CHAPTER 4
RESULTS

4.1 Effects of commercial coatings, polyethylene microemulsion and chitosan on the physico-chemical and physiological characters of tangerine fruit

4.1.1 Effects of commercial coatings, polyethylene microemulsion and chitosan on the physico-chemical and physiological characters of tangerine fruit during storage at room temperature

The study of changes in physical, chemical and physiological properties of tangerine fruit cv. 'Sai Nam Phueng' coated with 9 commercial coatings, prepared PE microemulsion, two concentrations of chitosan solutions (1.5% and 2.0%) during storage at room temperature (23±2°C) and 56±5% relative humidity for 7 days.

4.1.1.1 Weight loss

The results in Table 4.1 showed that there was significant effect of coating treatments on percent weight loss of tangerine fruit during storage. Tangerine fruit coated with Fomesa, Sealkote, Wax (unknown), Citrashine, Supershine-C, PE microemulsion, Zivdar, Citrosol AK, Rosy Plus, Perfect Shine, 2.0% chitosan and 1.5% chitosan had lower weight loss than non-coated fruit. Fruit coated with Fomesa had the lowest weight loss (2.91±0.50%). In addition, fruit coated with 2.0% or 1.5% chitosan can reduced weight loss better than non-coated control fruit, but higher loss of weight than fruit coated with commercial coatings and PE microemulsion. The loss of weight significantly increased throughout the storage period (Figure 4.1).

4.1.1.2 Gloss

Reflectance measurements of tangerine fruit shine were made in gloss units with the micro-TRI-gloss reflectance meter (BYK Gardner Inc., Silver Spring, MD) on day 1. The results shows that maximum mean of gloss unit was observed in fruit coated with Perfect Shine coating (4.53±0.45 unit), followed by Citrashine (4.28±0.45

unit) and PE microemulsion (4.22±0.59 unit) than those of fruit coated with Sealkote, Citrosol AK, Rosy Plus, Zivdar, Supershine-C, 2.0% chitosan, Wax (unknown), 1.5% chitosan, Fomesa and non-coated control fruit. The control fruit had the lowest gloss (2.70±0.39 unit). By observation with the naked eye, the gloss of all coatings decreased during storage but remained higher than the uncoated fruit (Table 4.1).

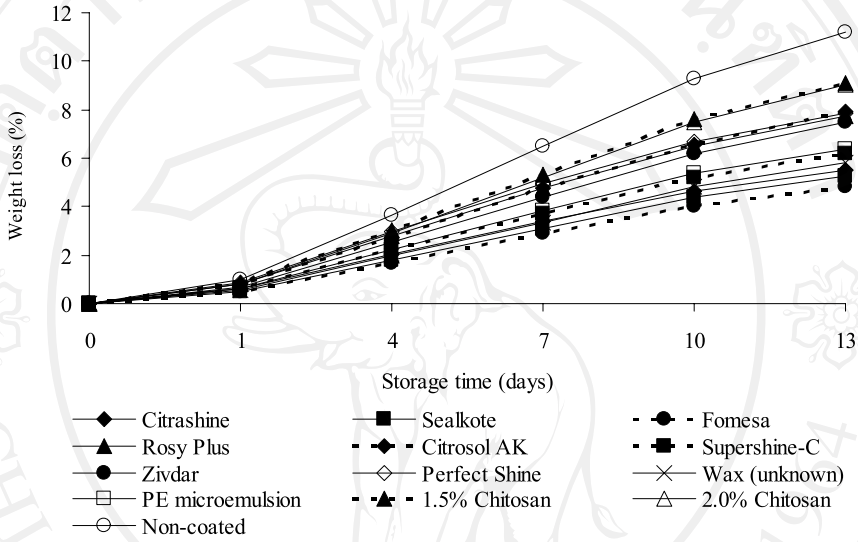

Figure 4.1 Effects of coating materials on the weight loss of tangerine fruit stored at room temperature (23±3°C) and 56±5% relative humidity for 13 days

4.1.1.3 Internal gases

4.1.1.3.1 Internal O_2

The lowest internal O_2 concentrations were found in fruit coated with Citrosol AK (1.51±0.31%), followed by fruit coated with Fomesa (1.63±0.29%), Rosy Plus (2.14±1.32%), Supershine-C (2.16±0.62%), Citrashine (2.18±1.29%), Wax (unknown) (2.44±1.72%), Sealkote (2.91±0.91%), 2.0% chitosan (2.96±1.14%), Perfect Shine (3.04±1.18%) and PE microemulsion (3.42±0.76%), respectively. The highest O_2 concentration was in control fruit (17.67±0.63%). Zivdar-coated fruit had lower O_2 concentration than control fruit. The amount of O_2 concentrations in the coated fruit decreased significantly on the first day of storage. While, internal O_2 concentration of control fruit remained constant throughout the storage period (Table 4.1 and Figure 4.2).

Table 4.1 Weight loss, gloss, internal O_2 and internal CO_2 of tangerine fruit cv. 'Sai Nam Phueng' coated with coating materials during storage at room temperature (23±3°C) and 56±5% relative humidity for 7 days

Treatments	Weight loss (%)	Gloss (units)	Internal O_2 (%)	Internal CO_2 (%)
Citrashine	3.41±0.35^{ef}	4.28±0.45^{ab}	2.18±1.29^{cde}	12.13±2.35^{bc}
Sealkote	3.11±0.20^{ef}	3.98±0.57^{bcd}	2.91±0.91^{cde}	6.22±1.71^{e}
Fomesa	2.91±0.50^{f}	3.26±0.50^{g}	1.63±0.29^{de}	14.23±4.48^{ab}
Rosy Plus	4.76±0.82^{bc}	3.70±0.48^{def}	2.14±1.32^{cde}	12.21±3.00^{bc}
Citrosol AK	4.75±0.59^{bc}	3.85±0.56^{cde}	1.51±0.31^{e}	18.17±7.78^{a}
Supershine-C	3.73±0.21^{de}	3.64±0.44^{defg}	2.16±0.62^{cde}	10.63±2.67^{bcde}
Zivdar	4.41±0.54^{cd}	3.66±0.40^{def}	8.26±1.67^{b}	7.36±0.63^{de}
Perfect Shine	4.92±0.33^{bc}	4.53±0.45^{a}	3.04±1.18^{cd}	6.34±1.63^{e}
Wax (unknown)	3.37±0.37^{ef}	3.51±0.32^{efg}	2.44±1.72^{cde}	11.32±3.49^{bcd}
PE microemulsion	3.84±0.25^{de}	4.22±0.59^{abc}	3.42±0.76^{c}	7.10±0.61^{de}
1.5% chitosan	5.31±0.74^{b}	3.41±0.23^{fg}	5.72±1.36^{b}	11.14±3.53^{bcd}
2.0% chitosan	5.20±0.83^{b}	3.52±0.26^{efg}	2.96±1.14^{cde}	13.46±1.93^{abc}
non-coated	6.47±0.57^{a}	2.70±0.39^{h}	17.67±0.63^{a}	2.91±0.60^{f}
$LSD_{0.05}$	0.77	0.40	1.52	4.77
C.V. (%)	12.28	12.05	26.44	31.28

Means followed by different superscript letters within a column are significantly different (P≤0.05)

4.1.1.3.2 Internal CO_2

Internal CO_2 concentration was the highest in tangerine fruit coated with Citrosol AK (18.17±7.78%), followed by Fomesa (14.23±4.48%), 2.0% chitosan (13.46±1.93%), Rosy Plus (12.21±3.00%), Citrashine (12.13±2.35%), Wax (unknown) (11.32±3.49%), 1.5% chitosan (11.14±3.53%) and Supershine-C (10.63±2.67%) coatings, which higher than CO_2 concentration of fruit coated with Zivdar , PE microemulsion, Perfect Shine and Sealkote. While, non-coated control fruit had the lowest internal CO_2 concentration (2.91±0.60%). Moreover, the internal CO_2 concentration in tangerine fruit had an increasing trend during storage. However, internal CO_2 concentration was lower in non-coated fruit as compared to coated fruit (Table 4.1 and Figure 4.2).

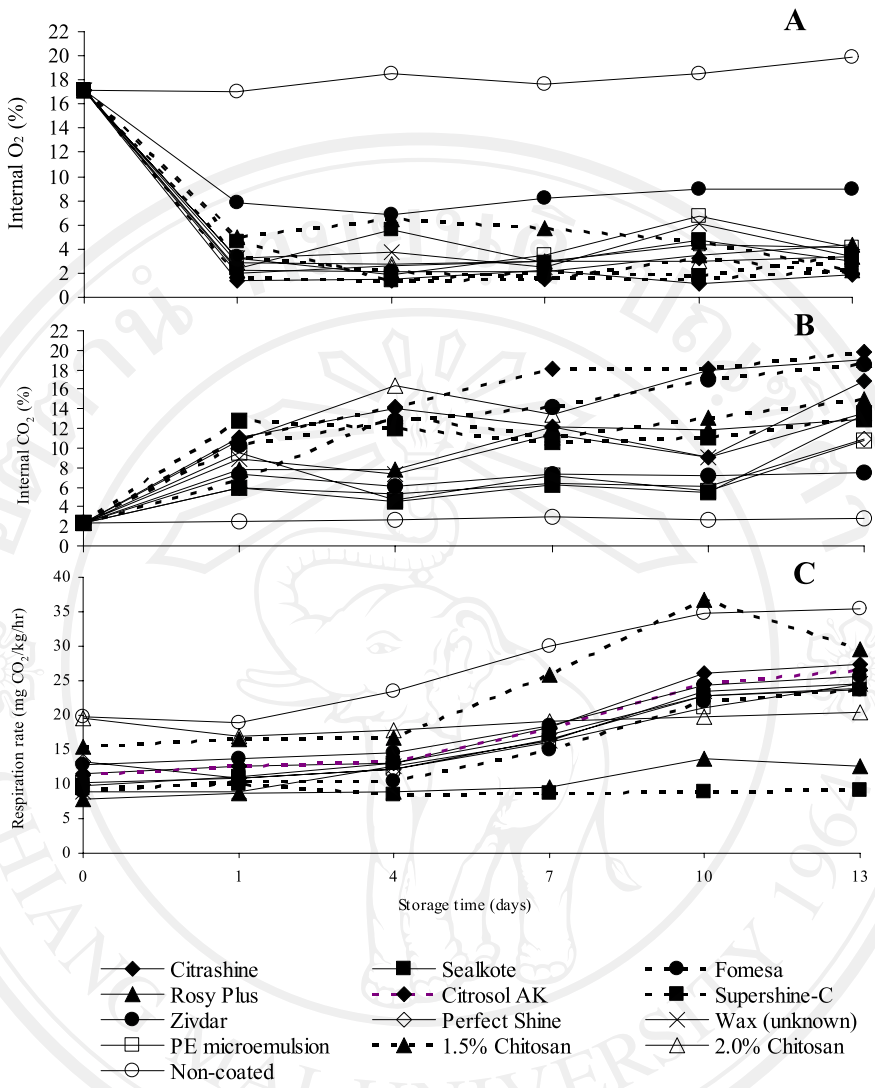

Figure 4.2 Effects of coating materials on the (A) internal O_2 concentration, (B) internal CO_2 concentration and (C) respiration rate of tangerine fruit stored at room temperature (23±3°C) and 56±5% relative humidity for 13 days

4.1.1.4 Respiration rate

Supershine-C-coated tangerine fruit exhibited significantly lower respiration rate (8.73±0.16 mg CO_2/kg/hr) as compared to the control and all other treatments, followed by Rosy Plus coated-fruit (9.56±0.47 mg CO_2/kg/hr). The fruit coated with Fomesa, PE microemulsion, Wax (unknown), Perfect Shine, Sealkote, Citrosol AK, Citrashine, Zivdar and 2.0% chitosan did not show any significant difference in the respiration rate. However, the respiration rate of tangerine fruit coated with these

coatings materials were lower than fruit coated with 1.5% chitosan and non-coated control fruit. In addition, the results indicated that non-coated fruit had the highest respiration rate throughout the storage period (Table 4.2 and Figure 4.2).

4.1.1.5 Ethanol content in juice

The ethanol content in juice of 'Sai Nam Phueng' tangerines was shown in Table 4.2. Ethanol, in various amounts, accumulated in all coated fruit. However, in control fruit, it accumulated lower than coated fruit about 2 to 5 times. Fruit coated with Zivdar (655.69±66.79 mg/l) and Perfect Shine (515.23±29.53 mg/l) contained the lowest quantity of ethanol after storage for 7 days. The highest amount of ethanol was found in Citrosol AK-, Fomesa- and Supershine-C-coated fruit (Table 4.2 and Figure 4.3).

Table 4.2 Respiration rate, ethanol content in juice and alcohol dehydrogenase activity of tangerine fruit cv. 'Sai Nam Phueng' coated with coating materials during storage at room temperature (23±3°C) and 56±5% relative humidity for 7 days

Treatments	Respiration rate (mg CO_2/kg/hr)	Ethanol content (mg/l)	Alcohol dehydrogenase activity (units/min/mg protein)
Citrashine	18.34±0.34^{c}	818.56±21.52^{c}	2.19±0.77^{cd}
Sealkote	17.09±0.17^{cd}	886.16±78.76^{c}	2.41±1.30^{cd}
Fomesa	15.05±2.44^{d}	1620.16±14.53^{a}	4.37±2.99^{cd}
Rosy Plus	9.56±0.47^{e}	709.58±14.53^{cd}	5.19±2.46^{cd}
Citrosol AK	18.13±0.18^{c}	1655.28±13.39^{a}	1.26±0.09^{d}
Supershine-C	8.73±0.16^{f}	1580.20±13.39^{a}	1.56±0.54^{d}
Zivdar	18.52±0.60^{c}	655.69±66.79^{d}	19.81±12.89^{b}
Perfect Shine	16.50±0.26^{cd}	515.23±29.53^{d}	8.99±7.87^{bcd}
Wax (unknown)	16.30±0.29^{cd}	1142.47±40.57^{b}	13.17±5.91^{bc}
PE microemulsion	16.16±0.18^{cd}	732.58±31.32^{c}	2.39±0.39^{cd}
1.5% chitosan	25.93±6.80^{b}	753.17±33.80^{c}	35.08±13.82^{a}
2.0% chitosan	19.11±0.94^{c}	1213.31±18.44^{b}	35.48±5.21^{a}
non-coated	29.98±0.70^{a}	294.80±61.25^{e}	3.42±2.03^{cd}
$LSD_{0.05}$	2.92	195.98	11.02
C.V. (%)	12.36	2.91	63.02

Means followed by different superscript letters within a column are significantly different (P≤0.05)

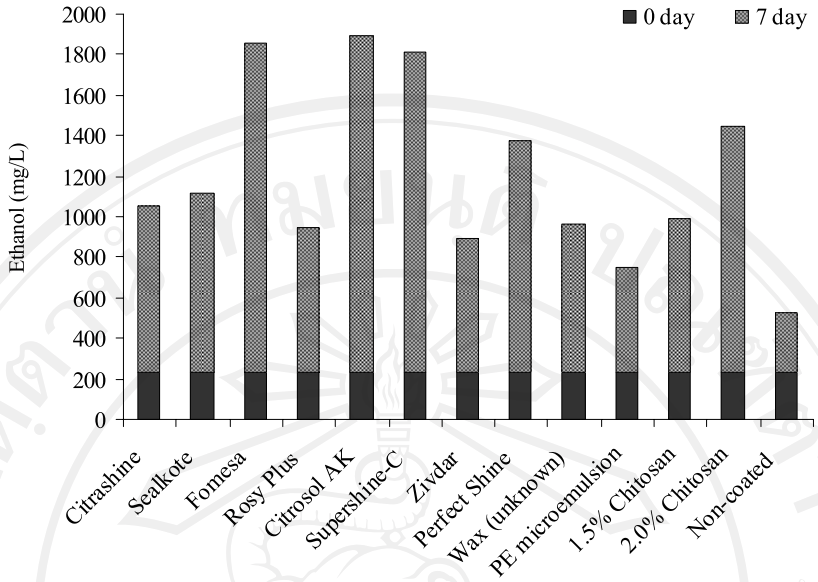

Figure 4.3 Effects of coating materials on the ethanol content in juice of tangerine fruit stored at room temperature (23±3°C) and 56±5% relative humidity for 7 days

4.1.1.6 Alcohol dehydrogenase activity (ADH activity)

The activities of alcohol dehydrogenase were highest in tangerine fruit coated with 1.5 and 2.0% chitosan (35.08±13.82 and 35.48±5.21 units/min/mg protein, respectively) compared to other treatments, followed by tangerine fruit coated with Zivdar (19.81±12.89 units/min/mg protein), Wax (unknown) (13.17±5.91 units/min/mg protein) and Perfect Shine (8.99±7.87 units/min/mg protein). There was no difference in activity of alcohol dehydrogenase among tangerine fruit coated with Rosy Plus, Fomesa, Sealkote, PE microemulsion, Citrashine, Supershine-C, Citrosol AK and non-coated fruit. Maximum alcohol dehydrogenase activity in all treatments occurred on day 4 of storage, except fruit coated with 1.5 and 2.0% chitosan that had the highest activity of enzyme on day 7 of storage. However, the activities of alcohol dehydrogenase in non-coated fruit slightly change during storage for 13 days (Table 4.2 and Figure 4.4).

