# CHAPTER 6

# Effects of Sodium Hypochlorite, Oxalic Acid and Wax Coating on the Postharvest Qualities of Fresh Vietnamese Longan Fruit cv. Long During Storage

## 6.1 Abstract

The objective of this study was to investigate the effects of sodium hypochlorite (SH) and oxalic acid (OA) dipping in combination with bees-carnauba mixed wax (MW) coating on postharvest decay and pericarp browning of Vietnamese longan fruit cv. Long. The experiments were firstly carried out by dipping fruits in 200 ppm SH solution for 2 min, and then dipping in 7.5% OA solution for 5 min. After drying in the shade, dipped fruits were coated in 4 and 6% MW for 30 seconds, and stored at 5±1ºC for 30 days. Untreated fruits were used as control. Pericarp browning, pericarp color, polyphenol oxidase (PPO) activity, total microorganisms, percentage of fruit decay and weight loss, eating quality, and total soluble solids (TSS) content were monitored during the storage period. It was found that dipped fruits coated in 6% MW had delayed pericarp browning and fruit decay for 25 days in storage, and the TSS content remained unchanged. Moreover, the fruits maintained low PPO activity, low total microorganism levels, low weight loss, and high eating quality score. This result suggests that application of 200 ppm SH, 7.5% OA, and 6% MW could be feasible for longan fruits storage on a commercial scale.



## 6.2 Introduction

Longan fruit (*Dimocarpus longan* Lour.) is one of the most valuable fruits in Vietnam for domestic and export markets because of its delicious taste and excellent nutritional properties. However, the fruit has a very short postharvest life of 3 to 4 days under ambient temperatures due to desiccation, rotting and browning (Tongdee, 2001; Jiang *et al*., 2002; Apai, 2010). In recent years, there has been a lot of research on storage of

'Long' longan fruits and reported data indicates that the shelf-life of fruits could be extended by carbendazim dipping (Hoan *et al*., 2001), $SO_2$ fumigation (Thuy and Duyen, 2011), and sodium metabisulfite soaking (Hai *et al*., 2011). $SO_2$ is able to protect longan fruits from turning brown as result of reducing PPO activity (Wu *et al*., 1999), and acts as a bleaching agent (Tongdee, 2001). Carbendazim and $SO_2$ play an important role in decay and fungal growth inhibition (Hoan *et al*., 2001; Tongdee, 2001). However, there were many reports on the negative effects of the toxic residue of $SO_2$ and carbendazim in humans, and other reactions with sensitive individuals. Therefore, chitosan coating was studied as an alternative treatment to sulfur compounds and carbendazim application (Huyen and Thuy, 2011). This research showed that the shelf-life of longan fruit cv. Long could be prolonged with good quality for 20 days, however the percentage of fruit decay was very high (11.4%). Thus there is a need to develop effective and safe methods not only to replace $SO_2$ and carbendazim treatments but also to reduce fruit decay and to prolong shelf-life longer than 20 days in 'Long' longan fruit. An alternative method is the use of SH and OA dipping in association with MW coating. Many researchers have routinely used SH for surface sanitation and sterilization of fruits and vegetables (Hong and Gross, 1998). The US Government regulations (21 CFR Part 178) allow food processing equipment and food contact surfaces to be sanitized with solutions containing bleach, if the solutions do not exceed 200 parts per million (ppm) available chlorine. Chlorine has no residual affect (Sawyer, 1978). The primary uses of chlorine have been to inactivate or destroy pathogenic bacteria, fungi, viruses, cysts, and other propagules of microoganisms associated with seeds, cuttings, etc. (Suslow, 2000). Khunpon *et al*. (2011) concluded that dipping in sodium chlorite has the potential to reduce exocarp browning in longan fruits cv. Daw by reducing the activity of PPO. Wax has been using as an effective technology to increase the quality of postharvest fruits and vegetables by preventing moisture loss, shriveling, and weight loss; reducing rates of respiration and ethylene production; protecting from mold growth; and maintaining attractiveness (Hagenmaier and Shaw, 1992; Kolattukudy, 2003; Thirupathi *et al*., 2006; Torres *et al*., 2009; Hu *et al*., 2011; Shahid and Abbasi, 2011). Acidulants, such as citric acid and oxalic acid retard browning by lowering the pH of the product to minimize the activity of PPO, and are generally recognized as safe (Suttirak and Manurakchinakorn, 2010). Oxalic acid prevented pericarp browning due to inhibited PPO activity in longan fruit

(Boonin *et al*., 2006; Whangchai *et al*., 2006). In a previous experiment (Hai *et al*., 2014a) found that MW coating maintained postharvest quality of longan fruits cv. Long for 20 days, but during extended storage time (25 days) the fruits began to decay (≥ 9.4%). In another research (Hai *et al*., 2014b) concluded that fruits soaked in 7.5% OA in association with wax coating could be stored with good postharvest quality for 25 days, however, the treated fruits had decay (≥ 2.6%). In a recent study (Hai *et al*., 2014c) demonstrated that 200 ppm SH soaking in combination with wax coating prevented fruit decay (0%) after 25 days in storage, however treated fruits were browned and not acceptable for marketing purposes.

The main purpose of this study was to investigate the effects of combination of 200 ppm SH and 7.5% OA dipping, and 4 and 6% MW coating on postharvest dcay and pericarp browning of fresh 'Long' longan fruit during a storage period at 5°C.

## 6.3 Material and Methods

### 6.3.1 Plant Materials

Bunches of mature 'Long' longan fruits (at harvesting date about from 185 to 190 days after full bloom) of a commercial orchard in harvesting crop of 2014 in Hung Yen Province, Vietnam were harvested, transported, and selected similar to the fruits mentioned in Chapter 4 and Chapter 5, and bunches of fruit were used for this research.

