CHAPTER 4

EFFECTS OF SODIUM METABISULFITE ON POSTHARVEST QUALITY AND STORAGE LIFE OF BUNCHES OF LONGAN FRUIT CV. LONG

4.1. Introduction

In recent years, there has been a significant increase in the yields and area of 'Long' cultivar being cultivated in northern Vietnam, producing fruit not only of a high quality but also with a high economic value (Nguyen *et al*., 2001). However, the storage time and selling period can affect the fruits' quality. The fruits have a very short postharvest life of three to four days under ambient temperatures (Tongdee, 2001). The main factors that reduce the storage life and marketability of the 'Long' longan fruit are pericarp browning, and fungal and microbial decay (Tran, 1999; Nguyen *et al*., 2001). The postharvest storage of 'Long' longan fruit is very important for controlling the price, especially during the off-season, and it is also very useful in the long distance transportation of the fruits to foreign markets. In addition, most consumers like to purchase fresh longan in bunches, because they believe that fruits detached from the bunch are not as fresh and not as good in terms of quality. Moreover, the price fetched for detached longan is lower than when it is sold in bunches, and as a result, there is a need to develop a suitable treatment for the preservation of 'Long' longan fruit quality, especially for those sold in a bunch.

The aim of this research is to study the effects of various concentrations of sodium metabisulfite on the postharvest quality and storage life of bunches of longan

fruit, in order to develop a suitable postharvest handling technique for commercial ‘Long’ longan fruit.

4.2. Material and Methods

4.2.1. Plant material

Mature ‘Long’ longan fruits from the 2010 crop of a commercial orchard in Hung Yen Province, Vietnam, were harvested at the same time as the fruits mentioned in Chapter 3, and were used for this research.

4.2.2. Methods

The data collection methods used for this research in terms of observing changes in the fruits visual appearance; measurement of the fruit pericarp color and total soluble solids content; an evaluation of the sensory properties of the fruit; an assessment of the percentage of fruit decay; and the statistical analysis, were all similar to the methods described in Chapter 3.

- Analysis of polyphenol oxidase activity

Polyphenol oxidase (PPO) was extracted according to the method of Huang *et al*. (1990). Longan pericarp (10g) was homogenized in 40 ml of 0.05 M potassium phosphate buffer (pH 6.2) containing 1 M KCl and 2 % polivinylpyroritidone and then centrifuged for 5 min at 13,500 rpm (Hermel model Z383K) and 4ºC. The supernatant was collected as the enzyme extract. PPO activity was assayed by a modification based on the method of Jiang and Fu (1998) using the reaction mixture of 0.05 M potassium phosphate buffer (pH 7.5) containing 0.2 M catechol (0.2

ml) and crude enzyme (0.5 ml). Tubes were incubated for 5 min at 30ºC, the absorbance was measured at 420 nm by visible spectrophotometer (model Thermo Spectronic). The unit of enzyme activity was defined as the amount of enzyme that caused a change of 0.01 in absorbance per minute.

- Evaluation of fruit drop

The level of fruit drop was determined as the percentage of fruit falling from the bunch, as follows:

$$\text{Percentage of fruit drop} = \frac{\text{Number of fruit dropped}}{\text{Total fruit}} \times 100$$

- Determination of storage life

Using the above indices, the quality of the longan fruit was deemed to be unacceptable:

- When fruit had a BI or FCI above 2.0
- When the percentage of fruit decay was above 10%
- When the fruits had an odor or flavor score above 1.5
- When the percentage fruit drop was above 10%

4.2.3. Experimental design

Uniform bunches of longan fruit were collected, then the bunches were soaked in 2.5 or 5 or 7.5% sodium metabisulfite solution for 5 and 10 minutes at room temperature (25 ± 2ºC), while the control fruit were not soaked. The bunches were air dried for 10 minutes at room temperature (25 ± 2ºC) and packed in polypropylene bags (305 x 457mm in size, and 0.035 mm thick) with 1 kg placed in each bag. Each treatment type and the control were replicated three

times; the bags were then stored at 5±1ºC in a cold room and samples were analyzed at 7 day intervals.

A completely randomized design was used for the experiment. The T_0 fruits were not treated (the control); the T_1 and T_2 fruits were treated with 2.5% sodium metabisulfite (SMB) for 5 and 10 minutes respectively; the T_3 and T_4 fruits were treated with 5% SMB for 5 and 10 minutes respectively; and the T_5 and T_6 fruits were treated with 7.5% SMB for 5 and 10 minutes respectively.

4.3. Results and Discussion

4.3.1. Changes in visual appearance of bunches of fruit during the storage period

Figure 4.1 and **Appendix Table B1** provide details of the changes in visual appearance of those fruits treated with various SMB concentrations as well as the control fruits (not treated), during the storage period, expressed as the browning index (BI). Fruits with a BI score above 2.0 (more than 25% pericarp browning area) are considered unacceptable for marketing purposes. As shown in **Figure 4.1**, there was a significant difference in the BI score of the control, T_1- T_2, and T_3–T_6 treatments after 7 days in storage ($P \leq 0.05$). The bunches of fruit under the T_0–T_2 treatments had a BI higher than 2.0 and were thus deemed not acceptable after 7 in storage. This result shows that fruit with no SMB or with low concentrations of SMB did not inhibit pericarp browning. For the untreated longan fruits, pericarp browning occurred after more than 5 days storage at 5ºC, with a BI above 2.0 (Apai, 2010). Jaitrong (2006) also found that untreated longan fruit pericarp brown after storage at 2-7ºC for 5 days. After 21 days in storage, there was a significant difference in the BI of all the treatments, and the T_3-T_5 treatments were not

acceptable because they had a BI higher than 2.0. Whangchai *et al*. (2006) reported that pericarp browning increases with increasing storage time. The T_6 treatment showed the best pericarp color and the longest storage life at 21 days. This result shows that soaking fruits in 7.5% SMB for 10 minutes prevents pericarp browning, with the SMB acting as an inhibiting agent for the enzymatic browning - which involves the oxidation of phenolic compounds present in the fruit's pericarp. Sodium metabisulfite prevented skin browning (Tongdee, 1993), which is in line with the findings of Jiang *et al*. (2002) who reported that dipping longan fruit in sodium metabisulfite is effective at preventing pericarp browning. Our results were also consistent with other studies into the BI of longan fruit pericarp (Whangchai *et al*., 2006; Nguyen *et al*., 2001; Apai, 2009 & 2010).

