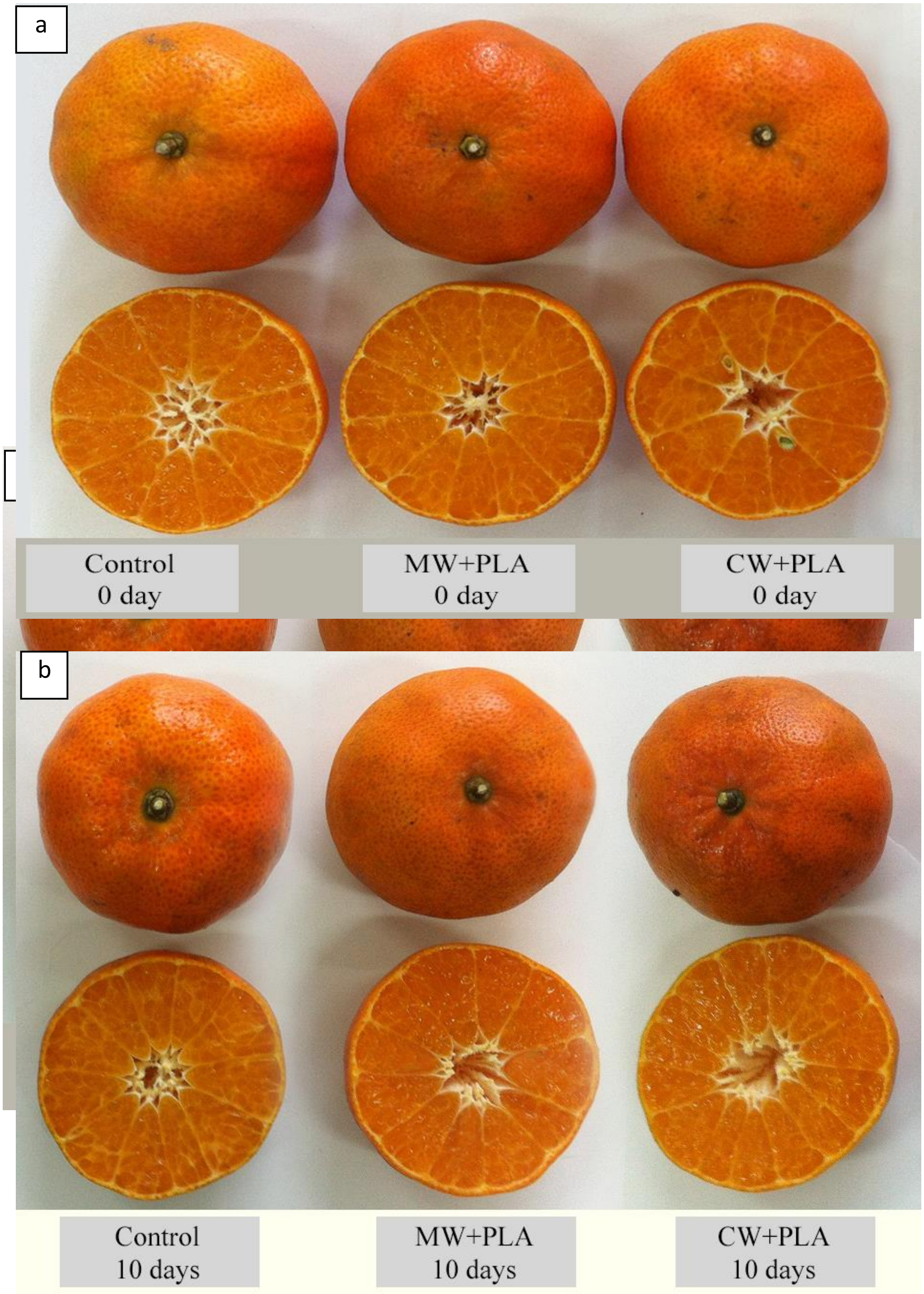
Oranges could be stored up to 12 weeks under optimum storage condition (Mark, 2013). A fungicide, bio-pesticide could also be added to the wax to provide added protection against decay and increase postharvest life (Postharvest Handling Technical Bulletin. 2004a). Po-Jung *et al.* (2007) concluded that the maintenance of quality and the extension of shelf life of 'Murcott tangor' fruit by coating with low molecular weight chitosan stored for 9 weeks at 15ºC. The ideal storage temperature for tangerines was 4°C (39°F), and at this temperature the fruit had a storage life of 4 to 6 weeks (Postharvest Handling Technical Bulletin. 2004b).