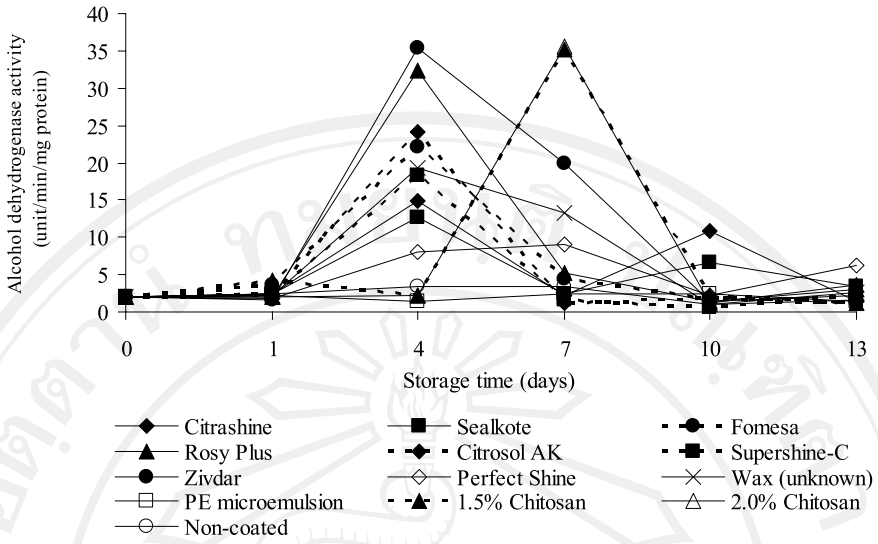

Figure 4.4 Effects of coating materials on the alcohol dehydrogenase activity of tangerine fruit stored at room temperature (23±3°C) and 56±5% relative humidity for 13 days

4.1.1.7 Assessment of flavor and visual appearance

4.1.1.7.1 Flavor

It is obvious from Table 4.3 that there was statistically significant effect of coating treatments on flavor score except fruit coated with Sealkote, Fomesa, Zivdar and non-coated fruit after 7 days of storage. The maximum flavor score (~3.88) of coated tangerine fruit was observed as compared to fruit coated with Rosy Plus (3.13±0.64), PE microemulsion (3.00±0.93), Wax (unknown) (2.25±0.71) and Supershine-C (1.63±0.74) which had minimum flavor. Coated fruit with Supershine-C had the lowest flavor score (1.63±0.74), indicated that had the most abnormal smell and taste. Figure 4.5 shows that the flavor score was decreased during 13 days of storage at ambient temperature. The flavor score rapidly decreased in fruit coated with Supershine-C, Wax (unknown), Citrosol AK, and Fomesa, while, gradually decreased in fruit coated with PE microemulsion, Perfect Shine, Rosy Plus, Citrashine, 1.5% chitosan, Sealkote, 2.0% chitosan and Zivdar. The retention of flavor score was higher in non-coated control fruit.

4.1.1.7.2 Visual appearance

Coating treatments effectively retarded wilting of tangerine fruit during storage. All nine commercial coatings, PE microemulsion and 2.0% chitosan significantly higher visual appearance score when compared with non-coated tangerine fruit. Tangerine fruit coated with Citrashine had the highest visual appearance score (4.88±0.35), followed by fruit coated with Sealkote, Fomesa, Citrosol AK, Perfect Shine, Rosy Plus, Wax (unknown) and PE microemulsion, which higher than visual appearance score of fruit coated with Supershine-C and Zivdar. However, chitosan coatings did not delay wilting of tangerine fruit after the 7^{th} day of storage as indicated by rapidly decreased in visual appearance score. While, non-coated control had the lowest visual appearance score during storage for 13 days. It also found that tangerine fruit coated with coating materials were significantly glossier and more attractive than the control fruit (Table 4.3 and Figure 4.5 and 4.6).

4.1.1.8 Peel color

4.1.1.8.1 L*

The L* value of tangerine fruit on day 7 of storage were shown in Table 4.3. Color measurement of initial quality of tangerine fruit indicated that non-coated fruit was brighter (higher L* value) than coated fruit (Table 4.3 and Figure 4.7).

4.1.1.8.2 chroma

Non-coated tangerine fruit showed a significantly higher chroma than coated fruit. Chroma of tangerine fruit coated with commercial coatings, PE microemulsion and chitosan solutions remained almost constant during storage in comparison to control fruit. Chroma of non-coated fruit gradually increased after 4 days of storage (Table 4.3 and Figure 4.7).

4.1.1.8.3 hue angle

Hue angle of skin color was higher in tangerine fruit coated with Fomesa (110.20±1.77°), followed by fruit coated with Supershine-C (107.33±2.50°), 2.0% chitosan (106.78±3.53°), Rosy Plus (106.00±1.97°) and Citrosol AK (105.63±2.67°). The hue angle of fruit coated with Fomesa greater than fruit coated with 1.5% chitosan, Citrashine, Zivdar, PE microemulsion, Perfect Shine, Sealkote and Wax

(unknown). Hue angle of non-coated tangerine fruit (96.10±6.35°) were significantly lower than other treatments. Moreover, hue angle of non-coated tangerine fruit slightly decreased during storage (Table 4.3 and Figure 4.7).

Table 4.3 Flavor score, visual appearance score and peel color of tangerine fruit cv. 'Sai Nam Phueng' coated with coating materials during storage at room temperature (23±3°C) and 56±5% relative humidity for 7 days

Treatments	Flavor (score)	Visual appearance (score)	Peel color		
			L*	chroma	hue angle
Citrashine	3.38±0.92^{abc}	4.88±0.35^{a}	55.30±3.46^{def}	43.40±5.15^{cdef}	104.25±4.65^{bcd}
Sealkote	3.88±0.35^{a}	4.75±0.71^{ab}	59.16±1.27^{bc}	48.96±2.27^{bc}	101.33±3.46^{cde}
Fomesa	3.88±0.74^{a}	4.63±0.52^{abc}	55.54±2.23^{def}	41.73±2.32^{def}	110.20±1.77^{a}
Rosy Plus	3.13±0.64^{bc}	4.38±0.74^{abcd}	54.24±1.85^{ef}	41.29±2.23^{ef}	106.00±1.97^{abcd}
Citrosol AK	3.63±0.74^{ab}	4.63±0.52^{abc}	56.41±0.87^{bcdef}	45.85±2.33^{bcdef}	105.63±2.67^{abcd}
Supershine-C	1.63±0.74^{g}	4.00±0.76^{cd}	57.73±2.61^{bcde}	45.91±3.37^{bcde}	107.33±2.50^{ab}
Zivdar	3.88±0.35^{a}	4.00±0.53^{cd}	57.82±1.38^{bcd}	47.92±1.56^{bc}	103.88±5.22^{bcd}
Perfect Shine	3.50±0.53^{abc}	4.50±1.07^{abc}	55.83±3.38^{cdef}	45.32±4.95^{cdef}	101.50±2.42^{cde}
Wax (unknown)	2.25±0.71^{efg}	4.38±0.74^{abcd}	59.68±2.08^{b}	50.02±3.82^{b}	101.23±5.86^{de}
PE microemulsion	3.00±0.93^{bcd}	4.25±0.46^{abcd}	57.11±0.68^{bcdef}	47.11±1.60^{bcd}	103.35±2.56^{bcd}
1.5% chitosan	3.25±0.71^{abc}	3.75±0.46^{de}	54.13±2.11^{f}	40.20±3.30^{f}	104.43±2.63^{bcd}
2.0% chitosan	3.50±0.76^{abc}	4.13±0.64^{bcd}	56.65±2.43^{bcdef}	43.35±6.57^{cdef}	106.78±3.53^{abc}
non-coated	3.88±0.64^{a}	3.25±1.04^{e}	64.24±4.27^{a}	57.56±6.32^{a}	96.10±6.35^{e}
$LSD_{0.05}$	0.69	0.68	3.54	5.68	5.52
C.V. (%)	23.95	16.15	4.28	8.54	3.66

Means followed by different superscript letters within a column are significantly different (P≤0.05)

Evaluation of flavor by tasting, using a scale of 1 to 4 where 4 = excellent, 3 = slightly off-flavor, 2 = moderately off-flavor and 1 = extremely off-flavor. Fruit taste was rated "unacceptable" when the taste score was below three.

Evaluation of visual appearance (wilting and shriveling), using a scale of 1 to 5 where 5 = excellent, 4 = good, 3 = fair, 2 = poor and 1 = unusable. Fruit appearance was rated "unacceptable" when the score was below three.

4.1.1.9 Total soluble solids (TSS)

The results demonstrated that coated tangerine fruit with Rosy Plus, PE microemulsion, Zivdar, Citrashine, Wax (unknown), Fomesa, and Citrosol AK had higher total soluble solids contents, as compared to fruit coated with 1.5% chitosan, 2.0% chitosan, Supershine-C or non-coated control fruit. Non-coated fruit had minimum total soluble solids content after 7 days of storage at ambient temperature (Table 4.4 and Figure 4.8).

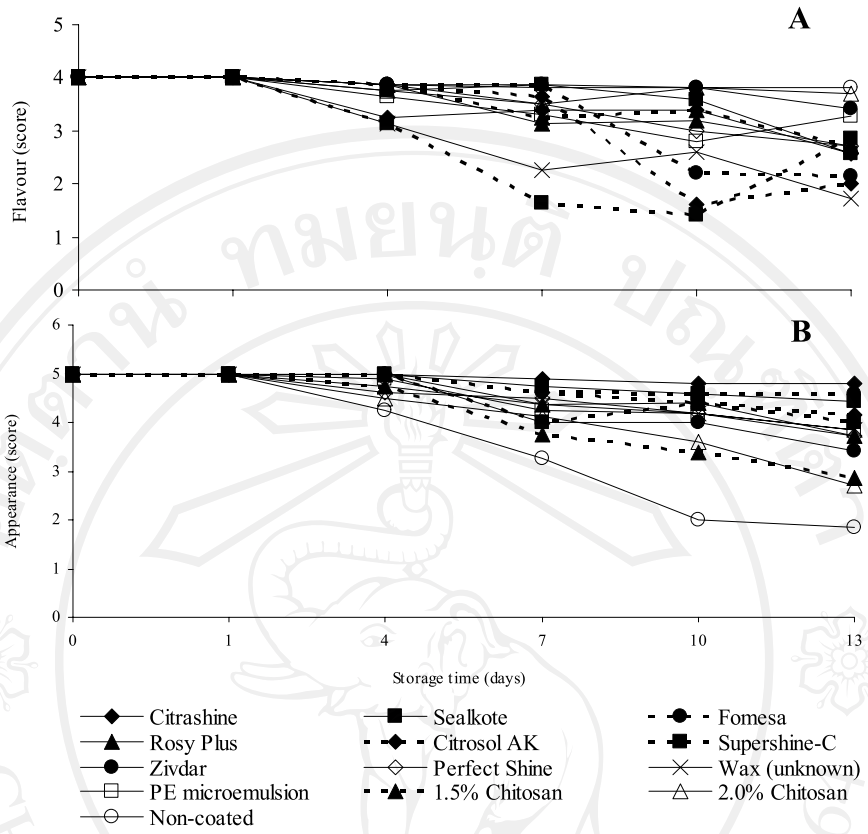

Figure 4.5 Effects of coating materials on the (A) flavor score and (B) visual appearance score of tangerine fruit stored at room temperature (23±3°C) and 56±5% relative humidity for 13 days

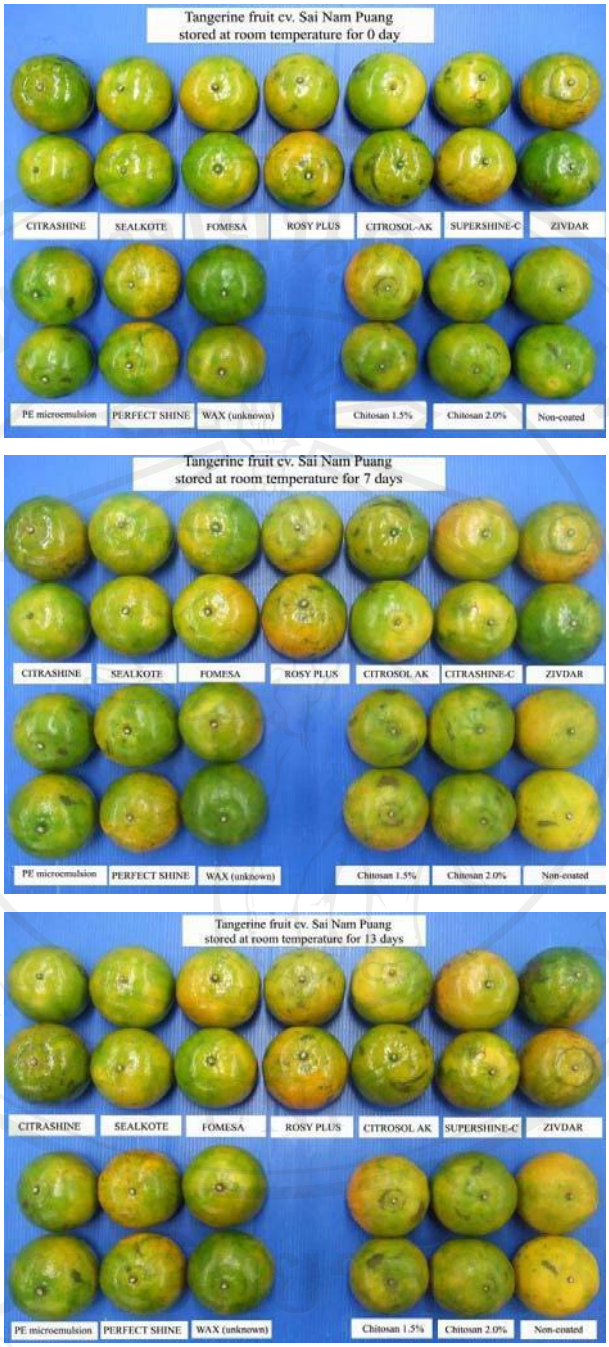

Figure 4.6 Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with coating materials during storage at room temperature (23±3°C) and 56±5% relative humidity for 0, 7 and 13 days