### 6.3.2 Studying Methods

The optimal concentrations of SH (200 ppm), and OA (7.5%) were selected in the Chapter 4 and Chapter 5. The optimal and feasible concentrations of MW (4 and 6%) were selected in the Chapter 3, and made according to the method of Hai *ei al*. (2014).

Bunches of fruit were firstly dipped in 200 ppm SH solution for 2 min and dried for 30 min, and then dipped in 7.5% OA solution for 5 min. After drying for 1 h, dipped fruits were coated in 4 and 6% MW for 30 seconds, and dried for 8 h at room temperature. While the control fruits were not dipped and coated. After that, bunches of fruit were packed in polypropylene bags, 5 kg per bag (0.035 mm thick with 8 holes of 1 $cm^2$ per hole). The fruits were then stored at 5±1ºC in a cold room and sampled/analyzed at 5 day intervals. Each treatment had three replications.

A completely randomized design was used for the experiment. Three treatments were applied to the longan fruit as following:

$H_0$ = non-treated fruit (control)

$H_1$ = fruit was soaked in 200 ppm SH for 2 min and 7.5% OA for 5 min and air dried before coated with 4% MW

$H_2$ = fruit was soaked in 200 ppm SH for 2 min and 7.5% OA for 5 min and air dried before coated with 6% MW

The data collection methods used for this research in terms of observing changes in the pericarp browning expressed as browning index (BI scale), measurement of the fruit pericarp color and total soluble solids content, an assessment of the percentage of fruit decay and weight loss, determination of PPO activity and total microorganism, assessment of eating quality, evaluation of storage life and the statistical analysis were all similar to the methods described in the Chapter 3, Chapter 4, and Chapter 5.

**6.4 Results and Discussion**

6.4.1 Pericarp browning, pericarp color and PPO activity

Pericarp browning expressed as browning index (BI) of treated and control fruits during the storage period at 5°C is shown in Figure 6.1. Fruits with BI above 2.0 (more than 25% pericarp browning area) were considered as unacceptable for marketing purposes. As shown in Figure 6.1, there was marked difference in BI between treated and control fruits during the storage period ($P \leq 0.05$). After 10 days in storage, control fruits had a BI higher than 2.0 and were not acceptable for marketing purposes. In contrast, fruits in $H_1$ and $H_2$ treatments maintained BI lower than 2.0 for 20 and 25 days respectively (Figure 6.1). Untreated longan fruits pericarp browned after 5 days in storage at 2-7ºC (Jaitrong, 2006; Apai, 2010). The results of this study are consistent with the reported data on BI of untreated longan fuits cv. Long (Hai *et al*., 2011; 2014a; 2014b; 2014c). Overall, the BI of treated and control fruits tended to increase with increasing of storage time, and fruits in $H_2$ treatment showed the best pericarp color and the longest storage life (25 days) (Figure 6.1). Pericarp browning of longan fruit increased with increasing of storage time (Whangchai *et al*., 2006; Khunpon *et al*., 2011). The results of this study are in accordance with the finding on pericarp browning of treated longan fruits cv. Long of Hai *et al*. (2014b), but better than the findings of Hai *et al*. (2011; 2014a;

2014c). The result of this study demonstrates the effectiveness of preservative agents used in prevention of pericarp browning of longan fruits cv. Long. Browning of longan fruit is the results of the oxidation of phenolic compounds by endogenous PPO (Jiang *et al*., 2002). PPO is activated by moisture loss from the fruit (Su and Yang, 1996). Fruits coated with wax could prevent moisture loss (Hagenmaier and Shaw, 1992; Kolattukudy, 2003; Thirupathi *et al*., 2006; Torres *et al*., 2009; Hu et al., 2011; Shahid and Abbasi, 2011). Oxalic acid retards browning by lowering the pH of the product to minimize the activity of PPO (Suttirak and Manurakchinakorn, 2010). Oxalic acid prevented pericarp browning due to inhibited PPO activity in longan fruit (Boonin *et al*., 2006; Whangchai *et al*., 2006). Oxalic acid could effectively control the pericarp browning of litchi fruit during postharvest storage (Zheng and Tian (2006).

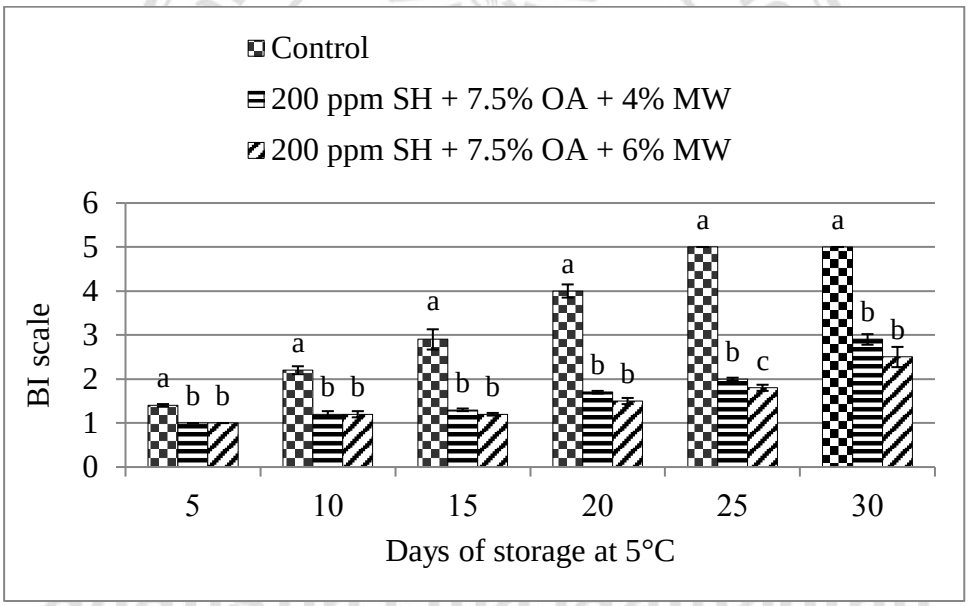


Figure 6.1 Change in BI of longan fruit pericarp either treated or not, during the storage period at 5ºC.