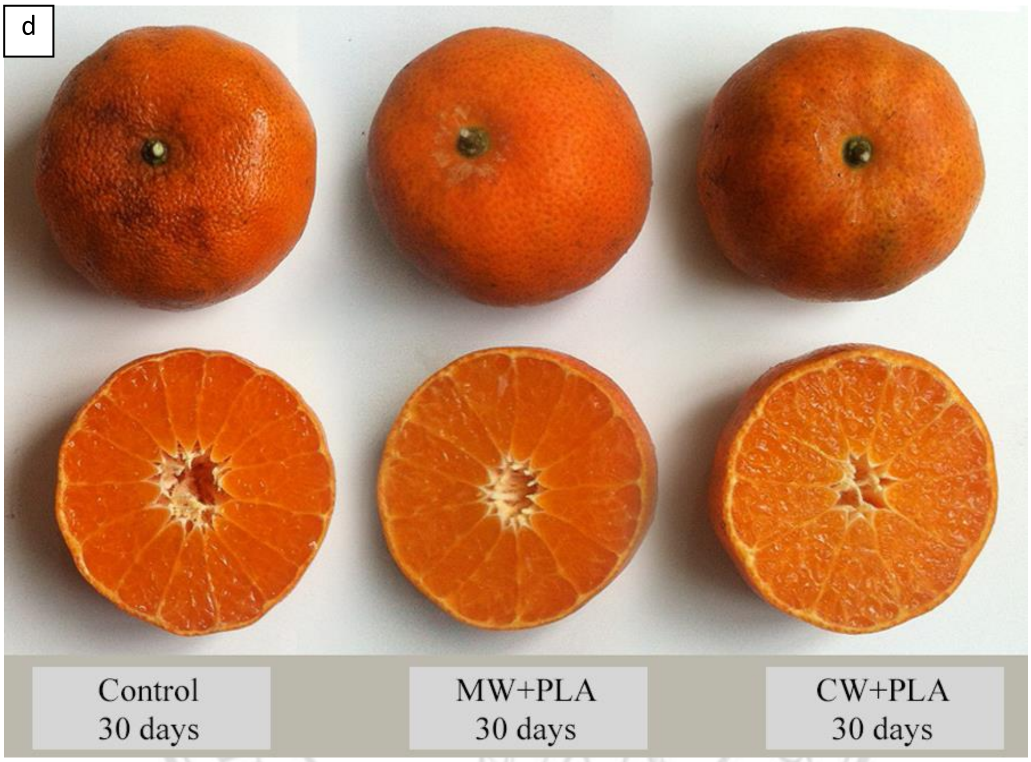
Table 6.2 Effect of PLA combined with MW on shelf-life of orange cv. Canh fruit stored at low temperature (5 ± 1°C), 80 ± 5%RH