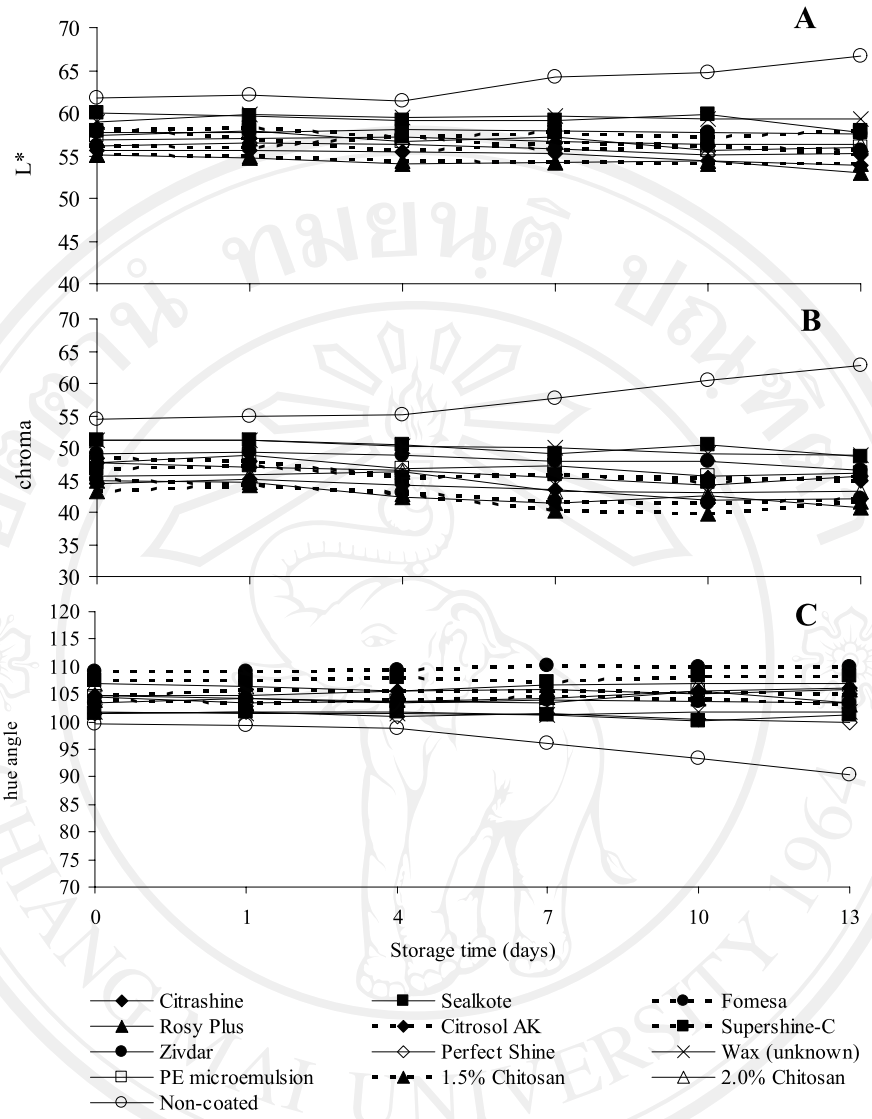

Figure 4.7 Effects of coating materials on the (A) L*, (B) chroma and (C) hue angle of tangerine fruit stored at room temperature (23±3°C) and 56±5% relative humidity for 13 days

4.1.1.10 Titratable acidity (TA)

Table 4.4 showed that tangerine fruit coated with Rosy Plus had the highest titratable acidity (0.71±0.07%), followed by fruit coated with Sealkote (0.59±0.09%) and Citrashine (0.59±0.04%). However, the titratable acidity of fruit coated with Rosy Plus was significant different from all other coated treatments and non-coated

fruit. It also found that titratable acidity of tangerine fruit in all treatments decreased during storage for 13 days at ambient temperature (Table 4.4 and Figure 4.8).

4.1.1.11 TSS/TA ratio

The TSS/TA ratio of tangerine fruit was highest in Zivdar-coated treatments (28.45±6.00) followed by Perfect Shine (24.94±1.70) and Citrosol AK (24.05±4.69). Rosy Plus-coated fruit had the lowest TSS/TA ratio (17.46 ± 2.79). The sugar-acid ratio was increased during storage at room temperature (Table 4.4 and Figure 4.8).

4.1.1.12 pH

After 7 days of storage, the results showed that tangerine coated with Zivdar had higher pH value than fruit coated with Sealkote, Rosy Plus and Citrashine. However, no significant differences were observed on the pH value of fruit coated with Zivdar, 1.5% chitosan, Wax (unknown), PE microemulsion, Citrosol AK, Perfect Shine, 2.0% chitosan, Supershine-C, Fomesa and non-coated control fruit (Table 4.4). Figure 4.9 shows that in general the pH value was slightly increased during 13 days of storage at ambient temperature.

4.1.1.13 Vitamin C

Vitamin C contents of both coated and non-coated samples were not significant difference. The vitamin C contents of tangerine in all treatments were quite variable during storage for 13 days (Table 4.4 and Figure 4.9).

Table 4.4 Total soluble solids (TSS), titratable acidity (TA), TSS/TA ratio, pH and vitamin C of tangerine fruit cv. 'Sai Nam Phueng' coated with coating materials during storage at room temperature (23±3°C) and 56±5% relative humidity for 7 days

Treatments	TSS (%)	TA (%)	TSS/TA ratio	pH	Vitamin C (mg/100 ml juice)
Citrashine	11.70±0.98^{ab}	0.59±0.04^{ab}	19.85±1.68^{bc}	3.23±0.19^{d}	21.02±1.91
Sealkote	11.13±0.45^{abc}	0.59±0.09^{ab}	19.13±3.13^{bc}	3.29±0.11^{bcd}	21.02±1.91
Fomesa	11.37±0.60^{ab}	0.53±0.06^{bc}	21.86±3.91^{bc}	3.36±0.02^{abcd}	21.66±1.10
Rosy Plus	12.27±0.76^{a}	0.71±0.07^{a}	17.46±2.79^{c}	3.25±0.18^{cd}	21.66±2.21
Citrosol AK	11.30±0.44^{ab}	0.48±0.10^{bc}	24.05±4.69^{ab}	3.45±0.17^{abc}	20.38±2.21
Supershine-C	10.80±1.21^{bc}	0.50±0.07^{bc}	21.89±3.53^{bc}	3.39±0.10^{abcd}	21.66±1.10
Zivdar	12.17±1.00^{a}	0.44±0.07^{c}	28.45±6.00^{a}	3.53±0.04^{a}	19.75±1.10
Perfect Shine	11.13±0.32^{abc}	0.45±0.04^{c}	24.94±1.70^{ab}	3.45±0.01^{abc}	20.38±1.10
Wax (unknown)	11.67±1.03^{ab}	0.55±0.17^{bc}	22.47±5.80^{abc}	3.48±0.15^{ab}	21.02±1.91
PE microemulsion	12.27±0.50^{a}	0.56±0.09^{bc}	22.32±4.35^{abc}	3.47±0.15^{ab}	21.02±1.91
1.5% chitosan	10.90±0.26^{bc}	0.49±0.04^{bc}	22.49±1.29^{abc}	3.49±0.12^{ab}	21.66±1.10
2.0% chitosan	10.83±0.68^{bc}	0.50±0.06^{bc}	21.90±4.27^{bc}	3.43±0.16^{abcd}	20.38±1.10
non-coated	9.90±0.70^{c}	0.48±0.06^{bc}	20.85±2.47^{bc}	3.49±0.08^{ab}	19.11±0.00
$LSD_{0.05}$	1.25	0.14	6.38	0.22	2.77
C.V. (%)	6.57	15.40	17.16	3.76	7.93

Means followed by different superscript letters within a column are significantly different (P≤0.05)

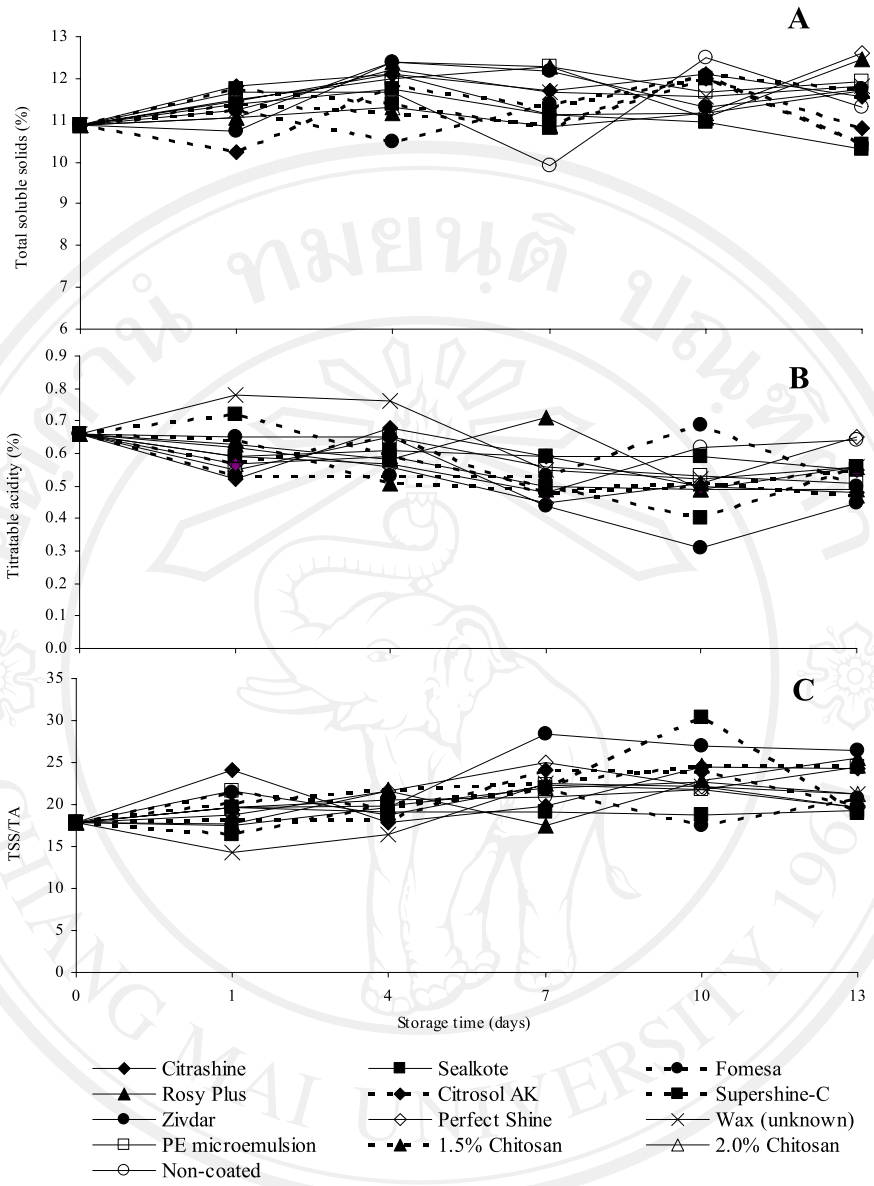

Figure 4.8 Effects of coating materials on the (A) total soluble solids, (B) titratable acidity and (C) TSS/TA ratio of tangerine fruit stored at room temperature (23±3°C) and 56±5% relative humidity for 13 days

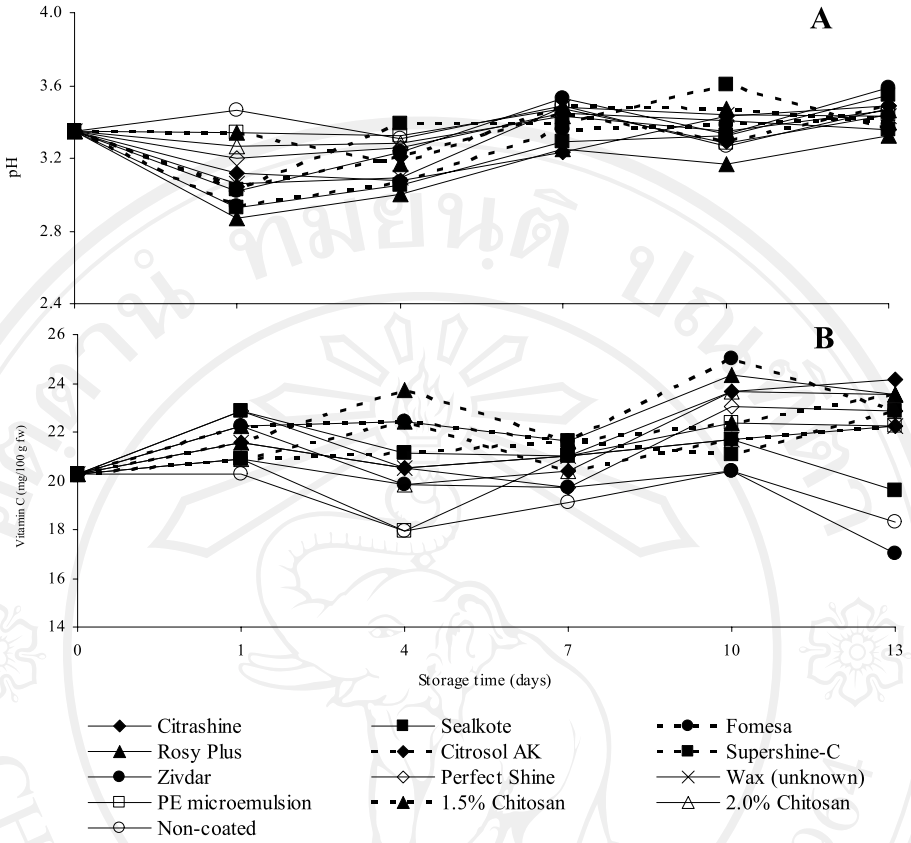

Figure 4.9 Effects of coating materials on the (A) pH and (B) vitamin C of tangerine fruit stored at room temperature (23±3°C) and 56±5% relative humidity for 13 days

4.1.2 Effect of storage temperatures and coating materials on the physico-chemical and physiological characters of tangerine fruit

The study on changes in physical, chemical and physiological properties of tangerine fruit cv. 'Sai Nam Phueng' coated with 5 commercial coatings, PE microemulsion and 2.0% chitosan solution during storage at 5, 10°C and room temperature for 10 days.

4.1.2.1 Weight loss

Low temperature storage at 5 and 10°C effectively delayed weight loss (2.41±1.09 and 2.30±0.71 %, respectively) of tangerine fruit compared to fruit held at room temperature (7.75±2.26 %). Weight loss from the fruit was increased at higher temperature, lower RH and longer duration of storage (Table 4.5 and Figure 4.10).

Results presented in Table 4.5 and Figure 4.10 for 'Sai Nam Phueng' tangerine, show that coated tangerine fruit with any materials have lower water losses than non-coated control. The minimum weight loss occurred in fruit coated with Citrashine (2.90±2.31%) and Sealkote (3.01±2.30%), followed by Zivdar and Rosy Plus as compared with non-coated fruit. It was found that as the storage time was prolonged, the weight loss percentage was also increased and the maximum weight loss was recorded at the end of storage.

4.1.2.2 Internal gases

4.1.2.2.1 Internal O_2

Internal O_2 concentrations (3.78±4.42%) had lower in tangerine fruit stored at room temperature than the ones stored at 5 and 10°C (10.54±5.13 and 8.90±5.41%, respectively). However, no significant differences in O_2 concentration were observed between 5 and 10°C after 10 days of storage (Table 4.5).

Table 4.5 and Figure 4.11 illustrated that internal O_2 concentration in tangerine fruit with seven coatings during storage. The lowest internal O_2 concentration was found in fruit coated with Citrashine (2.51±1.45%). The highest concentration was found in non-coated fruit (16.28±1.78%), followed by fruit coated with 2.0% chitosan, Rosy Plus, PE microemulsion and Zivdar. Moreover, the results

indicated that the amount of internal O_2 in all treatments tended to decrease continuously during storage (Table 4.5 and Figure 4.11).