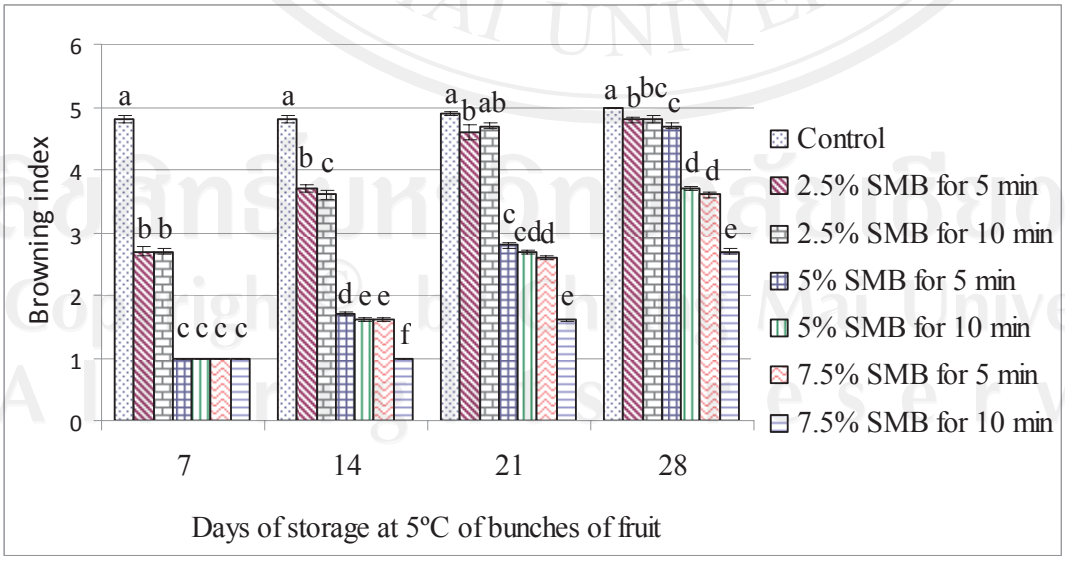

Figure 4.1 Changes in pericarp browning index (BI) of bunches of longan fruit either treated or not, during 28 days in storage at 5ºC.

BI: 1 = 0%; 2 = 1-25%; 3 = 26-50%; 4 = 51-75%, and; 5 = 76-100% pericarp browning area. Fruits with BI above 2.0 were considered as unacceptable. Vertical bars represent standard errors. Columns with different letters indicate significant differences by Duncan's multiple range test ($P \leq 0.05$).

Changes in the visual appearance of the fruit were observed, as expressed through the flesh color index (FCI) scores measured during storage, and the results are shown in **Figure 4.2** and **Appendix Table B2**. Fruits with an FCI above 2.0 are considered as unacceptable for sales and marketing purposes. For this study, the FCI was bellow 2.0 and the same across all treatments and for the control after 7 days in storage, but by day 14 there was a significant difference between the T_0–T_2 treatments and the T_3–T_6 treatments (the FCI of T_3–T_6 treatments was not significant difference) ($P \leq 0.05$). After 21 days in storage, the flesh color of the longan fruits remained acceptable for all treatments (FCI below 2.0) when compared to the control, which was not acceptable due to having an FCI above 2.0. This result demonstrates the effectiveness of SMB at maintaining the color of longan fruit flesh. The control fruits also revealed pulp rot in accordance with the highest browning index (Apai, 2009). Our results are in accordance with reported data on flesh quality of treated 'Long' longan fruit flesh, which showed that the flesh is still acceptable after 20 in storage (Nguyen *et al*., 2001). After 28 days in storage, the FCI of most of the treatments was significantly different (except for the T_4 and T_5 treatments which were similar), and the fruits of T_4–T_6 treatments maintained an acceptable flesh color (**Figure 4.2**). This means that those fruits treated with 5% SMB for 10 minutes, and 7.5% SMB for 5 and 10 minutes had an improved flesh color, due to the limitation of enzymatic browning, plus the control of microorganisms and fungi (Tongdee, 1993).