Vertical bars represent standard errors. Columns with different letters of each storage period indicate significant differences ($P \leq 0.05$).

Pericarp color, expressed as L* (lightness) and b* (yellowness) values, is one of the most important visual attributes for selling longan fruits. There were significant differences in L* and b* values between treated and control fruits ($P \leq 0.05$), with higher L* and b* values found in treated fruits during the storage period. In contrast, control fruits had the lowest L* and b* values which tended to decrease with storage time (Figure 6.2 and Figure 6.3). The results of this study are in accordance with the

reported data on L* and b* values of longan fruit (Jaitrong, 2006; Apai, 2010; Hai et al., 2011; Huyen & Thuy, 2011; Thuy & Duyen, 2011; Hai et al., 2014b). As seen in Figure 6.2 and Figure 6.3, the $H_2$ treatment maintained the highest L* and b* values during the storage period. This result demonstrates the effectiveness of SH and OA dipping in combination with MW coating in maintaining the pericarp color of longan fruit cv. Long by inhibiting the activity of PPO and preventing water loss from pericarp as described by Shi (1990); Son *et al*. (2000); Yoruk and Marshall (2003); Zheng and Tian (2006); Boonin *et al*. (2006); Whangchai *et al*. (2006); Thirupathi *et al*. (2006); Shahid and Abbasi (2011); and Hai *et al*. (2014a). This study shows that high L* and b* values correlate with low browning indexes (Figure 6.1, Figure 6.2, and Figure 6.3). Apai (2010) found that L* value is negatively correlated with browning index.

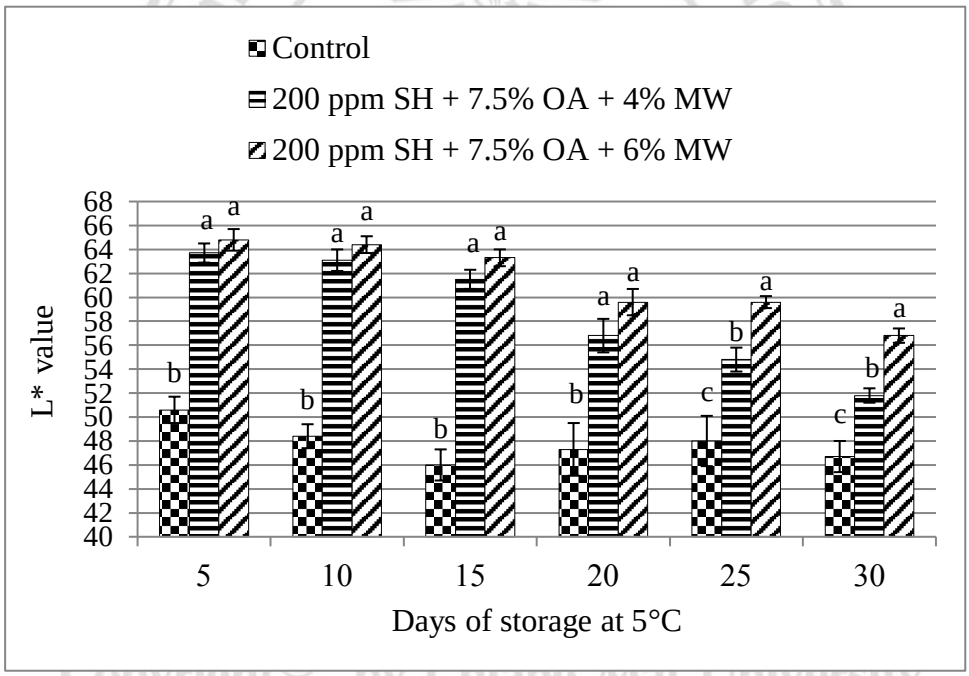




Figure 6.2 Change in L* values of treated and control longan fruits during storage at 5°C.

Vertical bars represent standard errors. Columns with different letters of each storage period indicate significant differences ($P \leq 0.05$).

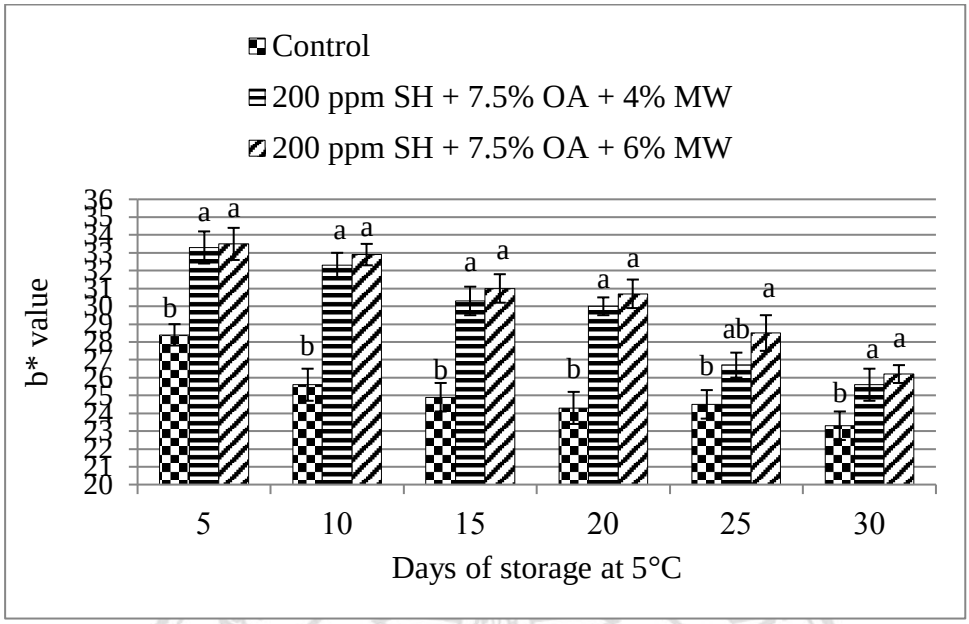


Figure 6.3 Change in b* values of treated and control longan fruits during storage at 5°C.