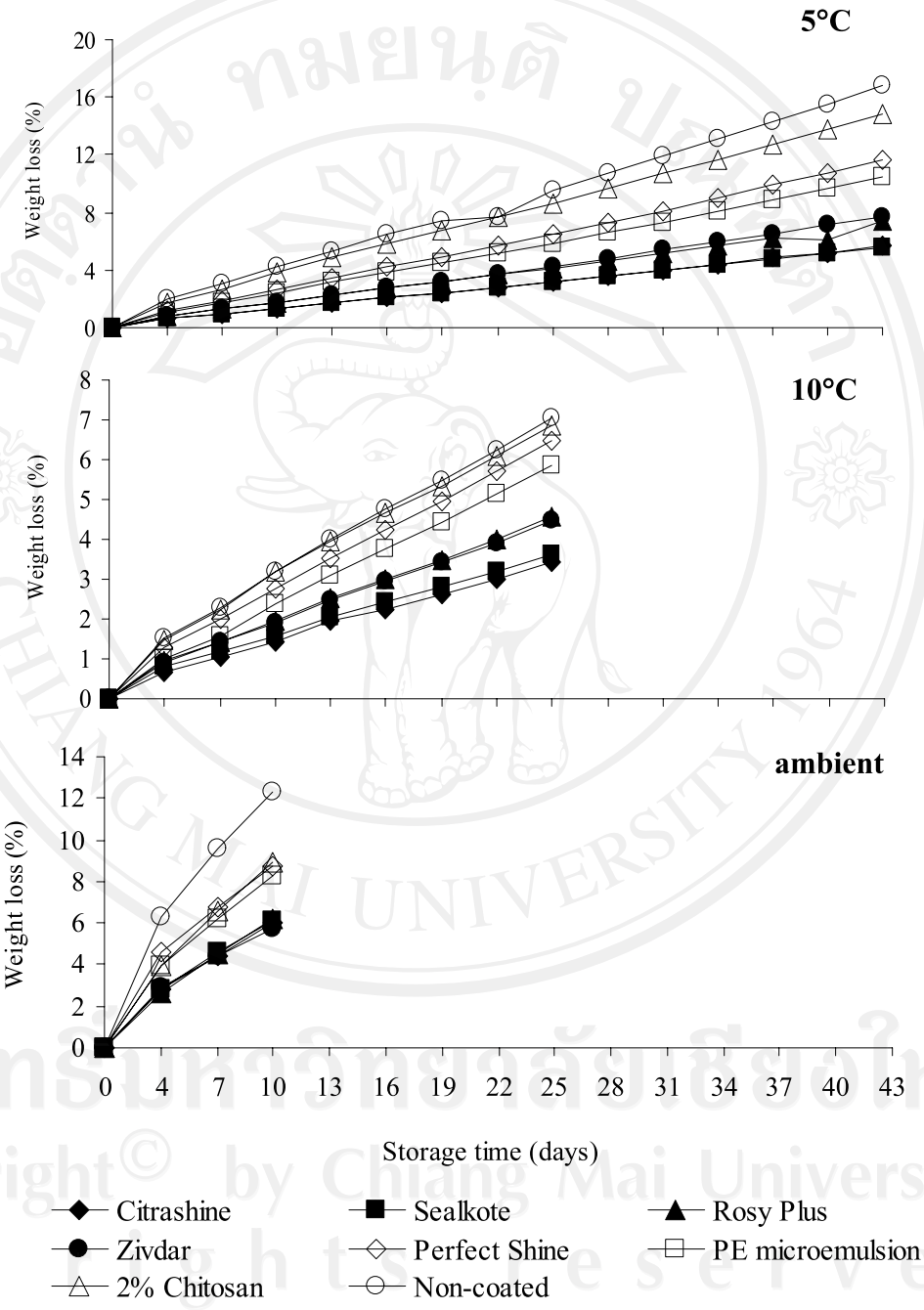

Figure 4.10 Effects of coating materials on the weight loss of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

Table 4.5 Weight loss, internal O_2, internal CO_2, ethanol content and alcohol dehydrogenase activity of tangerine fruit cv. 'Sai Nam Phueng' coated with coating materials during storage at 5, 10°C and room temperature for 10 days

Treatments	Weight loss (%)	Internal O_2 (%)	Internal CO_2 (%)	Ethanol content (mg/l)	Alcohol dehydrogenase activity (units/min/ mg protein)
Factor 1 : Storage temperature s					
5°C	2.41±1.09^{b}	10.54±5.13^{a}	4.60±1.20^{b}	433.57±122.82^{c}	64.28±46.79^{a}
10°C	2.30±0.71^{b}	8.90±5.41^{a}	5.98±2.15^{b}	666.44±318.03^{b}	21.30±25.39^{b}
Room temperature	7.75±2.26^{a}	3.78±4.42^{b}	14.95±10.12^{a}	1,396.68±470.06^{a}	6.51±2.55^{b}
Factor 2 : Coating materials					
Citrashine	2.90±2.31^{c}	2.51±1.45^{f}	16.45±3.47^{a}	1,093.02±541.79^{a}	46.99±34.05^{a}
Sealkote	3.01±2.30^{c}	4.87±3.50^{def}	8.43±4.86^{b}	1,024.21±395.66^{a}	28.68±20.49^{ab}
Rosy Plus	3.32±2.20^{bc}	8.71±6.81^{bcd}	9.21±9.60^{b}	1,063.97±718.34^{a}	26.14±23.37^{ab}
Zivdar	3.15±1.95^{bc}	7.47±4.92^{bcde}	7.55±2.73^{b}	888.19±434.47^{a}	39.66±16.12^{ab}
Perfect Shine	4.72±2.97^{abc}	4.20±2.04^{ef}	6.95±2.89^{b}	726.73±359.85^{ab}	47.05±13.18^{a}
PE microemulsion	4.33±2.90^{abc}	8.43±4.52^{bcd}	5.90±1.32^{bc}	686.37±419.23^{ab}	24.63±13.58^{b}
2.0% chitosan	5.29±2.74^{ab}	10.32±6.08^{b}	9.69±3.84^{b}	823.60±736.76^{ab}	27.96±17.06^{ab}
Non-coated	6.57±4.38^{a}	16.28±1.78^{a}	3.72±1.52^{c}	351.76±58.30^{b}	14.46±12.32^{b}
Factor 1	*	*	*	*	*
Factor 2	*	*	*	*	*
Factor 1×2	*	*	*	*	*

Means followed by different superscript letters within a column are significantly different (P≤0.05)

* = significant ns = non significant

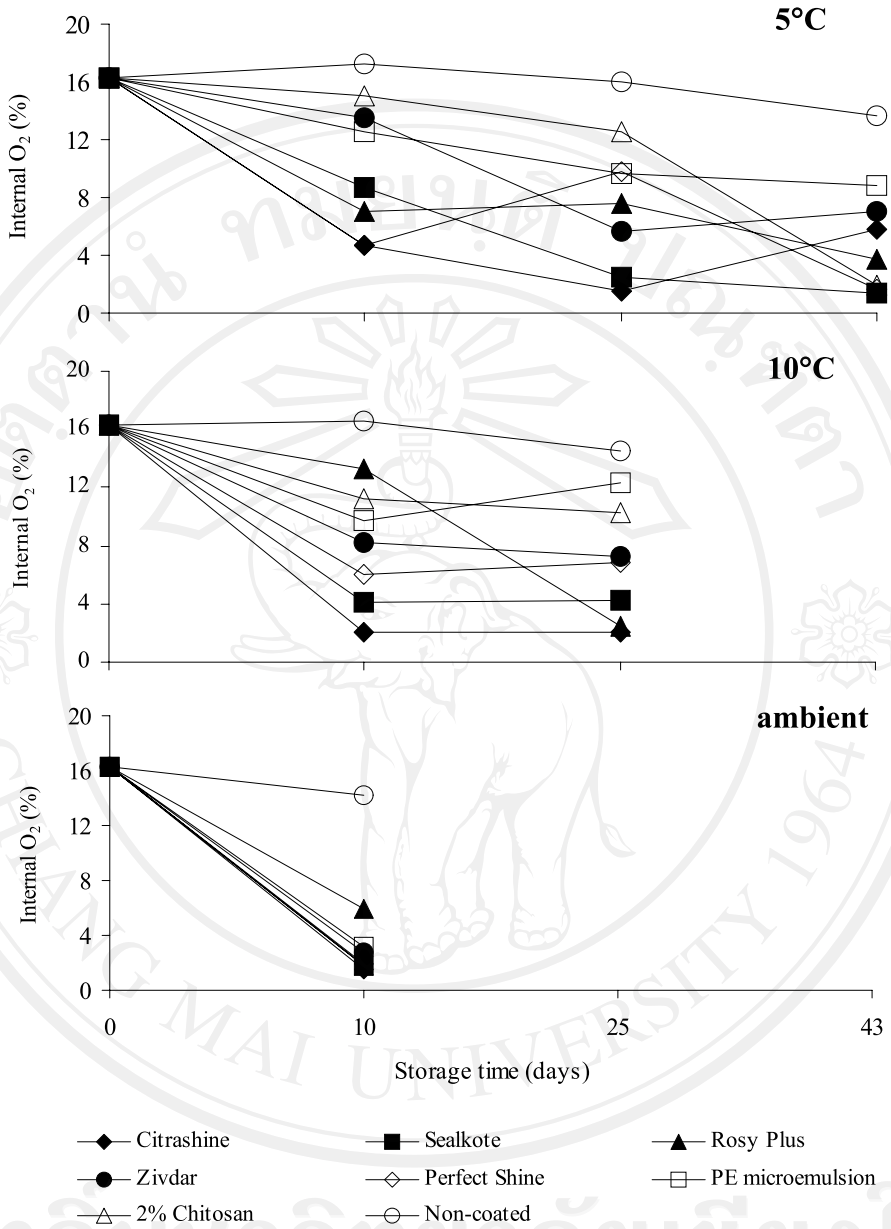

Figure 4.11 Effects of coating materials on the internal O_2 of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

4.1.2.2.2 Internal CO_2

After 10 days of storage, a significantly higher value of internal CO_2 was reached in tangerine fruit stored at room temperature (14.95±10.12%). Internal CO_2 concentrations of tangerine fruit did not show significant differences at 5 and 10°C (4.60±1.20 and 5.98±2.15%, respectively). The amount of internal CO_2 in all treatments continually increased (Figure 4.12). The tangerine fruit stored at room temperature had higher internal CO_2 than fruit stored at 5 and 10°C (Table 4.5).

Internal CO_2 concentration was highest in tangerines coated with Citrashine (16.45±3.47%), followed by 2.0% chitosan, Rosy Plus, Sealkote, Zivdar, Perfect Shine and PE microemulsion. Non-coated tangerine fruit had the lowest internal CO_2 (3.72±1.52%) (Table 4.5 and Figure 4.12).

4.1.2.3 Ethanol content in juice

Tangerine fruit stored at 5°C had the least amount of ethanol content in juice (433.57±122.82 mg/l), followed by fruit stored at 10°C (666.44±318.03 mg/l), while tangerine fruit stored at room temperature had the highest ethanol content (1,396.68±470.06 mg/l). Storage of tangerine fruit at room temperature resulted in the higher amount of ethanol content in juice than the fruit stored at 10 and 5°C for about 2 and 3 times, respectively. The storage period for 10 days indicated that fruit stored at low temperature had lower rate of increase in ethanol volume than fruit stored at room temperature (Table 4.5 and Figure 4.13).

Low concentrations of internal O_2 and/or high concentrations of internal CO_2 lead to partial anaerobiosis and thus to ethanol and acetaldehyde production. Table 4.5 and Figure 4.13 illustrated that the amount of ethanol found in juice of 'Sai Nam Phueng' tangerines coated with coating materials and non-coated control. Ethanol, in varying amounts, accumulated in all coated fruit, however, in control fruit it accumulated only after long storage periods. Fruit coated with PE microemulsion, Perfect Shine and 2.0% chitosan contained the lower quantity of ethanol content in juice, while in Citrashine, Rosy Plus, Sealkote and Zivdar-coated fruit, higher amounts of ethanol were found. Non-coated fruit had the lowest ethanol content in juice after storage for 10 days (Table 4.5 and Figure 4.13).

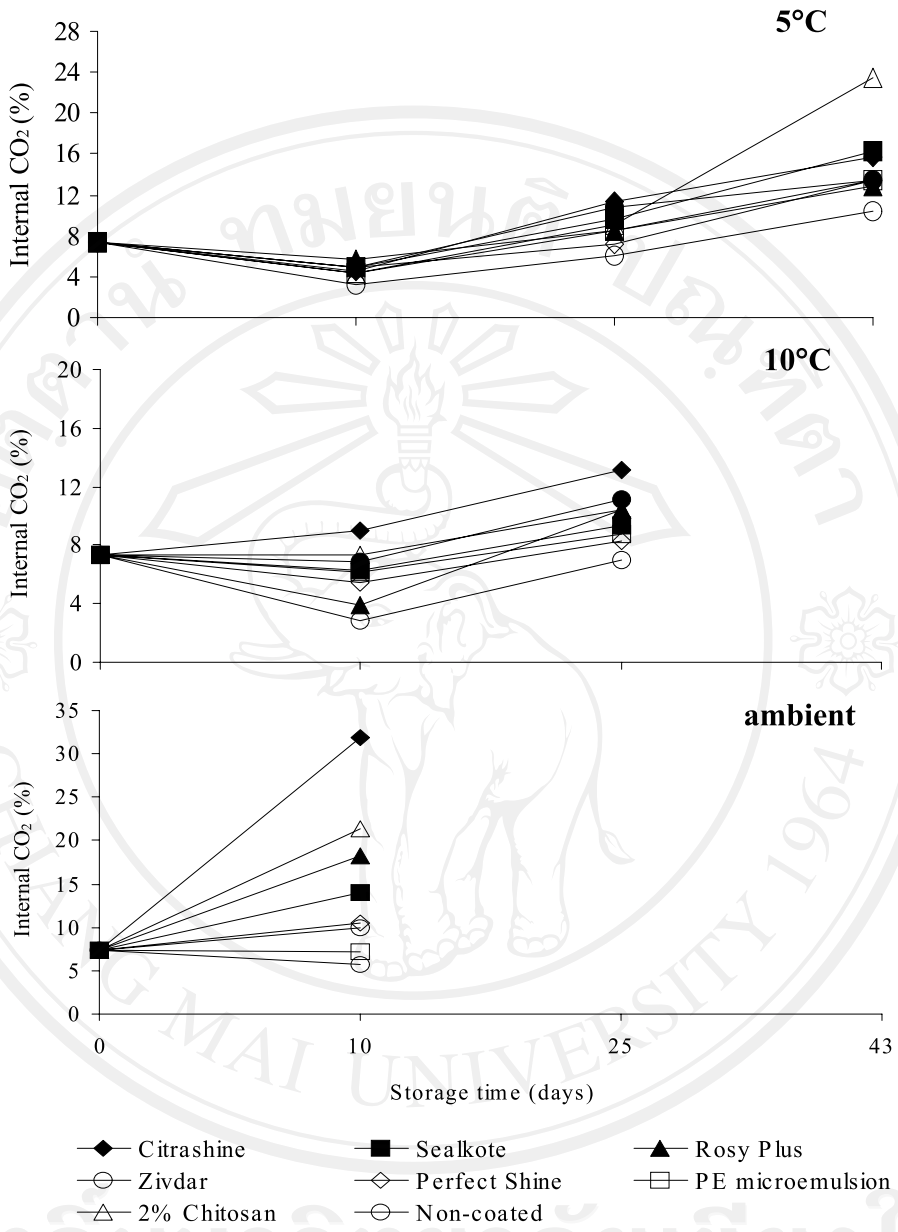

Figure 4.12 Effects of coating materials on the internal CO_2 of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

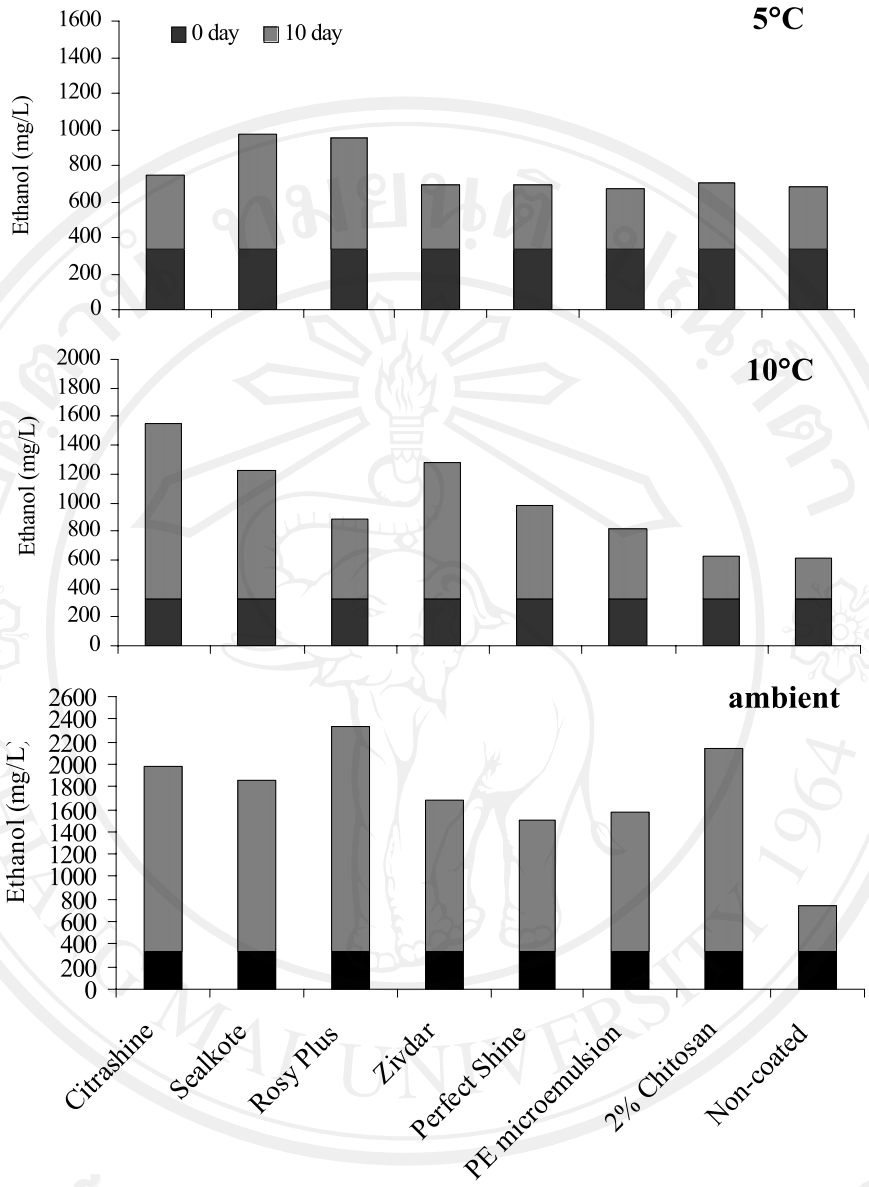

Figure 4.13 Effects of coating materials on the ethanol content in juice of tangerine fruit stored at 5, 10°C and room temperature for 10 days

4.1.2.4 Alcohol dehydrogenase activity (ADH activity)

After storage for 10 days, the results showed that storage temperatures had affected on alcohol dehydrogenase activity of tangerine fruit. Tangerine fruit stored at 5°C had the highest alcohol dehydrogenase activity (64.28±46.79 units/min/mg protein). There was no significant differences between tangerine fruit stored at 10°C

and room temperature on alcohol dehydrogenase activity (21.30±25.39 and 6.51±2.55 units/min/mg protein, respectively), catalyst the reaction on an acetaldehyde to ethanol. The alcohol dehydrogenase activity increased at day 10 for coated fruit kept at 5, 10°C and ambient temperature, while, at day 25 and 10 for non-coated fruit kept at 10 and 5°C, respectively (Table 4.5 and Figure 4.14).