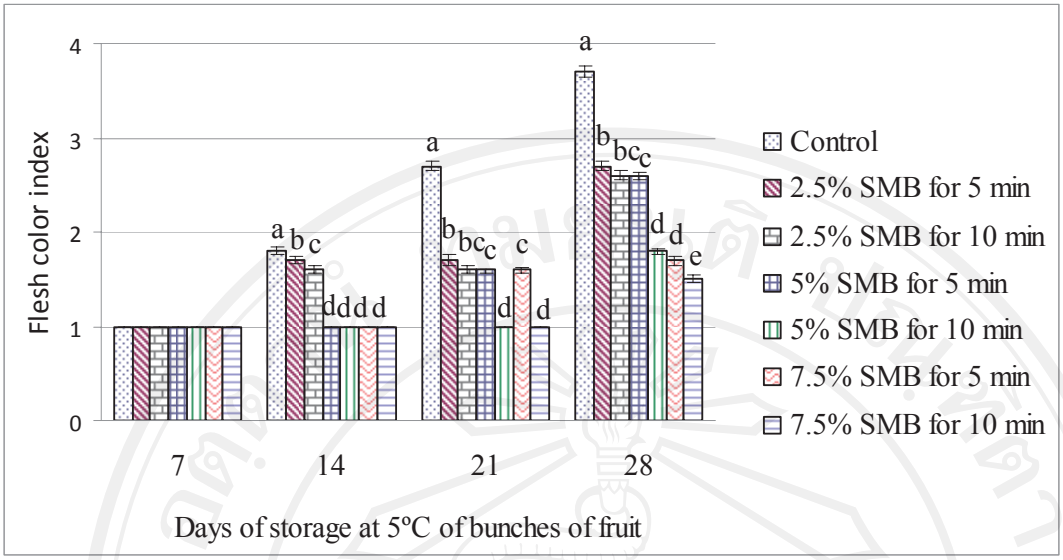

Figure 4.2 Changes in flesh color index (FCI) of whole bunches of longan fruit, either treated or not, during 28 days in storage at 5ºC.

The index shown is: 1 = normal color; 2 = slightly abnormal color, but still acceptable; 3 = moderately abnormal color and unacceptable, and; 4 = severely abnormal color. Fruits with FCI above 2.0 were considered as unacceptable. Vertical bars represent standard errors. Columns with different letters indicate significant differences by Duncan's multiple range test ($P \leq 0.05$).

4.3.2. Changes in L*, a*, and b* values of bunches of fruit during the storage period

The L* values (lightness) of the fruit pericarp were measured and the results are shown in **Table 4.1**. After 21 days in storage, there was a significant difference in L* values between the control and the T_1; T_2; T_3-T_4 treatments, plus the T_5 and T_6 treatments ($P \leq 0.05$). The L* values for the T_5 and T_6 treatments were higher than the other treatments and the control, and they were not different. The L* values of the treated fruits were higher than the L* values of the control fruits during the storage period. This result demonstrates the effectiveness of the anti-browning agent at maintaining the light color of fruit pericarp. Jiang (1999a) reported that the browning reaction of fruit pericarp is caused by the oxidation of phenolic compounds through PPO activity. Sodium metabisulfite inhibits the oxidation of phenolic compounds (Tongdee, 1993). After 28 days in storage, there was a significant difference in L* values for all treatments and the

control, with the L* values ranging from 40.4 to 46.4, and these L* values tended to decrease in all treatments ($P \leq 0.05$). The L* values of the longan fruit pericarp decreased from 53.5 to 42.3 when the treated fruits were stored at 5ºC for 24 days (Thavong, 2009). Our results are consistent with previous studies on the L* values of longan fruit pericarp (Rattanapanone *et al*., 2001; Jaitrong, 2006; Shodchit *et al*., 2008; Apai, 2009). Apai (2010) also demonstrated that untreated fruits have lower L* values. According to **Table 4.1**, the fruits soaked in 7.5% SMB for 10 minutes had higher L* values than the fruits which underwent other treatments and the control during the storage period. This result explains that treatment with 7.5% SMB for 10 minutes significantly inhibits the browning reaction of longan pericarp ($P \leq 0.05$).

Table 4.1 The L* values of pericarp of bunches of fruit during storage period.

Treatment	Days of storage at 5ºC[1]			
	7	14	21	28
T_0	39.7 ± 0.5d	39.9 ± 0.6d	41.1 ± 0.4d	40.4 ± 0.4f
T_1	45.0 ± 0.6c	45.8 ± 0.8b	45.1 ± 0.5bc	44.3 ± 0.5cd
T_2	47.7 ± 0.7b	43.6 ± 0.5c	43.9 ± 0.4c	45.8 ± 0.5ab
T_3	48.5 ± 0.5ab	46.8 ± 0.6b	46.5 ± 0.3b	43.1 ± 0.4de
T_4	49.5 ± 0.4a	46.9 ± 1.2b	46.0 ± 0.5b	45.0 ± 0.6bc
T_5	47.6 ± 0.5b	45.8 ± 0.7b	48.9 ± 0.6a	42.2 ± 0.6e
T_6	48.2 ± 0.5ab	50.5 ± 0.5a	49.6 ± 0.5a	46.4 ± 0.4a

[1]Means within a column with the same letter are not significantly different at 95% (P≤0.05) level by least significant difference comparison. Data are mean value ± SE. The average L* value of fruit pericarp at initial date was 47.8 ± 2.1.

Table 4.2 shows the a* values (redness) of the Longan pericarp for bunches of fruit treated with various concentrations of SMB solutions compared to the control. It can be seen that there was not a significant difference in a* values for the T_0–T_2 treatments, and that they were significantly different from other treatments by day 21 in storage ($P \leq 0.05$). After 28 days in storage, the a* values ranged from between 8.8 and 11.4. Furthermore, the a* values of the T_0, T_2 and T_3 treatments were similar, and were significantly different to the other treatments ($P \leq 0.05$). In **Table 4.2** it can be seen that fruits soaked in 7.5 sodium metabisulfite solution maintained a* values which were lower than the other treatments and the control by day 14 and day 21 (a* was 7.4 by day 14, and 7.1 by day 21). Sodchit *et al*. (2008) found that the a* values of longan pericarp cv. Daw range between 5.1 and 6.6 when fruits were kept at 15ºC for 6 days.

Table 4.2 The a* values of pericarp of bunches of fruit during storage period.