Vertical bars represent standard errors. Columns with different letters of each storage period indicate significant differences ($P \leq 0.05$).

The PPO activity in longan pericarp of treated and control fruits during the storage period were determined and results are shown in Figure 6.4. There was marked difference in PPO activity between treated and control fruits during the storage period ($P \leq 0.05$), and PPO activity ranged from 2.7 to 4.4 unit/mg protein for control fruits, 1.7 to 2.8 unit/mg protein for $H_1$ treatment, and 1.6 to 2.1 unit/mg protein for $H_2$ treatment after 25 days in storage. The results of this study are in accordance with the reported data on PPO activity in longan pericarp (Whangchai *et al*., 2006; Apai *et al*., 2009; Hai *et al*., 2011). Overall, PPO activity of treated and control fruits tended to increase with increasing of storage time, and the treated fruits had lower PPO activity than control fruits during the storage period. Tissue browning pericarp of longan fruit is dependent upon PPO activity (Kader, 2002). PPO is activated by moisture loss from the fruit (Su and Yang, 1996). Fruits coated with wax could prevent moisture loss (Thirupathi *et al*., 2006). OA retards browning by lowering the pH of the product to minimize the activity of PPO (Suttirak and Manurakchinakorn, 2010). The optimal pH for maximal PPO activity in longan fruit is 6.5 (Jiang, 1999). At pH value below 4, PPO has little activity due to the loss of copper at the active site (Sutirak and Manurakchinakorn, 2010). Inhibition of PPO by OA is due to its binding with copper to

form an inactive complex, and the inhibition was characterized as noncompetitive (Yoruk and Marshall, 2003). OA prevented pericarp browning due to inhibited PPO activity in longan fruit (Boonin *et al*., 2006; Whangchai *et al*., 2006). The results in this study explain that treatments significantly inhibited PPO activity in longan pericarp during the storage period when compared with the control. This study also indicates that low PPO activity correlated with low browning index (Figure 6.1 and Figure 6.4).

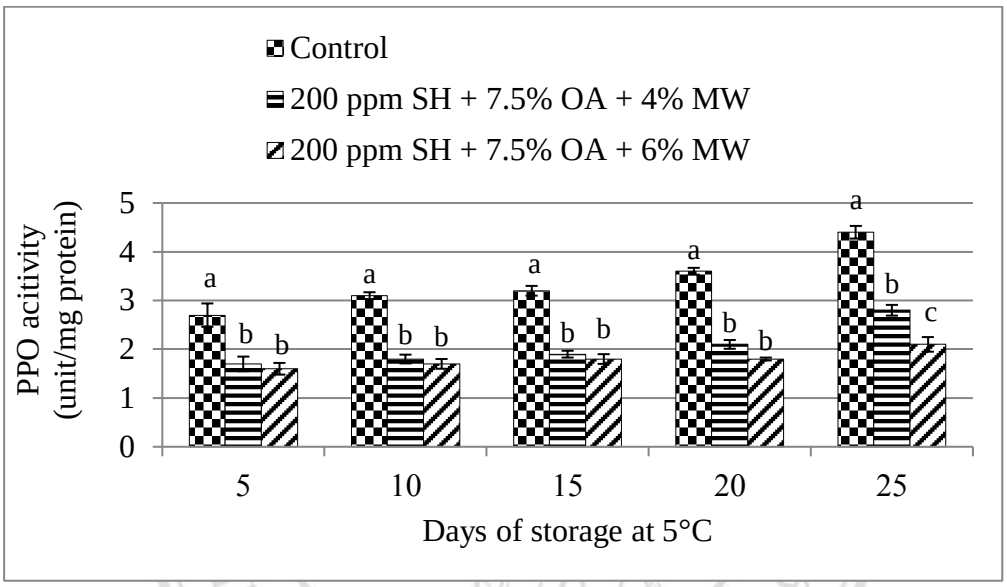


Figure 6.4 Change in PPO activity in longan pericarp of treated and control fruits during the storage period at 5°C.

Vertical bars represent standard errors. Columns with different letters of each storage period indicate significant differences ($P \leq 0.05$).

6.4.2 Fruit decay and total microorganisms

There was significant difference in percentage of fruit decay between treated and control fruits during the storage period ($P \leq 0.05$). The control fruits began to decay (2.8%) after 10 days in storage, and thereafter decay accelerated with increased storage time (after 25 and 30 days it was 58.9 and 98.8% respectively). In contrast, treated fruits did not decay throughout the first 25 days, and they began to decay (5.2% for $H_1$ treatment and 4.7% for $H_2$ treatment) after 30 days in storage (Figure 6.5). High percentage of fruit decay in control longan fruits was found by Hoan *et al*. (2001); Apai (2010); Hai *et al*. (2011); Thuy and Duyen (2011); Huyen and Thuy (2011); and Hai *et al*. (2014a; 2014b; 2014c). Results from this study demonstrate the effectiveness of