Tangerine fruit coated with Perfect Shine and Citrashine had higher alcohol dehydrogenase activity (47.05±13.18 and 46.99±34.05 units/min/mg protein, respectively) than PE microemulsion-coated fruit (24.63±13.58 units/min/mg protein) and non-coated control (14.46±12.32 units/min/mg protein), but did not differ from tangerine fruit that were coated with Zivdar, Sealkote, 2.0% chitosan and Rosy Plus. The alcohol dehydrogenase activity of coated tangerine fruit fluctuated where it increased gradually at day 10 and then decreased continuously during storage until the end of the storage time (Table 4.5 and Figure 4.14).

4.1.2.5 Assessment of flavor and visual appearance

4.1.2.5.1 Flavor

After 10 days of storage, better sensorial quality of tangerine fruit were found at 5 and 10°C than at room temperature, and tangerine fruit under 5 and 10°C treatments showed smell and taste quality above the limit of marketability. When storage time was prolonged, a significant reduction in flavor scores was found, lower at room temperature than at 5 and 10°C (Table 4.6 and Figure 4.15).

There was a statistically significant difference in taste evaluations between fruit coated with Zivdar, 2.0% chitosan and non-coated fruit in comparison to tangerine fruit coated with Perfect Shine, Rosy Plus, Sealkote and Citrashine. However, there was no significant difference in the flavor scores among Zivdar-, 2.0% chitosan-, PE microemulsion-coated fruit and non-coated control. Rate evaluation of flavor in all treatments decreased with longer storage, showing abnormal smell and taste of tangerine fruit (Table 4.6 and Figure 4.15).

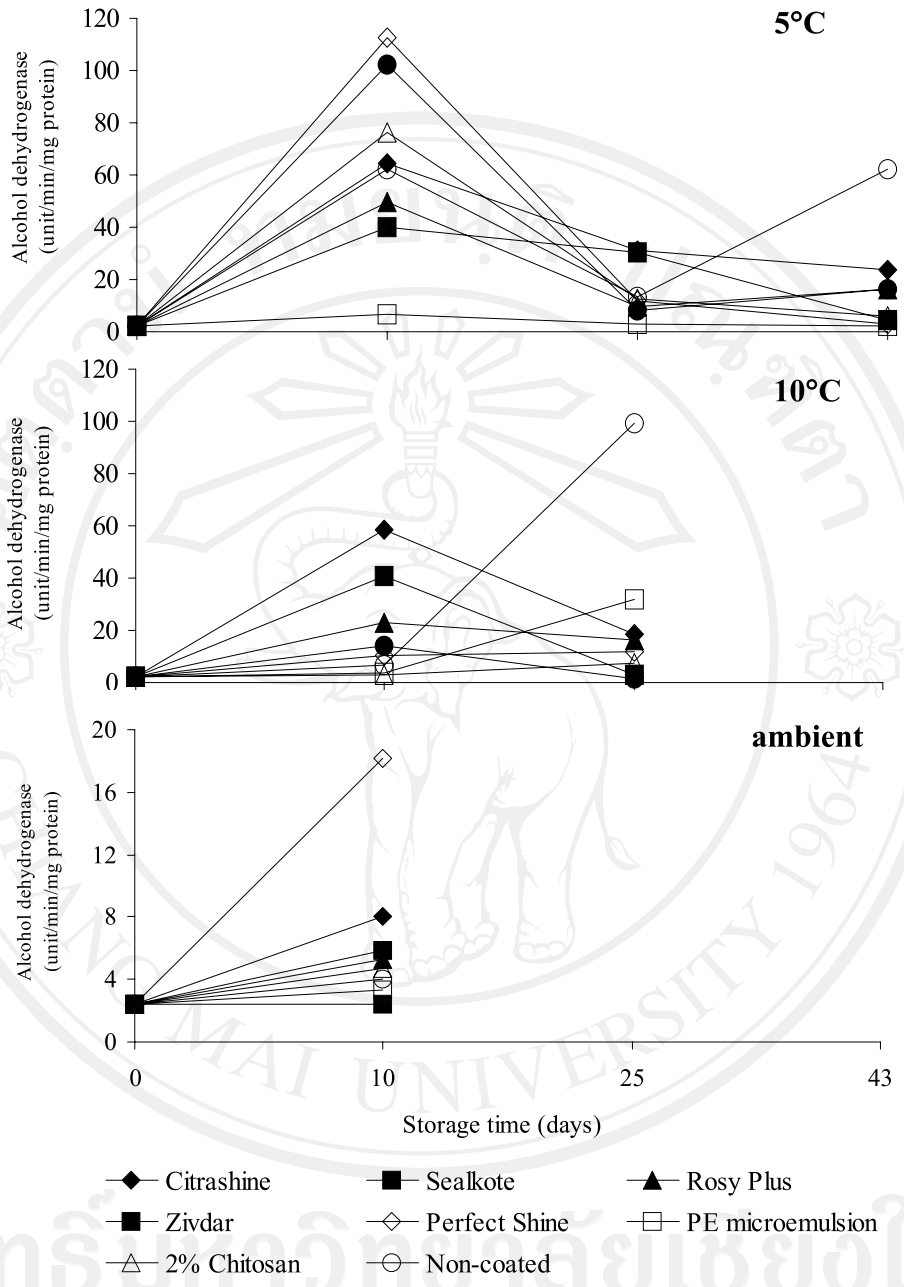

Figure 4.14 Effects of coating materials on the alcohol dehydrogenase activity of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

Table 4.6 Flavor score, visual appearance score and peel color of tangerine fruit cv. 'Sai Nam Phueng' coated with coating materials during storage at 5, 10°C and room temperature for 10 days

Treatments	Flavor (score)	Visual appearance (score)	Peel color		
			L*	chroma	hue angle
Factor 1 : Storage temperatures					
5°C	3.88±0.34^{a}	4.94±0.25^{a}	63.52±1.75^{b}	69.47±2.90^{a}	75.78±2.91^{a}
10°C	3.81±0.40^{a}	4.69±0.47^{a}	63.43±1.73^{b}	68.79±2.84^{a}	74.54±3.60^{ab}
Room temperature	2.44±1.39^{b}	2.56±1.29^{b}	64.40±1.99^{a}	64.38±3.17^{b}	74.05±2.69^{b}
Factor 2 : Coating materials					
Citrashine	2.33±0.98^{c}	4.67±0.49^{a}	62.91±2.26	64.82±4.17^{c}	75.79±3.34^{abc}
Sealkote	3.00±1.48^{bc}	4.17±0.94^{abc}	64.37±1.30	68.28±2.93^{ab}	76.63±2.86^{a}
Rosy Plus	3.00±1.48^{bc}	4.33±1.15^{ab}	63.14±1.24	65.98±3.71^{bc}	74.32±3.27^{ab}
Zivdar	4.00±0.00^{a}	4.83±0.39^{a}	65.14±1.85	67.99±3.06^{ab}	76.33±2.47^{a}
Perfect Shine	3.17±1.27^{b}	4.00±1.48^{abc}	63.44±1.81	67.32±3.81^{bc}	73.69±1.69^{b}
PE microemulsion	3.50±0.52^{ab}	3.83±1.40^{abc}	64.30±2.06	68.30±3.73^{ab}	73.59±2.96^{b}
2.0% chitosan	4.00±0.00^{a}	3.50±1.88^{bc}	63.12±1.81	67.34±2.88^{bc}	73.04±2.73^{b}
Non-coated	4.00±0.00^{a}	3.17±1.64^{c}	63.86±1.68	70.34±3.52^{a}	72.78±2.43^{b}
Factor 1	*	*	*	*	*
Factor 2	*	*	ns	*	*
Factor 1×2	*	*	ns	ns	ns

Means followed by different superscript letters within a column are significantly different (P≤0.05)

* = significant ns = non significant

Evaluation of flavor by tasting, using a scale of 1 to 4 where 4 = excellent, 3 = slightly off-flavor, 2 = moderately off-flavor and 1 = extremely off-flavor. Fruit taste was rated "unacceptable" when the taste score was below three.

Evaluation of visual appearance (wilting and shriveling), using a scale of 1 to 5 where 5 = excellent, 4 = good, 3 = fair, 2 = poor and 1 = unusable. Fruit appearance was rated "unacceptable" when the score was below three.

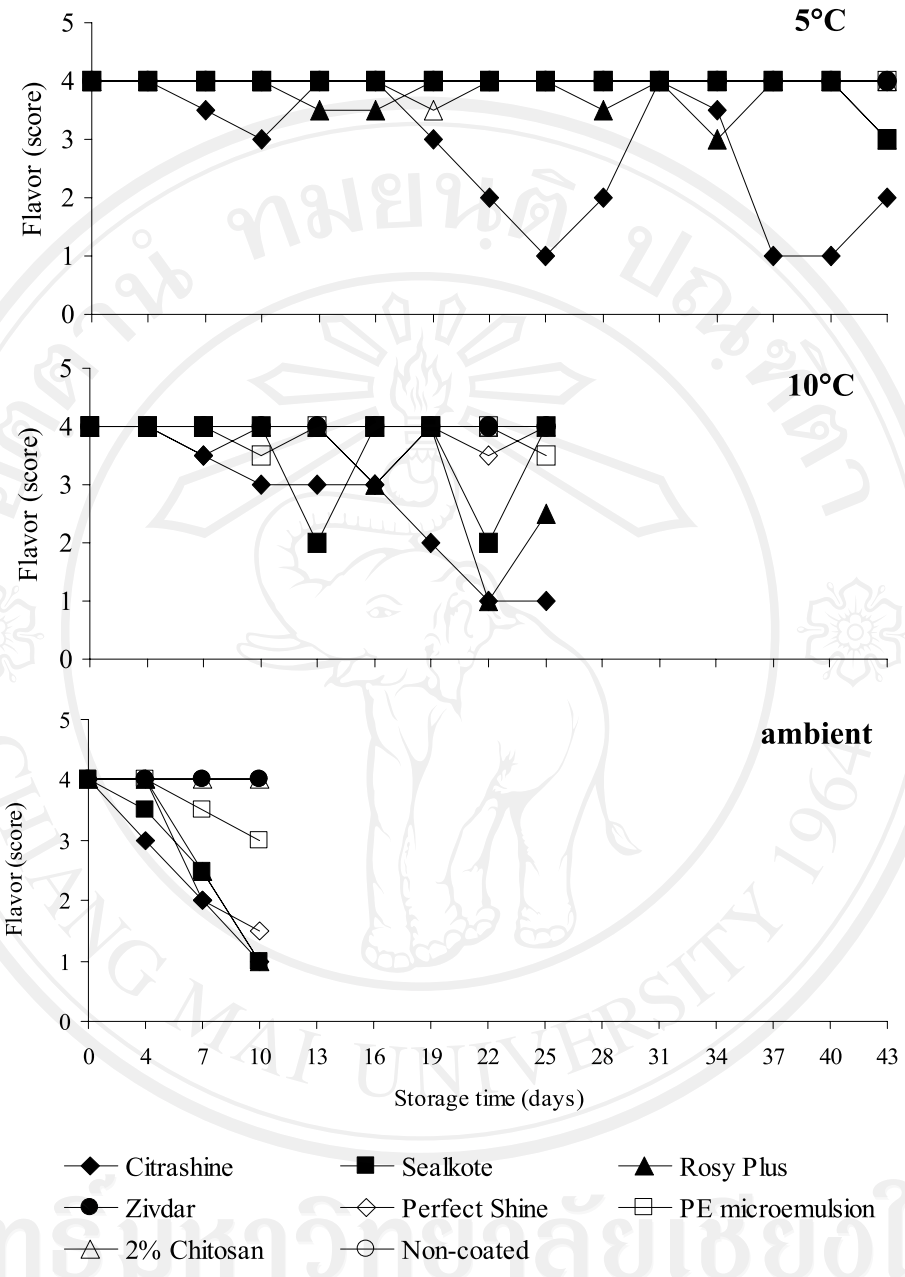

Figure 4.15 Effects of coating materials on the flavor score of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

4.1.2.5.2 Visual appearance

After 10 days of storage, a significantly lower visual appearance score was reached in fruit stored at room temperature (2.56±1.29) compared with those at 5 and 10°C (4.94±0.25 and 4.69±0.47, respectively) (Table 4.6).

The results obtained in present study indicated that there was significant difference in the visual appearance score of fruit subjected to treatments during storage, where the fruit coated with Zivdar (4.83±0.39) and Citrashine (4.67±0.49) gave the highest visual appearance score, followed by fruit coated with Rosy Plus, Sealkote, Perfect Shine and PE microemulsion. Non-coated control fruit had the lowest visual appearance score. The results obtained also indicated that there was a continuously decreases in visual appearance score from the early storage until the end of the storage time (Table 4.6 and Figure 4.16).

Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with coating materials during storage at 5, 10°C and room temperature for 0, 10, 25 and 43 days were shown in Figure 4.17 to 4.20, respectively.