Treatment	Days of storage at 5ºC[1]			
	7	14	21	28
T_0	10.5 ± 0.2a	11.1 ± 0.3a	9.6 ± 0.4c	11.4 ± 0.2a
T_1	9.4 ± 0.2b	9.6 ± 0.3b	9.4 ± 0.3c	9.5 ± 0.2bc
T_2	8.8 ± 0.3bc	9.1 ± 0.3b	9.5 ± 0.2c	10.8 ± 0.6a
T_3	9.5 ± 0.3b	9.4 ± 0.3b	10.7 ± 0.3ab	10.9 ± 0.3a
T_4	9.4 ± 0.4b	9.5 ± 0.4b	11.2 ± 0.3a	8.8 ± 0.2c
T_5	8.1 ± 0.3c	10.4 ± 0.3a	10.1 ± 0.3bc	9.9 ± 0.2b
T_6	9.2 ± 0.4b	7.4 ± 0.2c	7.1 ± 0.4d	9.3 ± 0.2bc

[1]Means within a column with the same letter are not significantly different at 95% ($P \leq 0.05$) level by least significant difference comparison. Data are mean value ± SE. The average a* value of fruit pericarp at initial date was 7.5 ± 1.1.

The b* values (yellowness) of the fruit pericarp were measured and the results are shown in **Table 4.3**. After 21 days in storage the b* values ranged from 16.9 to 27.4; the b* values of the T_3-T_5 treatments were similar, the T_1 treatment was similar to the T_2 treatment, and all these treatments were significantly different to the T_6 treatment and the control ($P \leq 0.05$). After 28 days in storage, the b* values ranged from 16.3 to 22.0, and the fruits in T_1, T_3, T_5 treatments had b* values which were not significantly different to each other. There was not a significant difference in b* value for the T_2, T_4 and T_6 treatments by day 28 ($P \leq 0.05$). The b* values of the treated fruits were higher than the b* values of the control fruit during the storage period. This result shows the effectiveness of SMB at maintaining the yellowness of fruit pericarp, protecting it against oxidation of the phenolic compounds by PPO activity, as described by Tongdee (1993) and Jiang (1999a). It can be seen from **Table 4.3** that the b* values tended to decrease in all treatments and the control after 28 days in storage. Shodchit *et al*. (2008) demonstrated that the b* values of treated fruits tend to decrease with increasing storage time. In this study, fruits soaked in 7.5% SMB for 10 minutes had higher b* values than the fruits which underwent other treatments and the control, during the storage period. This results show that treatment with 7.5% SMB for 10 minutes maintains the yellowness of fruit pericarp for longer than other treatments. Boonin *et al*. (2006) concluded that soaking longan fruit cv. Daw in 5% oxalic acid before 7.5% sodium metabisulfite, and then using a solution mix of sodium metabisulfite and oxalic acid solution, can maintain b* values when compared to other treatments and a control.

Table 4.3 The b* values of pericarp of bunches of fruit during storage period.

Treatment	Days of storage at 5ºC[1]			
	7	14	21	28
T_0	18.2 ± 0.7d	17.3 ± 0.7e	16.9 ± 0.6d	16.3 ± 0.4c
T_1	23.9 ± 0.6c	22.9 ± 0.8cd	20.6 ± 0.5c	19.4 ± 0.6b
T_2	25.7 ± 0.7abc	21.5 ± 0.7cd	20.2 ± 0.4c	21.4 ± 0.5a
T_3	25.2 ± 0.6bc	23.7 ± 0.6c	23.9 ± 0.6b	19.7 ± 0.5b
T_4	27.4 ± 0.5a	26.4 ± 1.0b	25.2 ± 0.6b	21.9 ± 0.8a
T_5	26.7 ± 0.8ab	21.3 ± 0.6d	25.3 ± 0.6b	18.8 ± 0.5b
T_6	26.6 ± 0.7ab	30.2 ± 0.6a	27.4 ± 1.0a	22.0 ± 0.6a

[1]Means within a column with the same letter are not significantly different at 95% (P≤0.05) level by least significant difference comparison. Data are mean value ± SE. The average b* value of fruit pericarp at initial date was 27.7 ± 1.4.

4.3.3. Changes in polyphenol oxidase activity

Tissue browning pericarp of longan fruit is dependent upon polyphenol oxidase (PPO) activity (Kader, 2002). There has been widespread acceptance that litchi pericarp browning is caused by a rapid degradation of phenols by PPO activity (Underhill *et al*., 2001). **Figure 4.3** and **Appendix Table B5** indicate the changes in PPO activity in 'Long' longan pericarp of treated

bunches of fruit and the control fruits during storage period at 5ºC. It can be seen that, there was significantly different on PPO activity in all treatments and the control by day 21 in storage. After 28 days in storage, the PPO activity of the T_4 - T_6 treatments was not different, and $T_1 – T_2$ treatments also was not different ($P \leq 0.05$). The control fruits had the highest PPO activity (which ranged from 3.1 to 4.3 unit/mg protein), and it was strongly different with treated fruits which remained low PPO activity (from 0.1 to 2.6 unit/mg protein) during storage period ($P \leq 0.05$). These results explain that sodium metabisulfite treatments in this study significantly inhibited PPO activity of longan pericarp during storage period when compared with the control. Sodium metabisulfite displays as an antioxidant and as a reducing agent by inhibition of enzymatic browning involving oxidation of phenolic compounds by PPO activity (Tongdee, 1993; Jiang, 1999a). Wu *et al*. (1999) found that sulfur dioxide inhibited enzymatic skin browning during storage by inhibited PPO activity. Low PPO activity was found by Whangchai *et al*. (2006) when fruits were treated by sulfur dioxide. This study indicates that low PPO activity correlated with high concentration and dipping time in SMB solution (**Figure 4.3**), and low PPO activity correlated with low browning index (**Figure 4.1** and **Figure 4.3**). The fruits soaked in 7.5% SMB for 10 min had the lowest PPO activity and which ranged from 0.1 to 0.6 unit/mg protein during 28 days in storage. This result demonstrates that the high concentration of SMB in combination with dipping time significantly inhibited PPO activity.