preservative agents used in controlling decay in longan fruit cv. Long during the storage period. The results of this study are in accordance with the findings of Hai *et al*. (2014c), and better than the study of Huyen and Thuy (2011) who reported that the best treatment of 2% chitosan coating in longan fruit had 11.4 and 20.8% fruit decay after 20 and 30 days in storage respectively. This study indicates that low fruit decay correlated with low browning index (Figure 6.1 and Figure 6.5). Longan fruits are very susceptible to postharvest decay as a result of both bacterial and fungal infections, including yeasts (Jiang *et al*., 2002). SH was included in treatment due to its fungicidal property (Cerioni *et al*., 2009). SH is used to prevent microbial inoculation (Sawyer, 1978). Hot water dipping with SH (200 ppm) at 52°C for 3 to 4 min was recommended for fungal disinfection of mango fruit (APEDA, 2007). Fresh-cut cilantro treated with SH had no decay by day 4 in storage (Kim *et al*., 2007). Waxing establishes a barrier against the entrance of fungal and bacterial pathogens into the product, and creates a hydrophobic (non-water compatible) surface which is not conducive to pathogen growth and development (Postharvest Handling Technical Bulletin, 2004). Carnauba wax coating reduced fruit decay in mango fruits during storage (Baldwin *et al*., 1999).

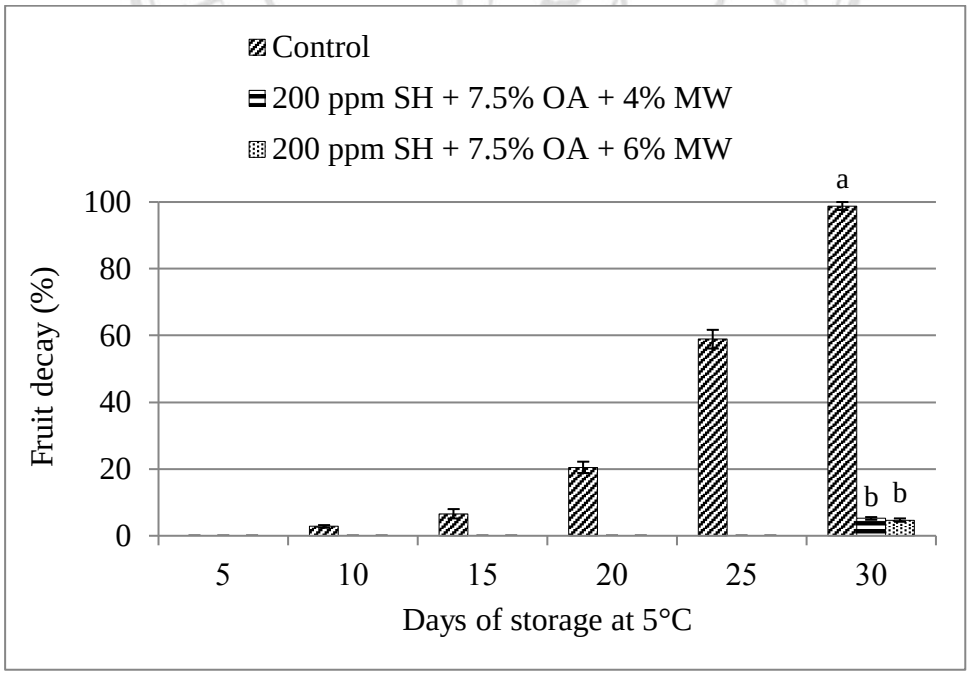


Figure 6.5 The percentage of fruit decay of treated and control fruits during the storage period at 5ºC.

Vertical bars represent standard errors. Columns with different letters of each storage period indicate significant differences ($P \leq 0.05$).

There was marked difference in total microorganism populations on the longan fruit surface between control and treated fruits ($P \leq 0.05$). Overall, total microorganisms tended to increase with the time spent in storage (control fruits increased from 2.0 to 14.1 x $10^6$ CFU $ml^{-1}$ and treated fruits increased from 0.2 to 2.2 x $10^6$ CFU $ml^{-1}$ after 25 days in storage) (Figure 6.6). Microorganism populations on the longan fruit surface markedly increased after 3 days in storage at 25°C (Whangchai *et al*., 2006). As shown in Figure 6.6, the control fruits had much higher total microorganism than treated fruits during the storage period. This result justifies that the treatments in this study significantly reduced total microorganism populations on the surface of longan fruit cv. Long. This study also indicates that low total microorganism populations correlated with low fruit decay and low browning index (Figure 6.1, Figure 6.5, and Figure 6.6). About 106 species of microorganisms have been isolated from longan fruit, comprising 36 bacteria, 63 mold and 7 yeast species (Lu *et al*., 1992). Major postharvest pathogens of longan fruit are *Enterobacter srtohrnrd* sp. and *Acinetobacte* sp. (Lu *et al*., 1992) for bacteria; and *Botryodiplodia* sp. (Jiang, 1997), *Penicillium* sp., *Rhizopus* sp., *Alternaria* sp. (Lu *et al*., 1992), *Lasiodiplodia* sp., and *Cladosposporim* sp. (Sardsud *et al*., 1994) for mold. Sawyer (1978) reported that SH is used to prevent microbial inoculation. Using 200 ppm of hypochlorite solutions reduced total bacterial, *Pseudomonas* spp., yeasts and moulds, and lactic acid bacteria counts in cantaloupes (Ukuku, 2006). Total bacterial count, and yeast and mould count were found to be nil (below detectable level) in the SH treated litchi fruits during the storage period (Kumar *et al*., 2012). Throughout refrigerated storage, strawberries pre-washed with SH (200 µg/mL) presented lower microbial loads ($P<0.05$) than untreated, ultrasonicated, UV-C irradiated or water-washed samples (Alexandre *et al*., 2012). Bhowmik and Pan (1992) observed a significant reduction in microbial spoilage after sanitation of tomato fruit with SH before packaging. Chlorine wash reduced final microbial count by 2.7 log units on fresh-cut iceberg lettuce when compared to controls (Beltran *et al*., 2005). All treatments containing SH significantly reduced initial aerobic plate count, coliform/*E. coli* counts on fresh-cut cilantro compared to those washed with tap water alone (Kim *et al*., 2007). Waxing is primarily done to protect from mold growth on fruits and vegetables (Thirupathi *et al*., 2006). Waxing establishes a barrier against the entrance of fungal and bacterial pathogens into the product (Postharvest Handling Technical Bulletin, 2004).