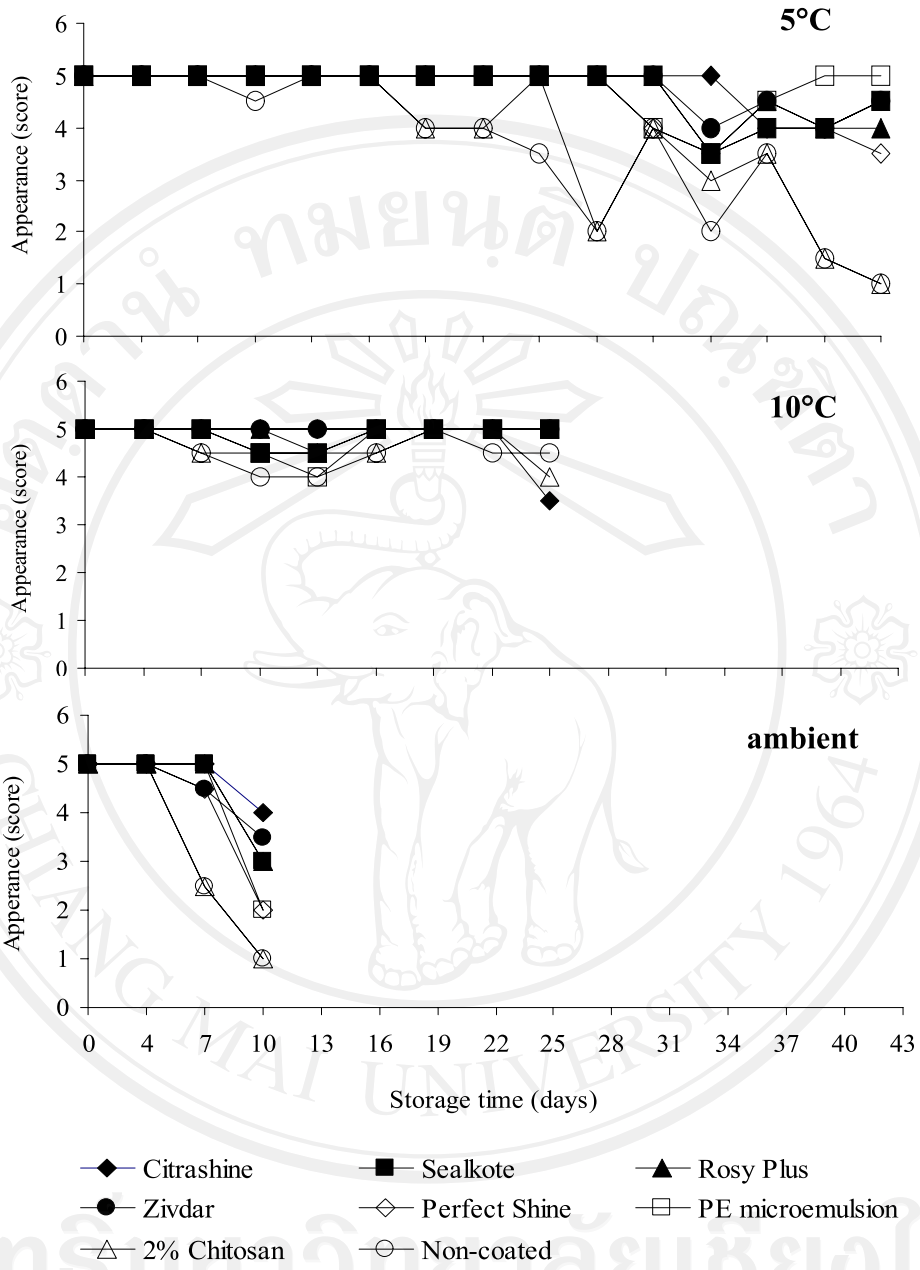

Figure 4.16 Effects of coating materials on the visual appearance score of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

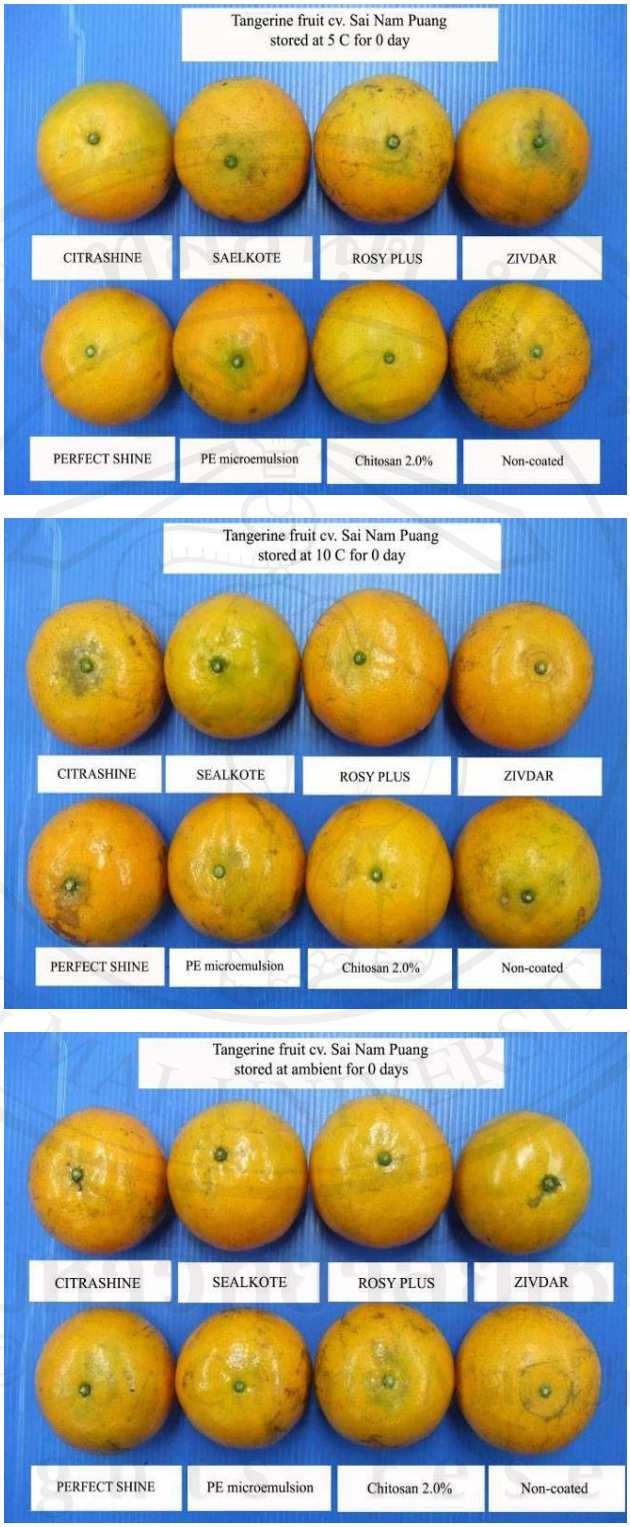

Figure 4.17 Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with coating materials during storage at 5, 10°C and room temperature on day 0

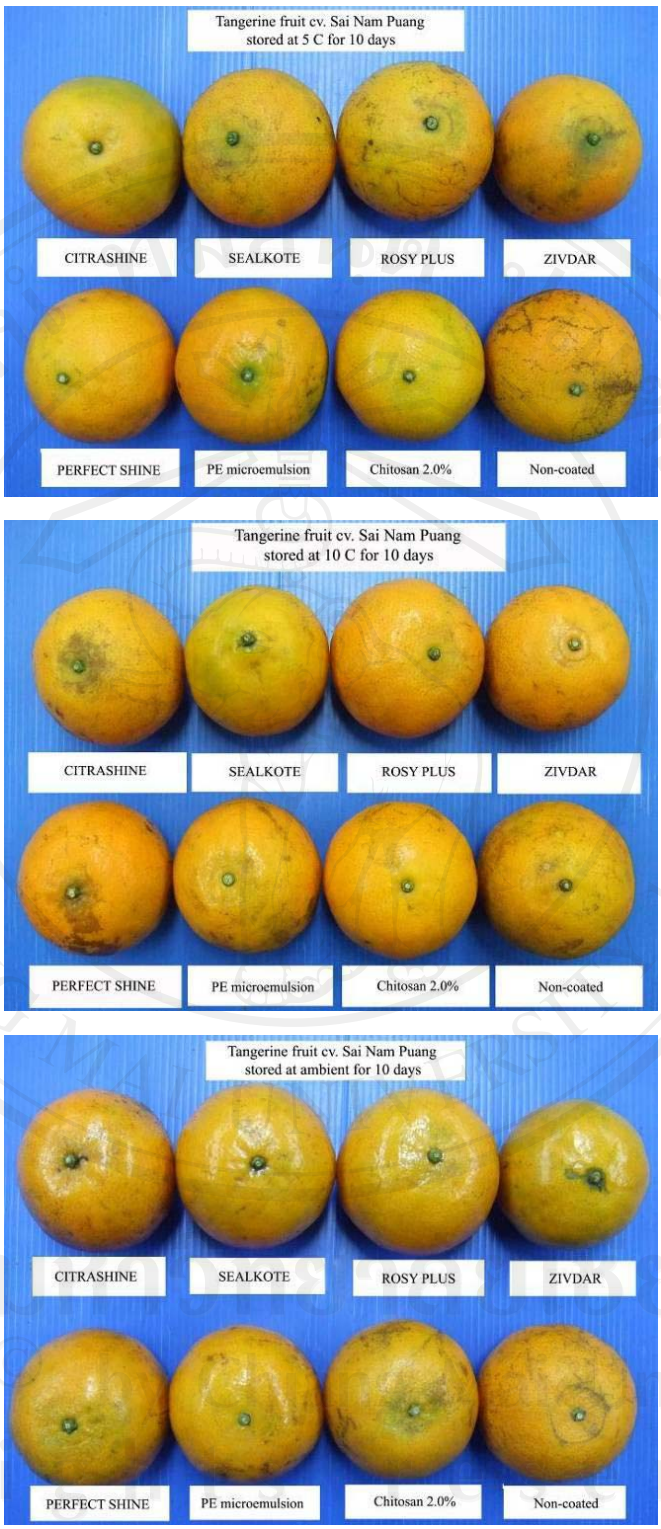

Figure 4.18 Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with coating materials during storage at 5, 10°C and room temperature for 10 days

Figure 4.19 Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with coating materials during storage at 5 and 10°C for 25 days

Figure 4.20 Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with coating materials during storage at 5°C for 43 days

4.1.2.6 Peel color

4.1.2.6.1 L*

Table 4.6 shows that L* value of tangerine fruit did not differ significantly between 5 and 10°C. Tangerine fruit stored at room temperature had the lowest L* value. In comparison with the initial value, there was a tendency toward darkening (lower L* value) (Figure 4.21).

Coating treatment did not affect significantly on L* values of peel. All treatments showed decreases in their peel L* values during storage (Table 4.6 and Figure 4.21).

4.1.2.6.2 chroma

The chroma values of tangerine fruit were significant higher at 5 and 10°C (69.47±2.90 and 68.79±2.84, respectively) than at room temperature (64.38±3.17) (Table 4.6).

Chroma value of non-coated fruit was not significantly different from that of fruit coated with PE microemulsion, Sealkote and Zivdar, but greater than fruit coated with 2.0% chitosan, Perfect Shine, Rosy Plus and Citrashine. The chroma value of tangerine fruit in all treatments did not changed during storage (Table 4.6 and Figure 4.22).

4.1.2.6.3 hue angle

Hue angle was significantly higher at 5°C (75.78±2.91°) than room temperature (74.05±2.69°), but was not significant difference with fruit stored at 10°C (74.54±3.60°). Tangerine fruit stored at room temperature presented greater losses of green skin coloration as compared to those stored at 5°C. Such results were expected, considering that the speed of metabolic reactions is directly related to temperature (Table 4.6).

Tangerine fruit coated with Sealkote and Zivdar had the highest hue angle (76.63±2.86 and 76.33±2.47°, respectively), followed by fruit coated with Citrashine and Rosy Plus. The hue angle of fruit coated with Sealkote and Zivdar significantly greater than in fruit coated with Perfect Shine, PE microemulsion, 2.0% chitosan and non-coated fruit. Hue angle of coated and non-coated control fruit declined during storage at 5, 10°C and ambient temperature (Table 4.6 and Figure 4.23).

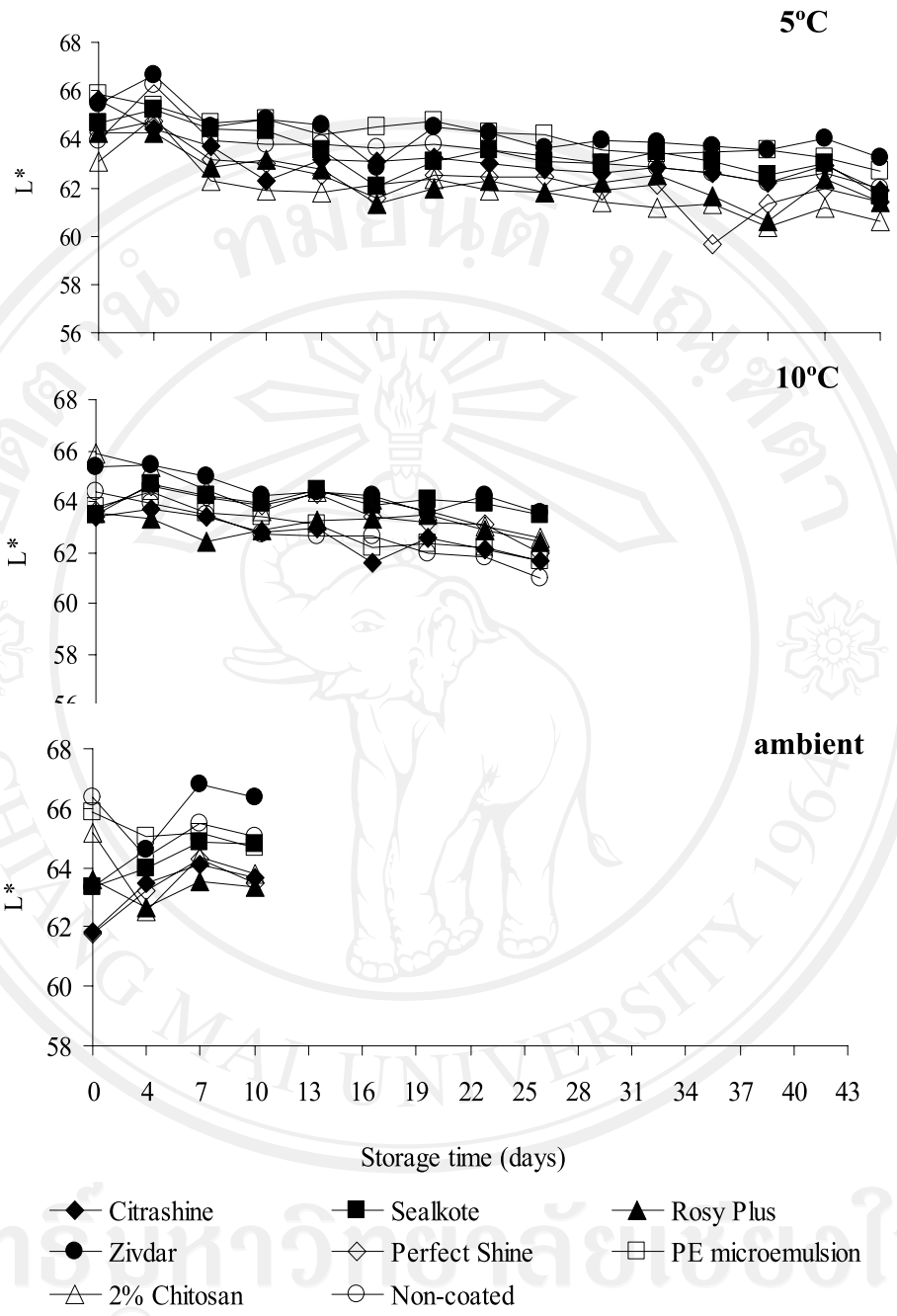

Figure 4.21 Effects of coating materials on the L* of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