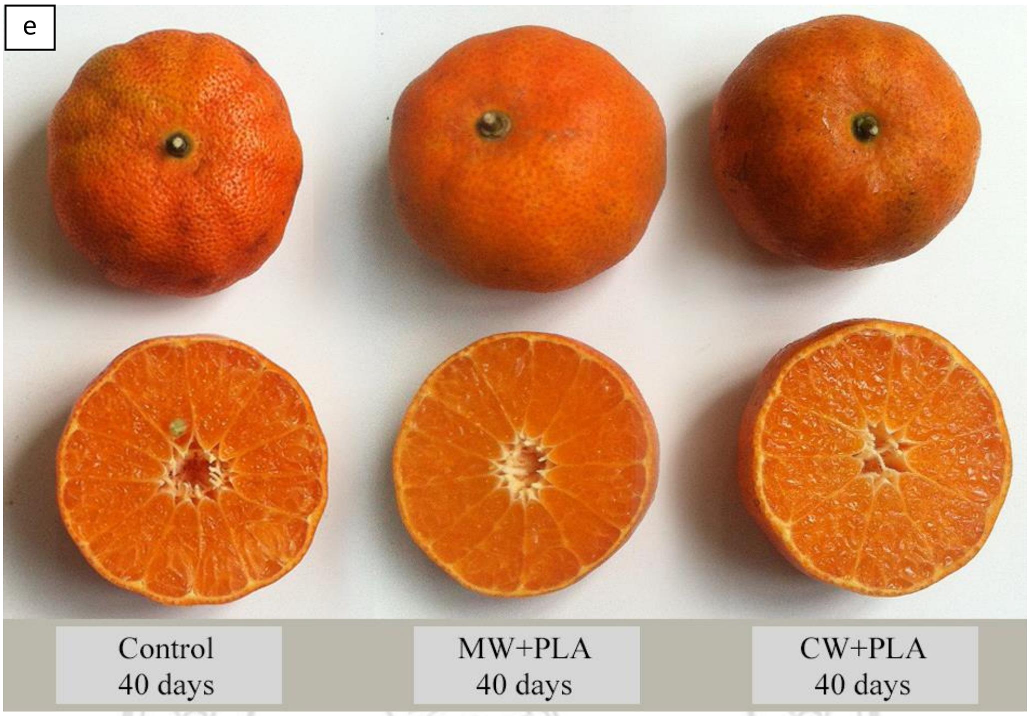
Treatments	Shelf-life (days)	Cause of shelf life limitation
Control	40	Percentage of fruit decay: 3.03%, sensory score: 5.5 (≤ 5.0)
MW+PLA	60	Percentage of fruit decay : 5.69%, sensory score : 5.2 (≤ 5.0)
CW+PLA	50	Percentage of fruit decay : 3.25%, sensory score : 5.0 (≤ 5.0)

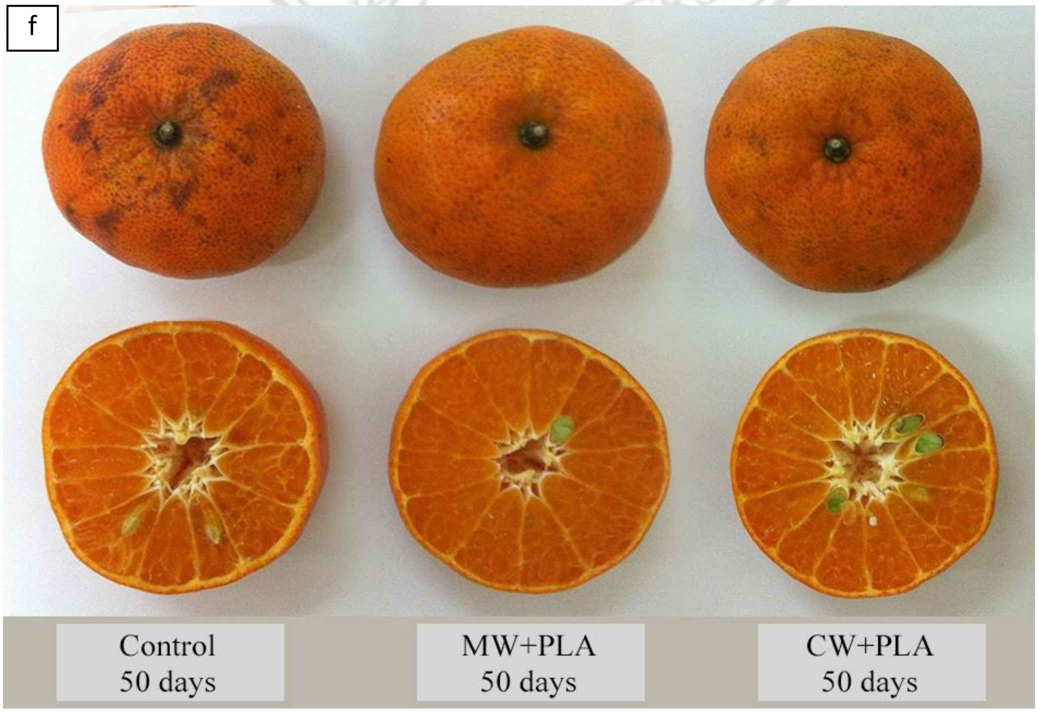
6.4 Conclusion

Application of 2.5% PLA in combination with 8% MW instead of pesticide treatments could be a feasible technology to store Vietnamese orange fruit cv. Canh in a commercial scale.