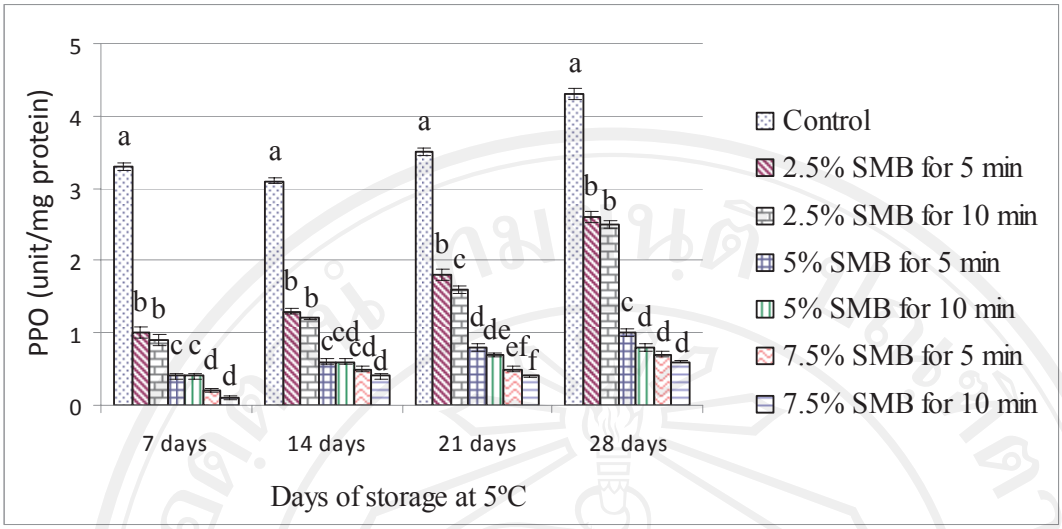

Figure 4.3 Changes in polyphenol oxidase activity in longan pericarp of treated bunches of fruit and the control fruits during storage period at 5ºC.

Vertical bars represent standard errors. Columns with different letters indicate significant differences by Duncan's multiple range test ($P \leq 0.05$).

4.3.4. Changes in total soluble solids content of bunches of fruit during storage period

The TSS contents of 'Long' longan fruits are shown in **Table 4.4**. After 21 days in storage, the TSS content of the treated fruits and the control fruits ranged from 17.7 to 19.8 %Brix. The TSS content of all treatments was not different when compared with the control by day 21 in storage (except T_5 treatment) ($P \leq 0.05$). These TTS content are in accordance with previous studies in which the values ranged from 16.9 to 20.9 %Brix (Tran, 1999; Nguyen *et al*., 2001; Thavong, 2009). After 28 days in storage, the TSS contents ranged from 18.1 to 19.4 %Brix, and the TSS content of the T_6 treatment was not different to the control and the $T_4 - T_5$ treatments ($P \leq 0.05$). These TSS contents are close to those found in fresh longan fruit (17 and 21 %Brix). From, these results it can be assumed that the SMB concentrations used in this research had no effect on the TSS content of the 'Long' longan fruit. Nguyen *et al*. (2001) reported that the carbendazim concentrations do not have an effect on the TSS content of 'Long'

longan fruit during storage period. Our results are also in accordance with those of Apai (2009 & 2010) in which the TSS content of Thai longan fruit cv. Daw ranged from 19.3 to 20.4 %Brix. In this study, the TSS measurements showed no consistent pattern between treatments, but generally the TSS content of fruit were in accordance with fresh longan fruit at harvesting time.

Table 4.4 Change in total solube solids content (%Brix) of bunches of fruit during storage period.

Treatment	Days of storage at 5ºC[1]			
	7	14	21	28
T_0	18.0 ± 0.6ab	18.5 ± 0.4ab	18.3 ± 0.3b	19.1 ± 0.6a
T_1	17.0 ± 0.8b	19.7 ± 0.2a	17.9 ± 0.4b	18.3 ± 0.4c
T_2	18.9 ± 0.4a	16.4 ± 0.4c	17.7 ± 0.3b	18.1 ± 0.5c
T_3	19.3 ± 0.6a	18.6 ± 0.4ab	18.9 ± 0.4b	18.7 ± 0.3c
T_4	18.9 ± 0.4a	18.7 ± 0.5ab	18.8 ± 0.3b	19.4 ± 0.6a
T_5	18.1 ± 0.4ab	19.4 ± 0.4a	19.8 ± 0.6a	19.2 ± 0.3a
T_6	18.8 ± 0.3a	17.8 ± 0.4b	18.5 ± 0.5b	19.0 ± 0.2a

[1]Means within a column with the same letter are not significantly different at 95% ($P \leq 0.05$) level by least significant difference comparison. Data are mean value ± SE. The average TSS content of fruit at initial date was 18.9 ± 1.4 %Brix.