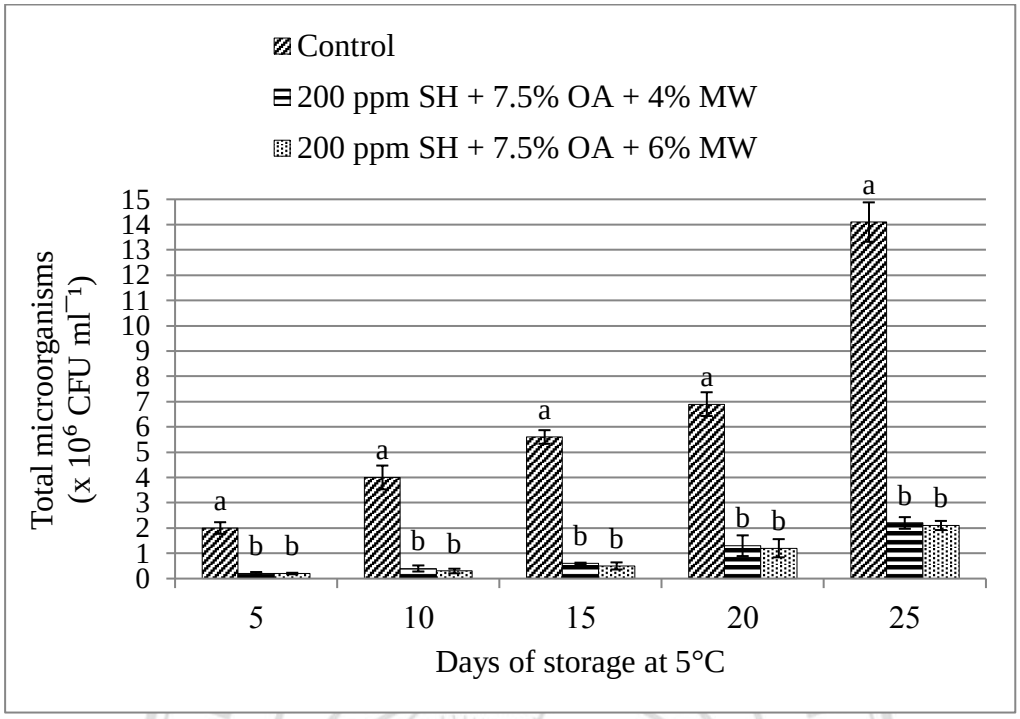


Figure 6.6 Change in total microorganism populations on fruit surface of treated and control fruits during the storage period at 5°C.

Vertical bars represent standard errors. Columns with different letters of each storage period indicate significant differences ($P \leq 0.05$).

6.4.3 Weight loss

The weight loss of treated and control longan fruits during the storage period is shown in Figure 6.7. There was marked difference in weight loss of treated and control fruits during the storage period, and between $H_1$ and $H_2$ treatments by day 5 and after 20 days in storage ($P \leq 0.05$). The percentage of weight loss of treated and control fruits tended to increase with increasing of storage time. Hai *et al*. (2014a, 2014b, 2014c), and Thuy and Duyen (2011) reported that the weight loss of longan fruits cv. Long increased with increasing of storage time. As seen in Figure 6.7, the $H_2$ treatment maintained the lowest weight loss during the storage period. Ater 30 days in storage, the weight loss of the control, $H_1$ treatment, and $H_2$ treatment was 11.9, 8.6, and 6.3% respectively. This result demonstrates that $H_2$ treatment has the best effectiveness on reducing the weight loss in longan fruit cv. Long during the storage period. The results of this study are in accordance with the reported data on weight loss of longan fruit (Jiang and Li, 2001; Apai *et al*., 2009; Huyen and Thuy, 2011; Hai *et al*., 2014a; 2014b; 2014c), and are much lower than the findings of Hoan *et al*. (2001) who reported that the percentage of

weight loss of treated longan fruits was approximately 10% after 20 days in storage at low temperature. The purpose of wax coating was to reduce weight loss in fruits and vegetables (Thirupathi *et al*., 2006). Use of two different waxes reduced water loss from longan fruit cv. Tongbi over 2 days at ambient temperature (Shi, 1990). Waxing tomato fruits delays weight loss (Torres *et al*., 2009). Carnauba wax coating significantly reduced water loss compared to uncoated mango fruits (Baldwin *et al*., 1999). Sta-Fresh 2952 wax (60g/l) was effective in alleviating weight loss in pineapple fruits (Hu et al., 2011). Shahid and Abbasi (2011) reported that 5% bees wax showed the minimum weight loss in sweet orange fruits cv. Blood Red at room temperature storage. Wax emulsions Fruitex, Britex-561 and SB 65 coated on oranges, kinnow, lemons and grape fruits reduced weight loss (Farooqi *et al*., 1988). Waxing Xiang Sui and Pien Pu pears reduced weight loss at all storage temperatures (Sornsrivichai *et al*., 1990).