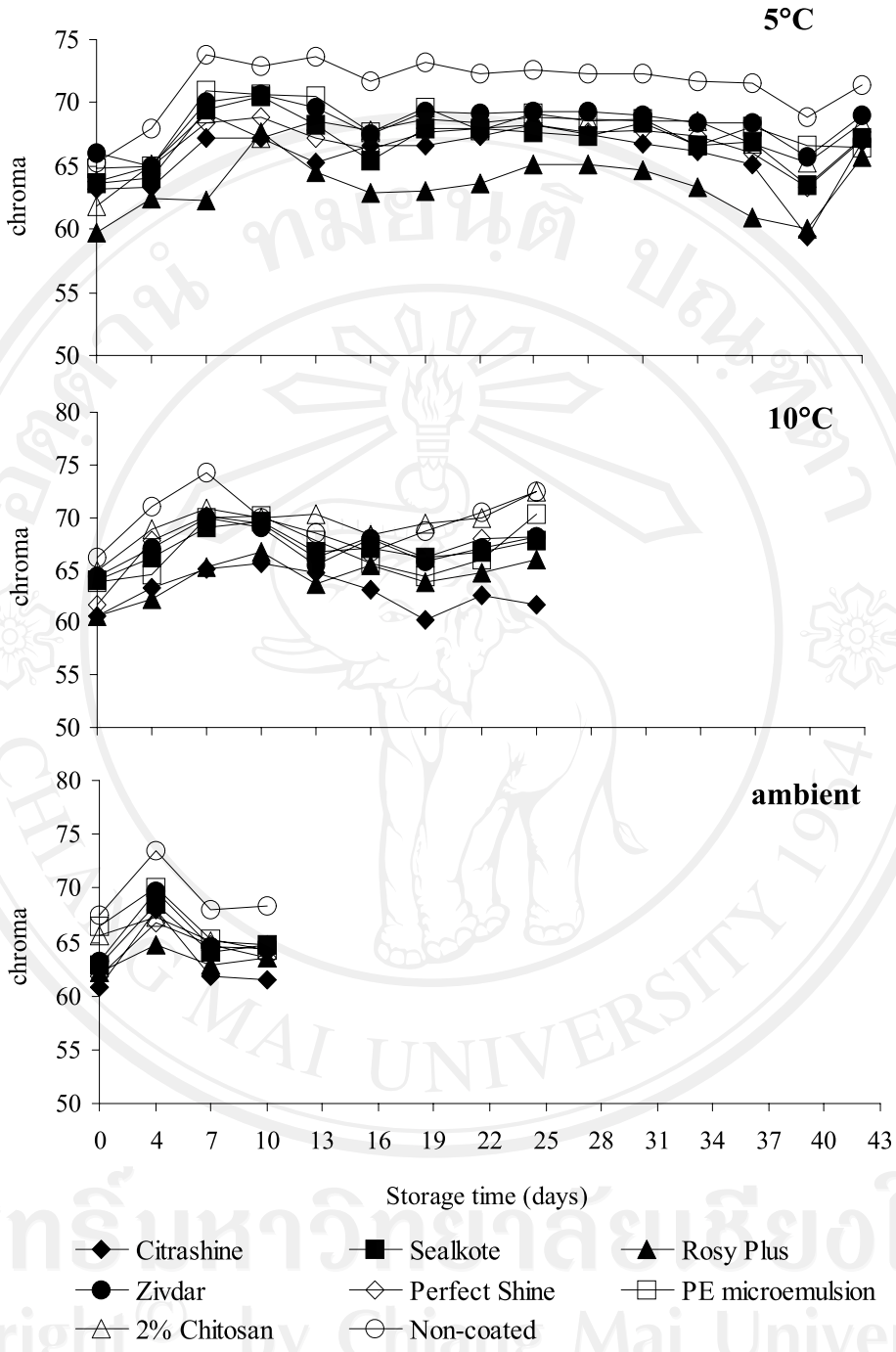

Figure 4.22 Effects of coating materials on the chroma of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

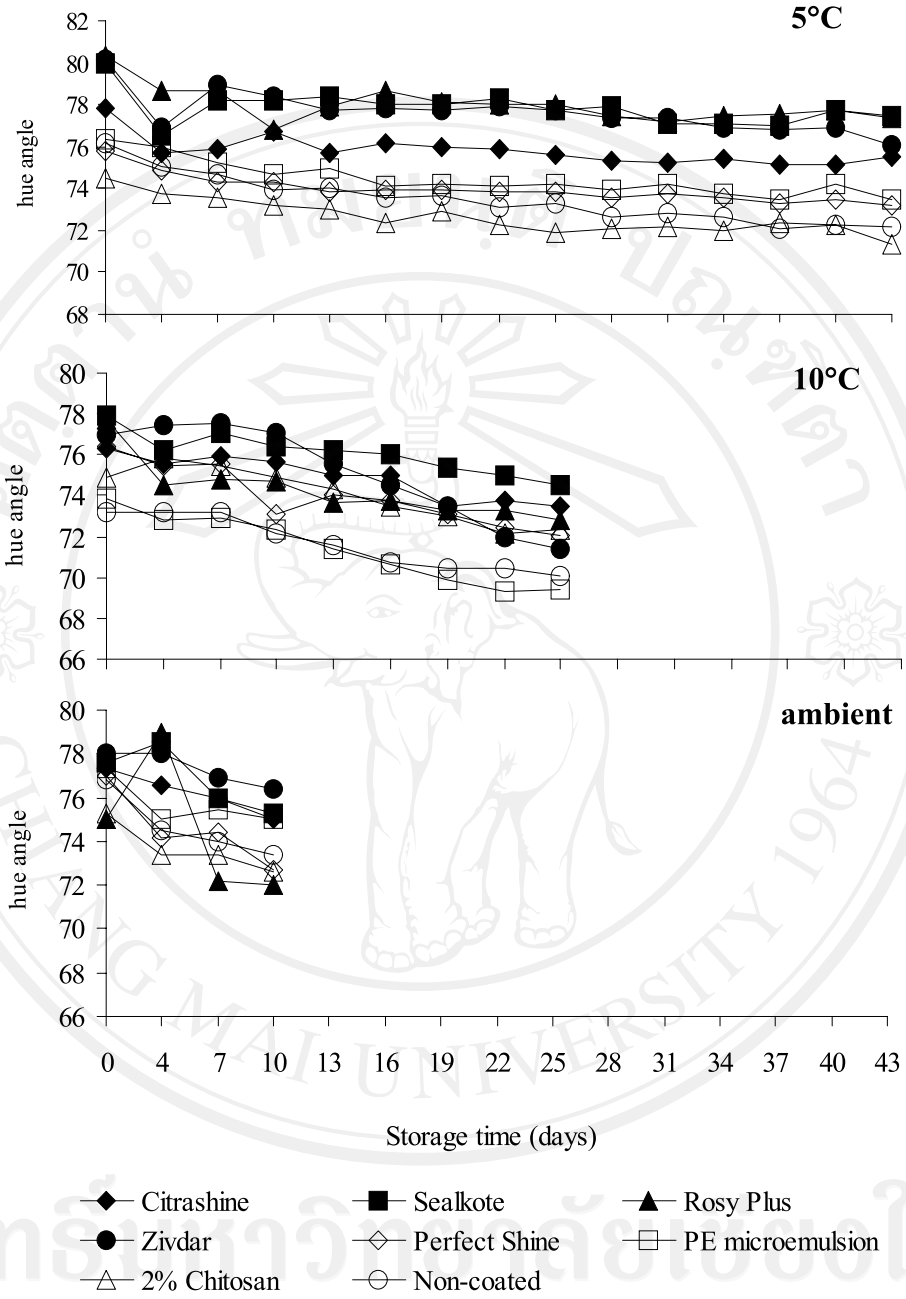

Figure 4.23 Effects of coating materials on the hue angle of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

4.1.2.7 Total soluble solids (TSS)

On day 10 of storage, there was a significantly higher total soluble solids in fruit held at room temperature (14.25±0.72%) compared with 10 and 5°C (13.04±1.22 and 12.59±1.49%, respectively) (Table 4.7).

After storage for 10 days, it was found that there were no significant differences among coated and non-coated treatments in total soluble solids contents during storage at 5, 10°C and room temperature (Table 4.7 and Figure 4.24).

4.1.2.8 Titratable acidity (TA)

Tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, did not show significant differences in percentage of titratable acidity. A pattern of decreasing in titratable acidity at the end of the shelf-life was observed under all temperatures in comparison to the initial value (Table 4.7 and Figure 4.25).

Titratable acidity of both coated and non-coated fruit also showed no significant differences in the range of 0.64±0.05 to 0.75±0.17% after 10 days of storage. Concerning the changes of titratable acidity of tangerine fruit due to the coatings and temperature of storage treatments, there was slight significant decrease in fruit acid content as the storage period progressed (Table 4.7 and Figure 4.25).

4.1.2.9 TSS/TA ratio

No significant difference in TSS/TA ratio was found among fruit stored at 5, 10°C and room temperature (19.53±3.82, 18.53±2.65 and 20.65±4.06, respectively) after 10 days of storage (Table 4.7).

There were no significant differences among coated and non-coated fruit in term of TSS/TA for 10 days of storage. It was clear that TSS/TA ratio of 'Sai Nam Phueng' tangerine fruit juice increased during storage period (Table 4.7 and Figure 4.26).

4.1.2.10 pH

Table 4.7 shows that no significant difference in pH values was observed among temperatures. It was also found that the pH value showed a trend of

decreasing during storage when held at 5, 10°C and room temperature (Figure 4.7 and Figure 4.27).

There were no differences in pH value of tangerine fruit among 7 coating materials and non-coated (Table 4.7).

4.1.2.11 Vitamin C

Vitamin C contents of tangerine fruit stored at 5, 10°C and room temperature were not significantly different (Table 4.7).

The results showed that coating materials did not affect on the ascorbic acid content of tangerine fruit after storage for 10 days. Vitamin C contents varied in all treatments during storage (Table 4.7 and Figure 4.28).

4.1.2.12 Interaction of storage temperature and coating materials on tangerine fruit quality

Interactions between fruit storage temperatures and coating materials had significant influence on weight loss, internal O_2, internal CO_2, ethanol content in juice, alcohol dehydrogenase activity, flavor and visual appearance of tangerine fruit (Table 4.5 and 4.6), but had no significant influence on peel color, total soluble solids, pH, titratable acidity, TSS/TA ratio and vitamin C content (Table 4.6 and 4.7).

Table 4.7 Total soluble solids (TSS), titratable acidity (TA), TSS/TA ratio, pH and vitamin C content of tangerine fruit cv. 'Sai Nam Phueng' coated with coating materials during storage at 5, 10°C and room temperature for 10 days

Treatments	TSS (%)	TA (%)	TSS/TA ratio	pH	Vitamin C (mg/100 ml juice
Factor 1 : Storage temperatures					
5°C	12.59±1.49[b]	0.66±0.10	19.53±3.82	3.56±0.10	17.99±1.99
10°C	13.04±1.22[b]	0.71±0.08	18.53±2.65	3.53±0.10	18.52±2.11
Room temperature	14.25±0.72[a]	0.71±0.14	20.65±4.06	3.53±0.18	17.53±1.70
Factor 2 : Coating materials					
Citrashine	13.46±1.68	0.70±0.12	19.75±4.34	3.54±0.09	18.29±2.42
Sealkote	13.40±1.39	0.75±0.17	18.68±4.07	3.45±0.20	18.29±1.83
Rosy Plus	13.38±1.32	0.71±0.10	19.05±2.52	3.50±0.12	18.29±0.91
Zivdar	13.48±1.11	0.66±0.12	21.07±5.74	3.61±0.16	17.68±2.24
Perfect Shine	12.63±1.78	0.64±0.05	19.78±2.12	3.59±0.07	18.09±1.43
PE microemulsion	13.23±1.23	0.65±0.09	20.59±3.53	3.58±0.09	17.89±2.38
2.0% chitosan	12.84±1.62	0.70±0.07	18.61±3.32	3.52±0.08	19.11±1.85
Non-coated	13.94±0.51	0.71±0.11	19.04±2.69	3.52±0.11	16.46±1.83
Factor 1	*	ns	ns	ns	ns
Factor 2	ns	ns	ns	ns	ns
Factor 1×2	ns	ns	ns	ns	ns

Means followed by different superscript letters within a column are significantly different (P≤0.05)

* = significant ns = non significant

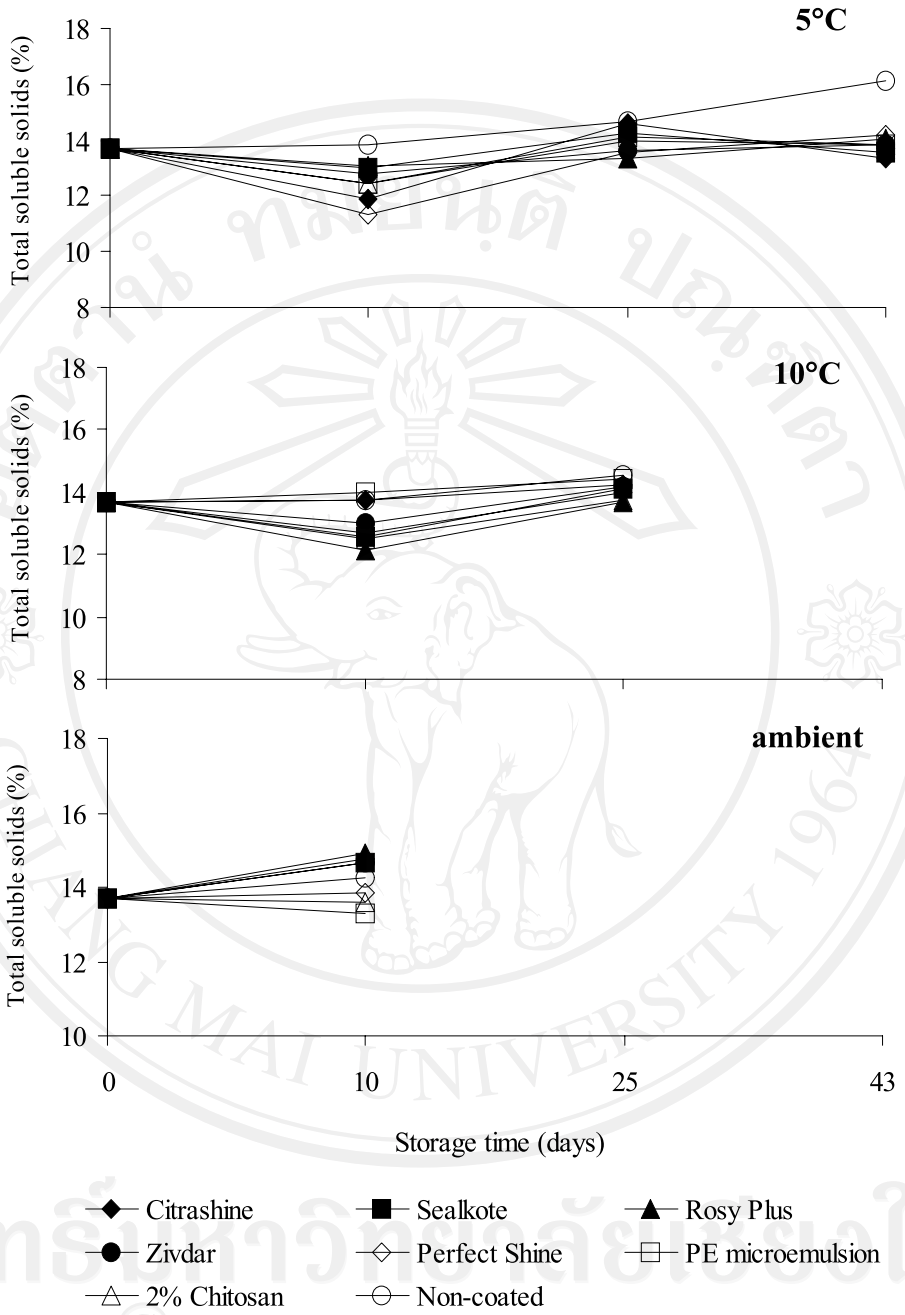

Figure 4.24 Effects of coating materials on the total soluble solids of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

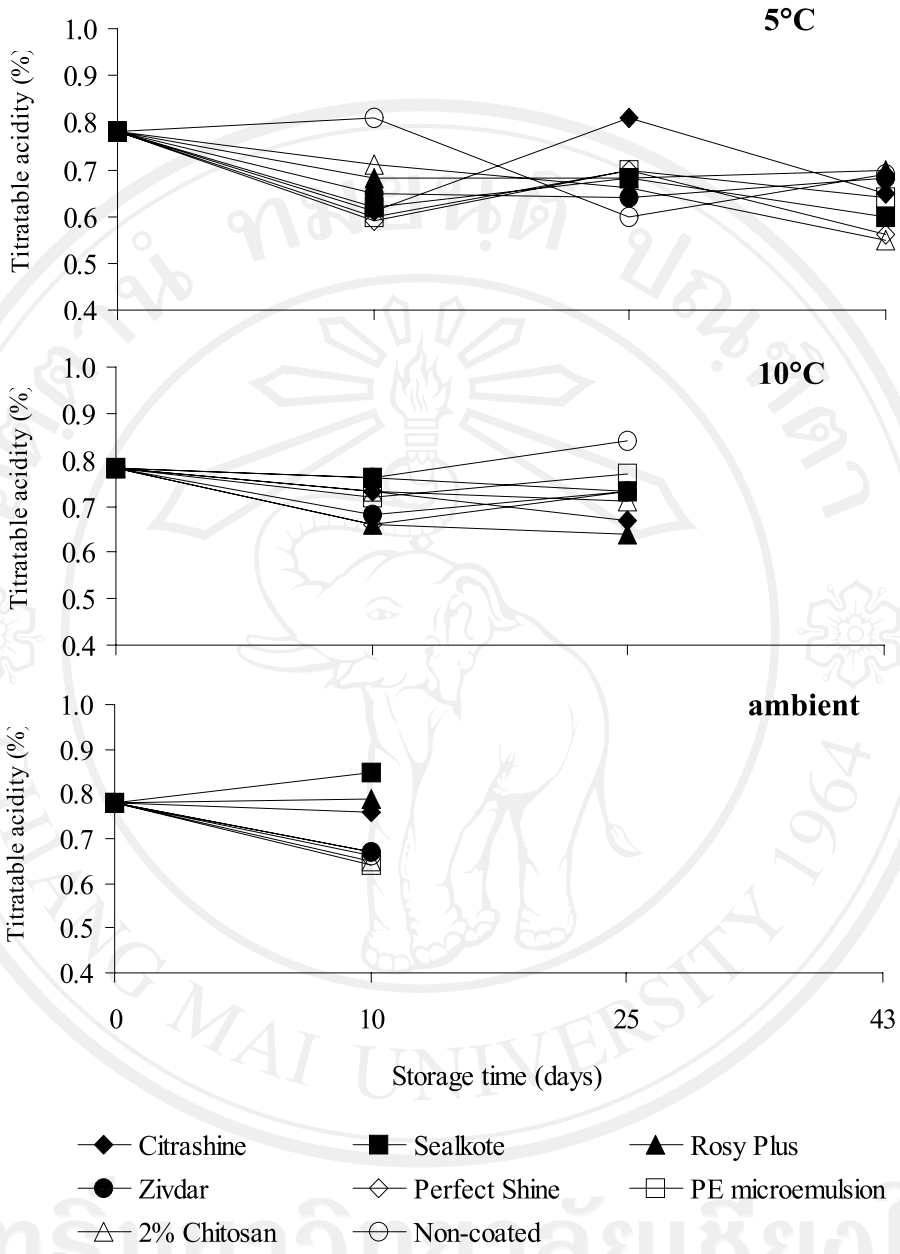

Figure 4.25 Effects of coating materials on the titratable acidity of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