4.3.5. Changes in sensory quality of bunches of fruit during storage period

The sensory quality of the bunches of fruit, expressed in terms of odor and flavor, during the 28 days in storage at 5ºC were evaluated, and results are shown in **Figure 4.4**, **Appendix Table B3** and **Figure 4.5**, **Appendix Table B4**. Fruits with an odor or flavor score above 1.5 can be considered as unacceptable for sales and marketing purposes. It can be seen from **Figure 4.4**

that the odor scores were below 1.5, and that there was no significant difference in odor scores among all treatments by day 7 in storage. After 14 days in storage, the odor scores of the T_0 - T_4 treatments were similar and were significantly different to the T_5 and T_6 treatments, though the fruits were normal across all treatments (odor score below 1.5) ($P \leq 0.05$). After 21 days in storage, the odor scores of the T_0, T_1 and T_3 treatments were above 1.5, and after 28 days in storage, there was a significant difference between the odor scores of the T_4 - T_6 treatments when compared to the T_0 – T_3 treatments - which were similar to each other, and the T_5 and T_6 treatments maintained normal odor (odor score below 1.5). Unlike the odor scores, the flavor scores for both the control and T_2 were above 1.5, and were significantly different to the other treatments by day 14 in storage. After 21 days in storage, the T_4 - T_6 treatments had a normal flavor, with flavor scores below 1.5, and they were not different to each other ($P \leq 0.05$). The T_6 treatment continued to maintain a flavor score below 1.5 until 28 days in storage, and this treatment was significantly different to the other treatments. Meanwhile, the flavor scores of the T_0 – T_4 treatments were similar, but differed from the T_5 treatment, though their flavor scores were higher than 1.5 (**Figure 4.5**). Thus, the bunches of longan fruit soaked in 7.5% SMB for 10 minutes kept their sensory quality for 28 days in storage at 5ºC. Our results are not in accordance with other findings regarding the sensory quality of 'Long' longan fruit, in which quality was only acceptable up to 20 days in storage (Nguyen *et al*., 2001).

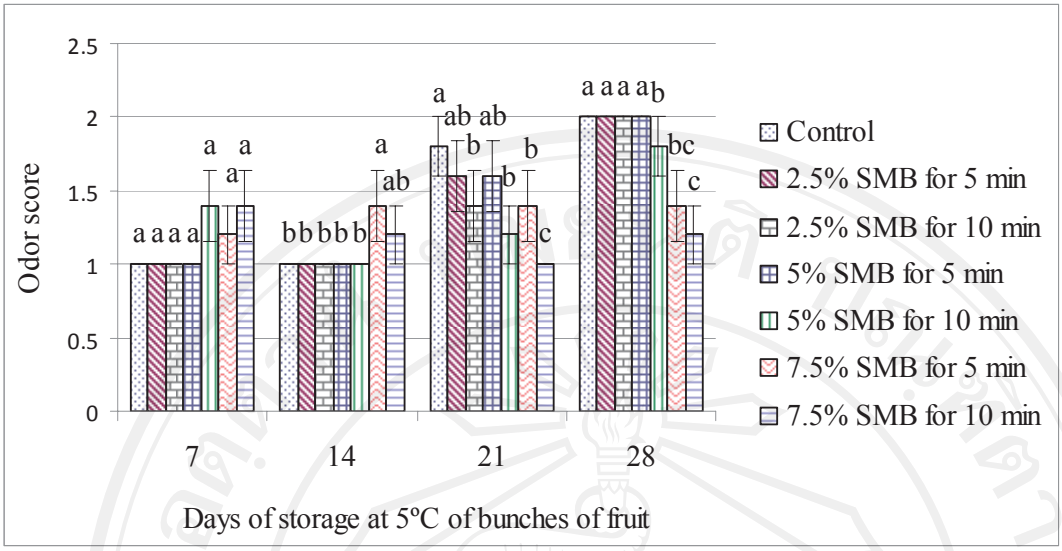

Figure 4.4 Changes in odor score of bunches of longan fruit during storage period at 5ºC.

Fruits with odor score above 1.5 were considered as unacceptable. Vertical bars represent standard errors. Columns with different letters indicate significant differences by Duncan's multiple range test ($P \leq 0.05$).

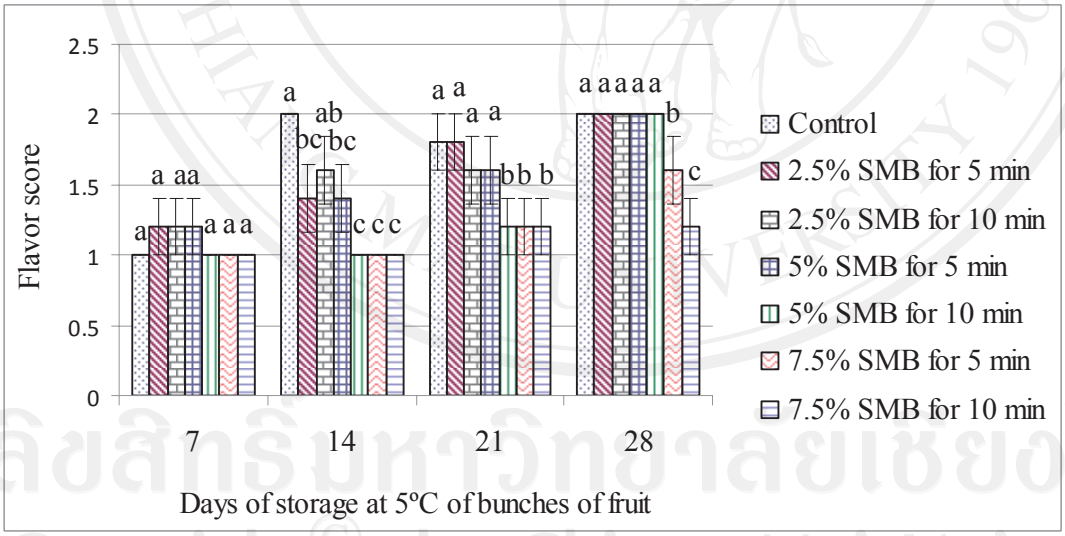

Figure 4.5 Changes in flavor score of bunches of longan fruit during storage period at 5ºC.