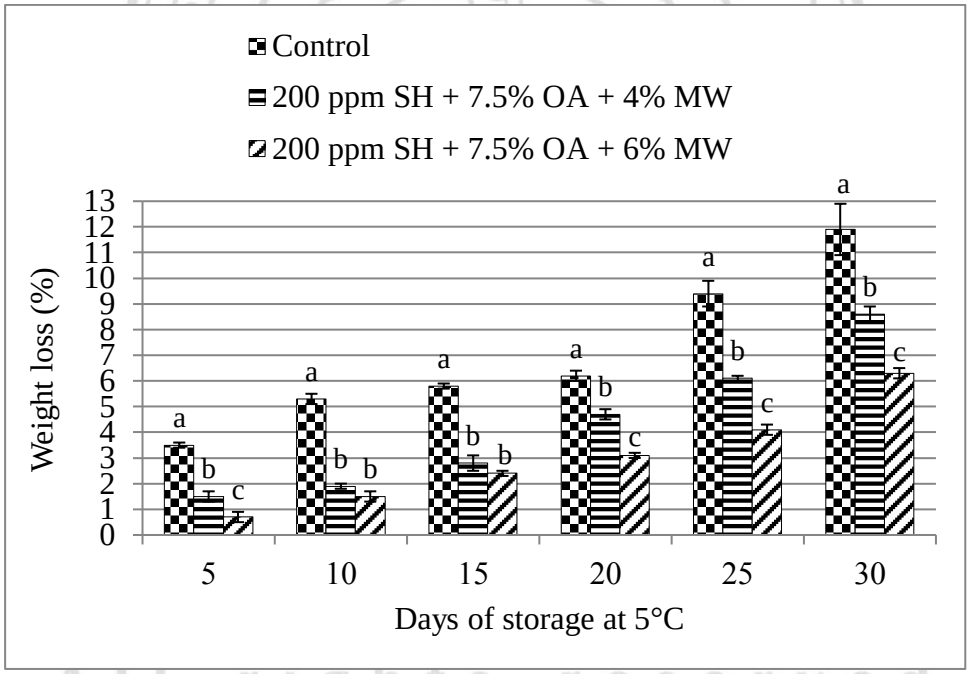




Figure 6.7 The percentage of weight loss of treated and control fruits during the storage period at 5ºC.

Vertical bars represent standard errors. Columns with different letters of each storage period indicate significant differences ($P \leq 0.05$).

6.4.4 Total soluble solids (TSS) contents and eating quality

The TSS content of treated and control fruits increased slightly during the storage period. After 25 days in storage, the TSS content of control fruits was 22.4%, and

treated fruits ranged from 21.6 to 22.3% (Figure 6.8). The results of this study are in accordance with the reported data on TSS contents of longan fruit cv. Long (Hoan *et al*., 2001; Hai *et al*., 2011; Huyen and Thuy, 2011; Thuy and Duyen, 2011; Hai *et al*., 2014a; 2014b; 2014c). As seen in Figure 6.8, the treated fruits had TSS contents which were close to those found in the fresh longan cv. Long at harvesting time (19.9%). From these results it can be assumed that the preservative agents used in this research had no effect on the TSS content of fruits during the storage period. In this study the TSS measurement showed no consistent pattern between treatments or the control fruits, but generally the TSS content of fruit in all treatments and the control increased after storage time, perhaps due to dehydration. Apai (2010), Hai *et al*. (2011; 2014a; 2014b; 2014c) assumed that the increase of TSS content in longan fruits during the storage period was perhaps due to dehydration.

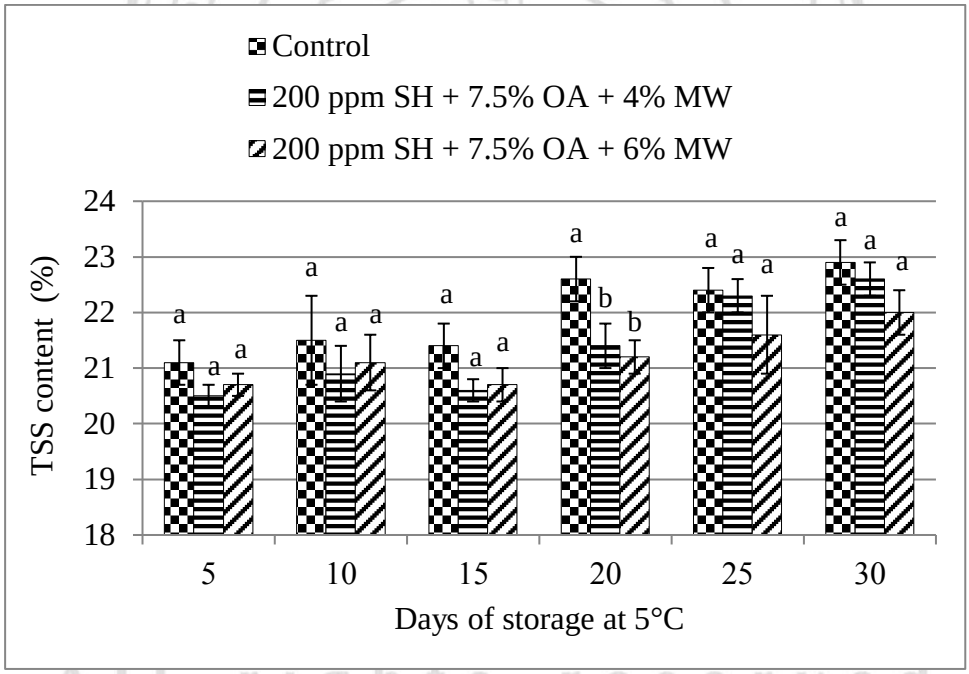




Figure 6.8 The TSS content of treated and control fruits during the storage period at 5ºC.

Vertical bars represent standard errors. Columns with different letters of each storage period indicate significant differences ($P \leq 0.05$).