d
Control
30 days
MW+PLA
30 days
CW+PLA
30 days


e
Control
40 days
MW+PLA
40 days
CW+PLA
40 days


f
Control
50 days
MW+PLA
50 days
CW+PLA
50 days

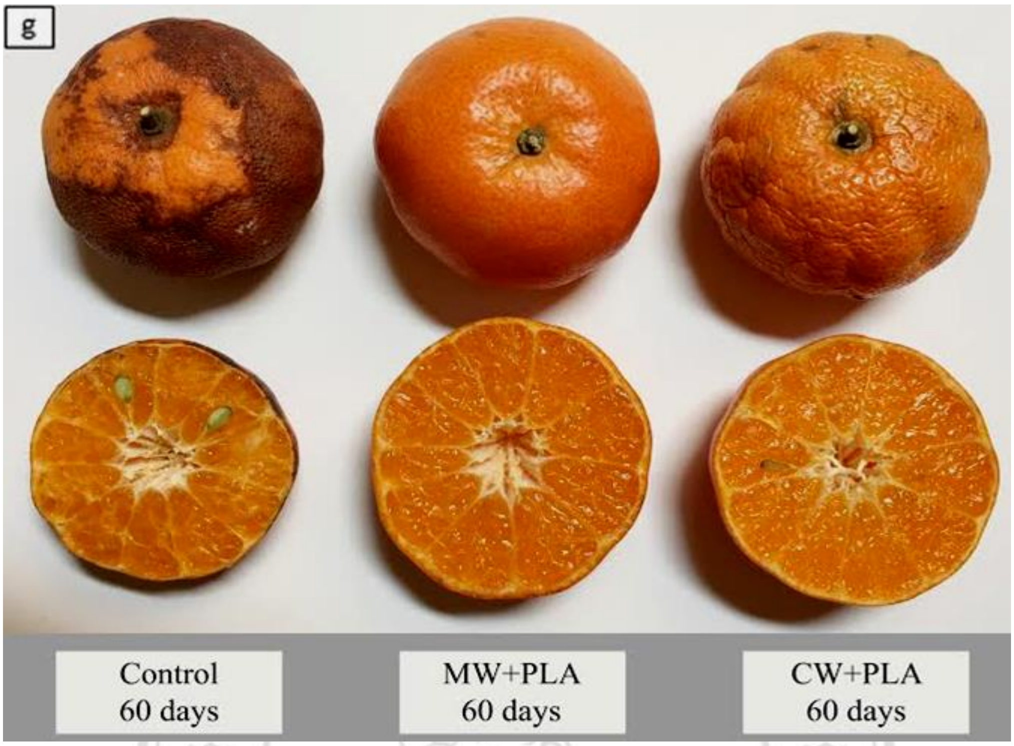


Figure 6.8 Effect of PLA combined with MW on storage time (a-g) oforange cv. Canh fruit stored at low temperature(5 ± 1°C), 80 ± 5%RH

CHAPTER 7

Conclusions

Coating orange fruit cv. Canh in 8%MW (bees wax and carnauba wax) and storing at ambient temperature (22±2°C), 80 ± 5%RH reduced shrinkage pattern throughout the 20 d in storage. Thickness of orange cv. Canh coated 10%MW was highest. Lenticels and stomata was observed by SEM.

Coating orange fruit cv. Canh in 8%MW and storing at ambient temperature (22±2°C), 80 ± 5%RH reduced weight loss, fruit decay and throughout the 20 d in storage. In addition, fruit maintained lower respiration rate, titrable acid, TSS content, total sugars, vitamin C, and ethanol content than other treatments and control.

Coating orange fruit cv. Canh in 8% MW maintained a good postharvest qualities expressed as titrable acid, TSS content, total sugars vitamin C, and sensory values for 50d at 5°C. Moreover, this treatment reduced respiration rate, weight loss, fruit decay, and increasing of ethanol. In addition, acetaldehyde did not find.

Aspergillus sp. and *Penicillium* sp. on orange fruit cv. Canh were isolated and identified. Soaking fruit in 2.5%PLA and coating in 8% MW totally inhibited both fungal strains, and controlled the development of *Penicilium* sp. spoilage on orange cv. Canh. In addition, this treatment maintained the postharvest quality of fruit expressed as titrable acid, TSS, and sensory values; and reduced total microoganisms, weight loss, and fruit decay after storage for 25 d at ambient temperatures, compare with CBZ 0.2% and control.

Application of 2.5% PLA in combination with 8% MW instead of pesticide treatments could be a feasible technology to store Vietnamese orange fruit cv. Canh in a commercial scale.