Fruits with flavor score above 1.5 were considered as unacceptable. Vertical bars represent standard errors. Columns with different letters indicate significant differences by Duncan's multiple range test ($P \leq 0.05$).

4.3.6. The percentage of fruit decay in bunches of fruit during storage period

The effects of SMB on the percentage of fruit decay in the bunches of fruit were also investigated and the results are shown in **Table 4.5**. The rate of fruit decay in the control was 11.0 % after 14 days in storage, thereafter increasing with the time spent in storage (after 21 days it was 15.0 % and after 28 days it was 100%). The control fruits had the highest rate of disease development and flesh rot in accordance with having the highest browning index during storage period (Apai, 2009). Apai (2010) demonstrated that, there was little or no disease development during the first 5 days of storage, but after that disease incidence increased as storage time went on. Fruit decay in longan fruit manifests itself through wilting and freshness reduction, and then results in browning on the pericarp (Shodchit *et al*., 2008). For this study, it can be seen from **Table 4.5** that the fruits soaked in 5 or 7.5% SMB for 10 minutes showed no fruit decay by day 21, and had the lowest fruit decay (3.7%) by day 28 in storage, which was significantly different to the other treatments and the control ($P \leq 0.05$). These results demonstrate that a high concentration of SMB in combination with the dipping times used, significantly prevents fruit decay in 'Long' longan fruit during storage period. Our results are significantly different to the results of Nguyen *et al*. (2001), who found that the rate of fruit decay for 'Long' longan fruit is about 10% after 20 days in storage at 10ºC. Tongdee (2001) found that Longan fruit deteriorate rapidly after being harvested, mainly on account of the rotting caused by saprophytic fungal growth on the fruit surface and due to dehydration of the rind. The most important microorganisms in this process are *Botryodiplodia* sp. and the yeast *Saccharomyces* sp. Sodium metabisulfite controls saprophytic surface fungi and also inhibits and controls the development of microorganisms (Tongdee, 1993). Sulphur dioxide also has fungistatic properties (Coates and Johnson, 1993).

Table 4.5 The percentage of fruit decay in bunches of fruit during storage period.

Treatment	Days of storage at 5ºC[1]			
	7	14	21	28
T_0	0.0 ± 0.0	11.0 ± 0.4a	15.0 ± 0.1a	100 ± 0.0a
T_1	0.0 ± 0.0	0.0 ± 0.0b	5.3 ± 0.2c	94.7 ± 0.3b
T_2	0.0 ± 0.0	0.0 ± 0.0b	9.6 ± 0.2b	81.9 ± 0.3c
T_3	0.0 ± 0.0	0.0 ± 0.0b	3.8 ± 0.1d	5.5 ± 0.1e
T_4	0.0 ± 0.0	0.0 ± 0.0b	0.0 ± 0.0f	3.7 ± 0.0f
T_5	0.0 ± 0.0	0.0 ± 0.0b	1.8 ± 0.0e	9.3 ± 0.2d
T_6	0.0 ± 0.0	0.0 ± 0.0b	0.0 ± 0.0f	3.7 ± 0.0f

[1]Means within a column with the same letter are not significantly different at 95% (P≤0.05) level by least significant difference comparison. Data are mean value ± SE.

4.3.7. The percentage of fruit drop from the bunches during storage period

The percentage of fruit drop was calculated and the results are shown in **Table 4.6**. After 14 days in storage, no fruit had fallen from the bunches, after which time the percentage of fruit drop tended to increase, ranging from 5.2 to 5.9% by day 21, and from 5.9 to 6.6 % by day 28. According to **Table 4.6**, after 21 days in storage, the percentage fruit drop in the T_1, T_4 treatments did not differ significantly from the control, and there was a slight difference in the percentage of fruit drop between the treated fruits and the control after 28 days in storage, but the difference was not significant ($P \leq 0.05$). These results demonstrate that using an anti-browning agent does not influence the percentage of fruit drop. Our results are consistent with the findings of Nguyen *et al*. (2001), who found that 'Long' longan fruit drop ranged from 4.9 to 5.7%, and that the percentage of fruit drop for treated fruits was not different to the control fruits used after

20 days in storage. Shodchit *et al*. (2008) reported that those longan fruits cv. Daw that had fallen and which were treated with various concentrations of N-acetyl -L-cysteine, 4-hexylresorcinol solutions, were not different from the control when stored for 6 days at 15 ±2ºC.

Table 4.6 The percentage of fruit drop from the bunches during storage period.

Treatment	Days of storage at 5ºC[1]			
	7	14	21	28
T_0	0.0 ± 0.0	0.0 ± 0.0	5.8 ± 0.0b	6.5 ± 0.0ab
T_1	0.0 ± 0.0	0.0 ± 0.0	5.7 ± 0.0b	6.4 ± 0.0b
T_2	0.0 ± 0.0	0.0 ± 0.0	5.9 ± 0.0a	6.6 ± 0.1a
T_3	0.0 ± 0.0	0.0 ± 0.0	5.9 ± 0.1a	6.1 ± 0.0cd
T_4	0.0 ± 0.0	0.0 ± 0.0	5.7 ± 0.0b	6.2 ± 0.1c
T_5	0.0 ± 0.0	0.0 ± 0.0	5.5 ± 0.1c	6.2 ± 0.1c
T_6	0.0 ± 0.0	0.0 ± 0.0	5.2 ± 0.1d	5.9 ± 0.1d

[1]Means within a column with the same letter are not significantly different at 95% ($P \leq 0.05$) level by least significant difference comparison. Data are mean value ± SE.