Eating quality scores of treated and control fruits during the storage period were evaluated and results are shown in Figure 6.9. Overall, the eating quality score of treated and control fruits tended to decrease with increasing of storage time, and the

eating quality score of treated fruits significantly differed from that of control fruits during the storage period ($P \leq 0.05$). Whangchai *et al*. (2006) reported that eating quality of all treated fruits decreased gradually with storage period. As shown in Figure 6.9, there was marked difference in eating quality score between $H_1$ treatment and $H_2$ treatment by day 20, 25, and 30 in storage. The eating quality of $H_1$ and $H_2$ treatments was acceptable until day 25 and 30 in storage respectively. In contrast, the eating quality of control fruits was acceptable by day 15 in storage. The $H_3$ treatment had the highest eating quality scores during the storage period (Figure 6.9). This result demonstrates that 200 ppm SH and 7.5% OA dipping in combination with 6% MW coating did not adversely affect eating quality of longan fruit cv. Long. Citric, ascorbic or oxalic acid dipping in combination with ozone fumigation did not adversely affect eating quality of longan fruit cv. Daw (Whangchai *et al*., 2006). The 'Shahi' and 'China' litchi fruits treated with SH remained organoleptically acceptable until 45 and 30 days respectively, whereas, untreated fruits were considered as unusable after a storage time longer than 15 days due to visible mould growth was observed (Kumar *et al*., 2012). Fresh-cut cilantro (coriander) treated with SH resulted in better quality score than the control (Kim *et al*., 2007).

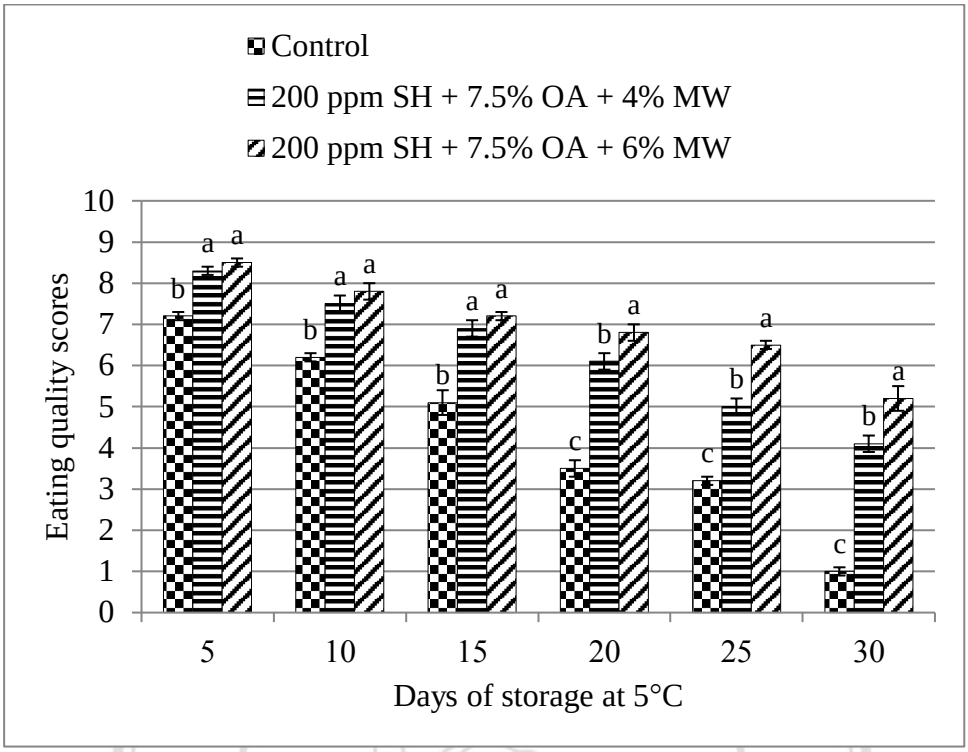


Figure 6.9 Eating quality scores of treated and control fruits during the storage period at 5°C.

Vertical bars represent standard errors. Columns with different letters of each storage period indicate significant differences ($P \leq 0.05$).

6.4.5 Storage life of longan fruits

The control fruits were acceptable for marketing purposes by day 5 in storage. Fruits under $H_1$ treatment accepted for marketable by day 20 in storage, while fruits under $H_3$ treatment showed the best postharvest quality and the longest storage life for 25 days in storage (Table 6.1; and Figures 6.10, 6.11 and 6.12).

Table 6.1 The storage life of bunches of 'Long' longan fruit were considered as acceptable for marketing purposes

| Treatments | Storage life (days) | Cause of limitation when extend storage time |
|---|---|---|
| Control ($H_0$) | 5 | BI ≥ 2.0, fruit decay ≥ 10%, high weight loss and eating score < 5 |
| 200 ppm SH + 7.5% OA + 4% MW ($H_1$) | 20 | BI ≥ 2.0, high weight loss and eating quality score < 5 |
| 200 ppm SH + 7.5% OA + 6% MW ($H_2$) | 25 | BI ≥ 2.0 |

(BI: Browning Index)

**6.5 Conclusion**

Application of 200 ppm SH and 7.5% OA dipping in association with 6% MW coating could delay pericarp browning and fruit decay for 25 days at 5°C. This treatment can be feasible for longan fruits storage on a commercial scale.


(a) (b)

Figure 6.10 Control bunches of fruit after 5 days (a) and 10 days (b) in storage at 5°C.


(c) (d)

Figure 6.11 Bunches of longan fruits dipped in 200 ppm SH and 7.5% OA, and then coated in 4% MW after 20 days (c) and 25 days (d) in storage at 5°C.


(e) (f)

Figure 6.12 Bunches of longan fruits dipped in 200 ppm SH and 7.5% OA, and then coated in 6% MW after 25 days (e) and 30 days (f) in storage at 5°C.