4.3.8. Storage life of bunches of fruit

Fruits under the T_0–T_2 treatments were not acceptable for sales and marketing purposes by day 7 in storage, and the T_3-T_5 treatments were not acceptable by day 21 in storage. The T_6 treatment showed the longest storage life at 21 days (**Table 4.7**).

Table 4.7 The storage life of bunches of longan fruit at 5ºC.

Treatment	Storage life (days)	Cause of limitation in storage life
T_0	Less than 7	BI above 2.0, flavor score above 1.5, fruit decay

Treatment	Storage life (days)	Cause of limitation in storage life
		was 11.0%
T_1	Less than 7	BI above 2.0
T_2	Less than 7	BI above 2.0, flavor score above 1.5
T_3	14	BI above 2.0, odor and flavor score above 1.5
T_4	14	BI above 2.0
T_5	14	BI above 2.0
T_6	21	BI above 2.0

BI: Browning index

4.4. Conclusion

Soaking bunches of 'Long' longan fruit in 7.5% sodium metabisulfite solution for 10 minutes and storing them at 5ºC maintained the highest L*, b* values and the lowest PPO activity, and the fruit showed no severe pericarp browning during the first 21 days in storage, when compared to the bunches of fruit given other treatments and to the control. In addition, there was no fruit decay displayed and the rate of fruit drop was only 5.2%, and the flesh color was acceptable. The quality of the flesh, expressed as the total soluble solids content was no different to fresh longan. Moreover, the sensory quality of the fruit in terms of odor and flavor stayed normal during the first 21 days in storage.

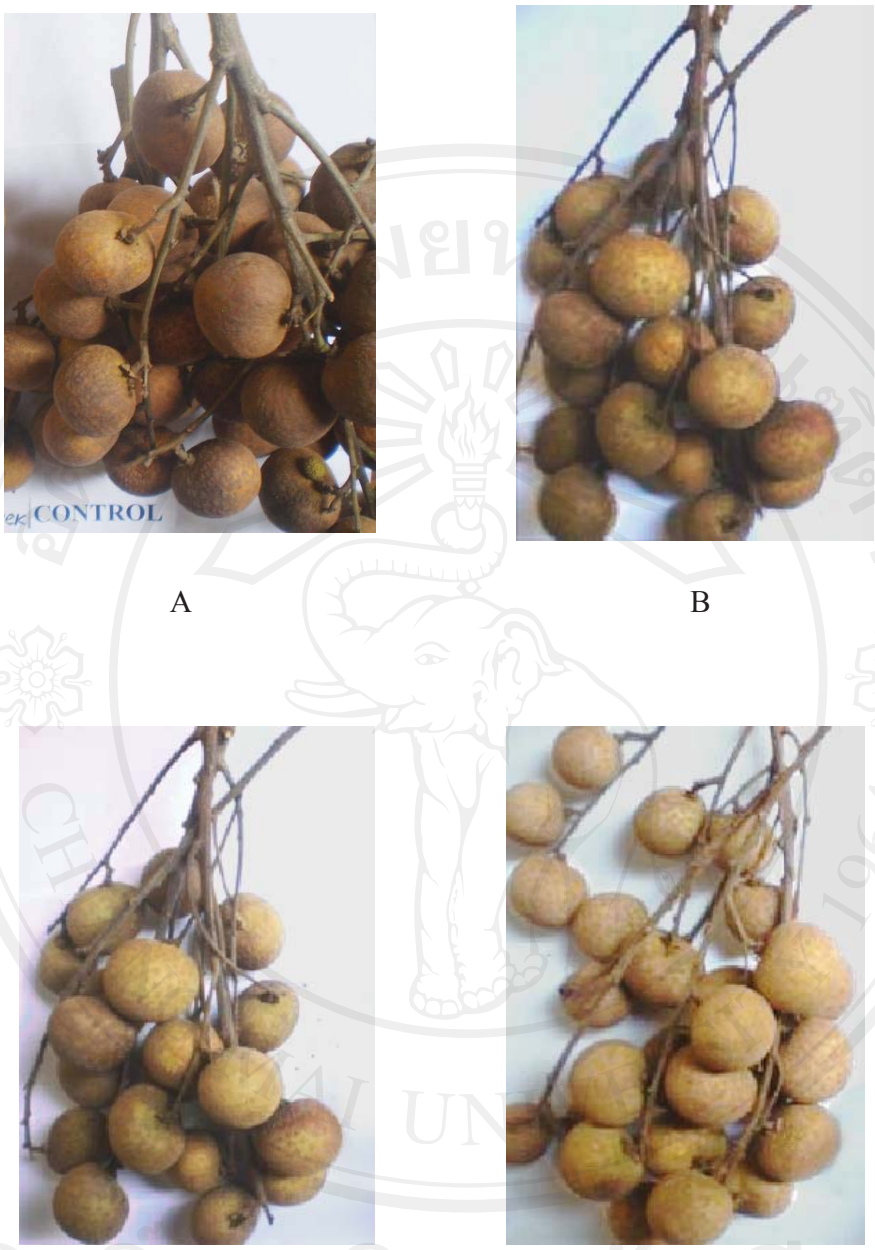

Figure 4.6 The storage life of bunches of longan fruits during storage period at 5ºC.

A: Control fruit by day 7 in storage

B: 2.5% SMB for 5 minutes by day 7 in storage

C: 2.5% SMB for 10 minutes by day 7 in storage

D: 5% SMB for 5 minutes by day 14 in storage

E

F

G

Figure 4.6 The storage life of bunches of longan fruits during storage period at 5ºC **(**Continued).

E: 5% SMB for 10 minutes by day 14 in storage

F: 7.5% SMB for 5 minutes by day 14 in storage

G: 7.5% SMB for 10 minutes by day 21 in storage