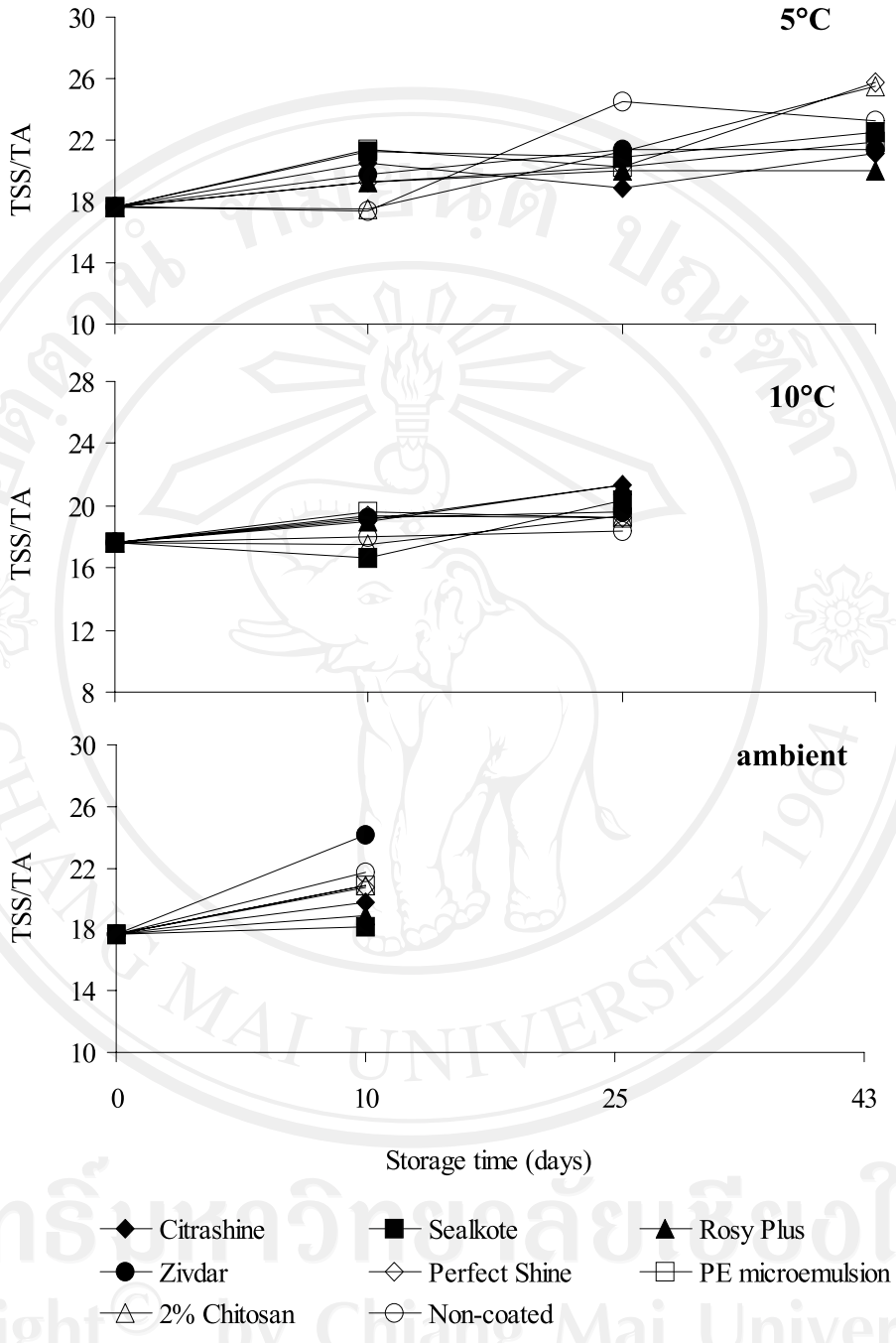

Figure 4.26 Effects of coating materials on the TSS/TA ratio of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

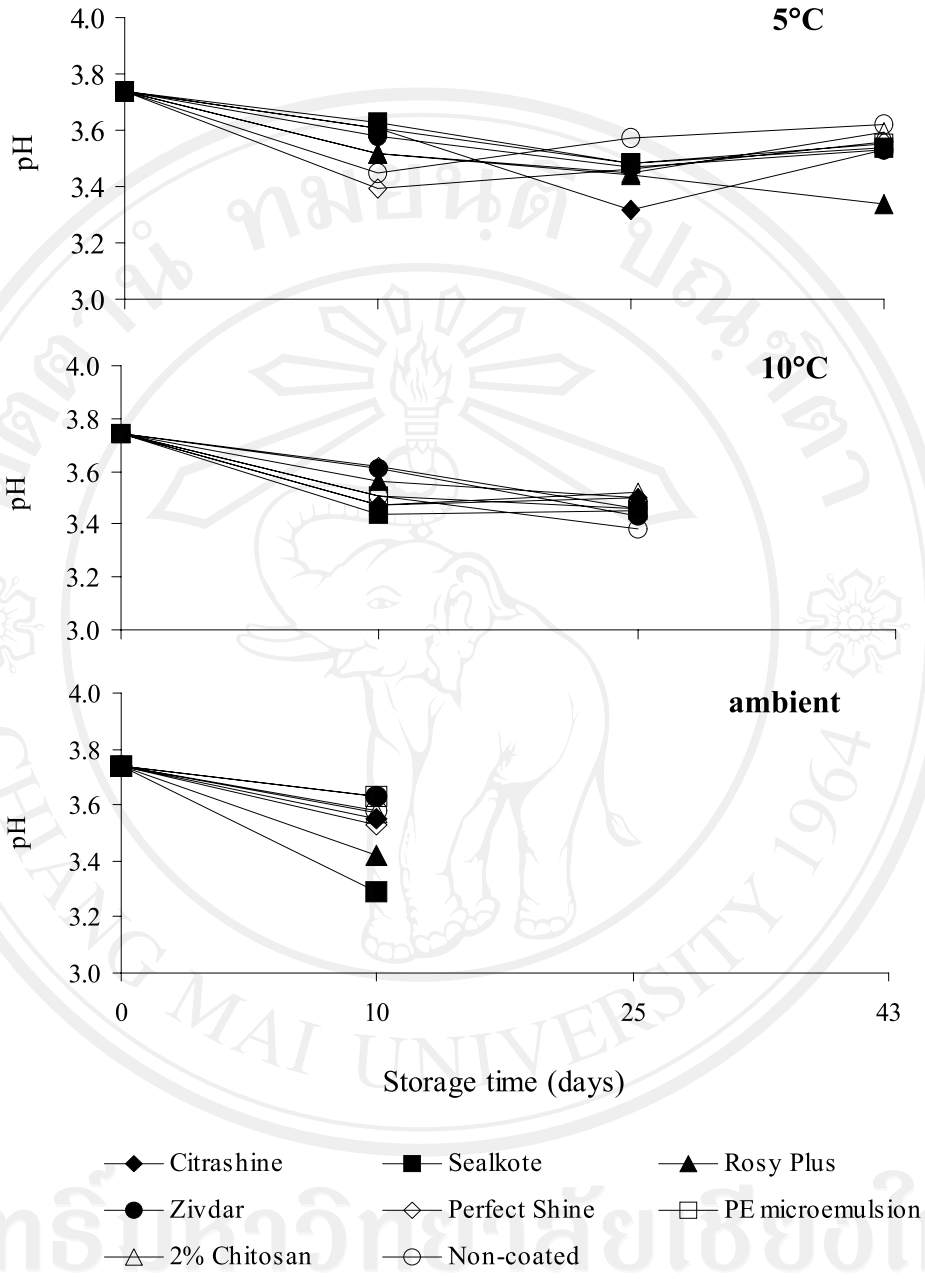

Figure 4.27 Effects of coating materials on the pH of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

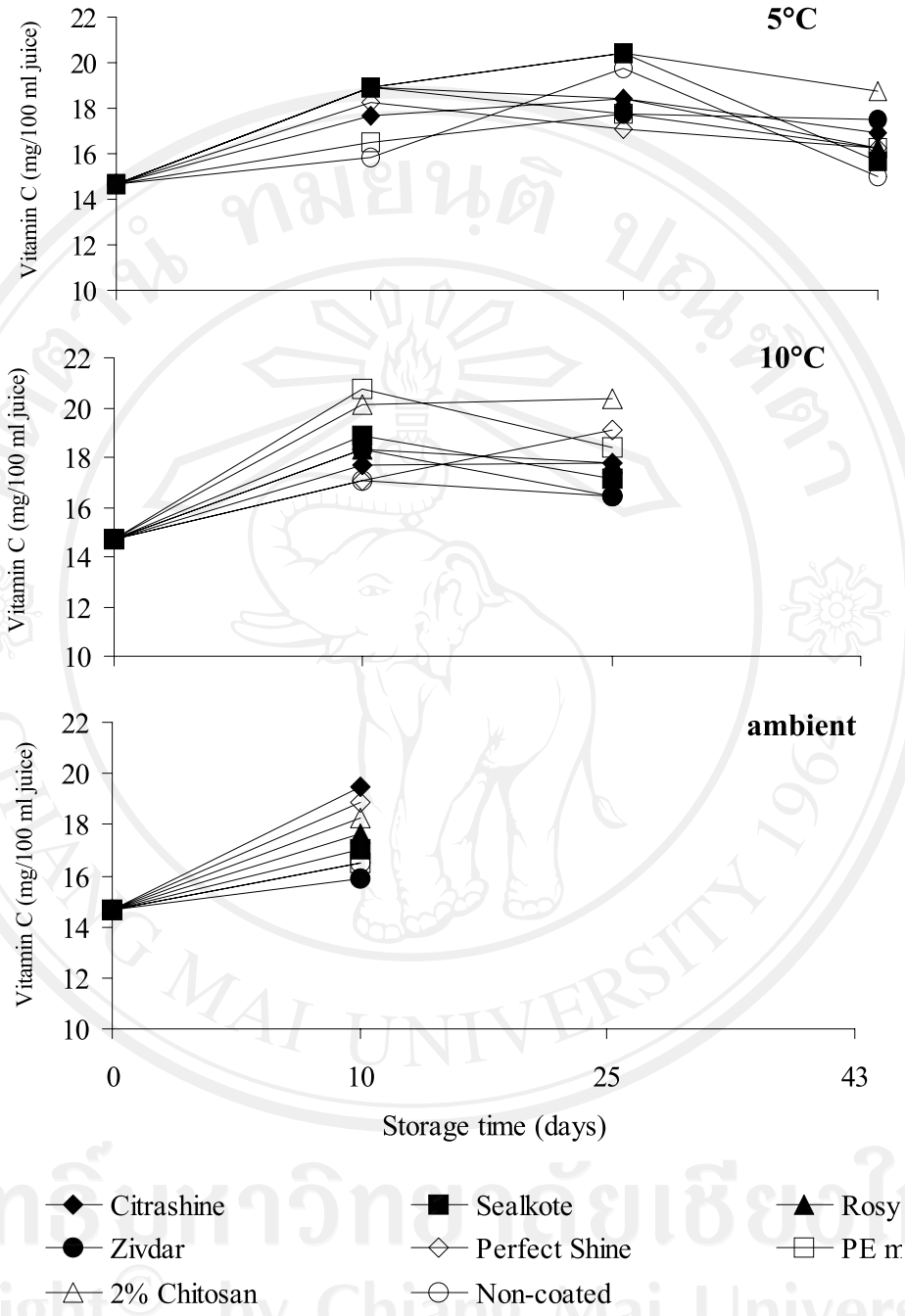

Figure 4.28 Effects of coating materials on the vitamin C of tangerine fruit stored at 5, 10°C and room temperature for 43, 25 and 10 days, respectively

4.2 Effect of commercial coatings by commercial method on the physico-chemical and physiological characters of tangerine fruit

4.2.1 Effect of commercial coatings by commercial method on the physico-chemical and physiological characters of tangerine fruit during storage at room temperature

Tangerine fruit cv. 'Sai Nam Phueng' were coated with 3 commercial coatings (Zivdar, Fomesa and Citrashine) by commercial methods and then stored at room temperature (24±3°C) and 59±6% relative humidity for 10 days.

4.2.1.1 Weight loss

There was a similar pattern of increasing weight loss with storage time for both coated and non-coated tangerine fruit. However, weight loss was greater for non-coated control (7.88±1.99%) than coated fruit (5.93±0.90, 6.38±0.70 and 6.77±0.89% for fruit coated with Fomesa, Citrashine and Zivdar, respectively). There was significant difference between Fomesa and Zivdar (Table 4.8 and Figure 4.29).

Table 4.8 Weight loss, internal O_2, internal CO_2 and ethanol content in juice of tangerine fruit cv. 'Sai Nam Phueng' coated with 3 commercial coatings by commercial method during storage at room temperature (24±3°C) and 59±6% relative humidity for 10 days

Commercial coatings	Weight loss (%)	Internal O_2 (%)	Internal CO_2 (%)	Ethanol content in juice (mg/l)
Zivdar	6.77±0.89^{b}	6.88±2.46^{b}	10.06±1.61^{b}	1084.89±42.12^{c}
Fomesa	5.93±0.90^{c}	2.09±1.69^{c}	12.02±1.62^{a}	1613.30±109.29^{b}
Citrashine	6.38±0.70^{bc}	2.46±1.54^{c}	12.20±0.89^{a}	2518.72±28.08^{a}
Non-coated	7.88±1.99^{a}	12.93±1.77^{a}	7.10±1.02^{c}	581.55±82.22^{d}
$LSD_{0.05}$	0.78	3.81	1.81	137.24
C.V. (%)	18.24	21.56	11.77	5.03

Means followed by different superscript letters within a column are significantly different (P≤0.05)

4.2.1.2 Internal gases

4.2.1.2.1 Internal O_2

After 10 days of storage, the results showed that non-coated tangerine fruit had the highest internal O_2 concentration (12.93±1.77%), which significant different from Zivdar-, Citrashine- and Fomesa-coated fruit. Fruit coated with Zivdar had the higher internal O_2 concentration than those coated with Fomesa and Citrashine. The internal O_2 concentration of coated tangerine fruit showed dramatically decreases at the first day of storage. While, internal O_2 concentration of non-coated control fruit gradually decreases during storage for 13 days (Table 4.8 and Figure 4.30).

4.2.1.2.2 Internal CO_2

After 10 days of storage, it was found that tangerine fruit coated with Citrashine and Fomesa had the highest internal CO_2 (12.20±0.89 and 12.02±1.62%, respectively), followed by fruit coated with Zivdar (10.06±1.61%). Internal CO_2 concentrations of fruit in all coating treatments increased on the first day of storage, and then continuously increased, while non-coated fruit had the lowest internal CO_2 concentration during storage period (Table 4.8 and Figure 4.30).

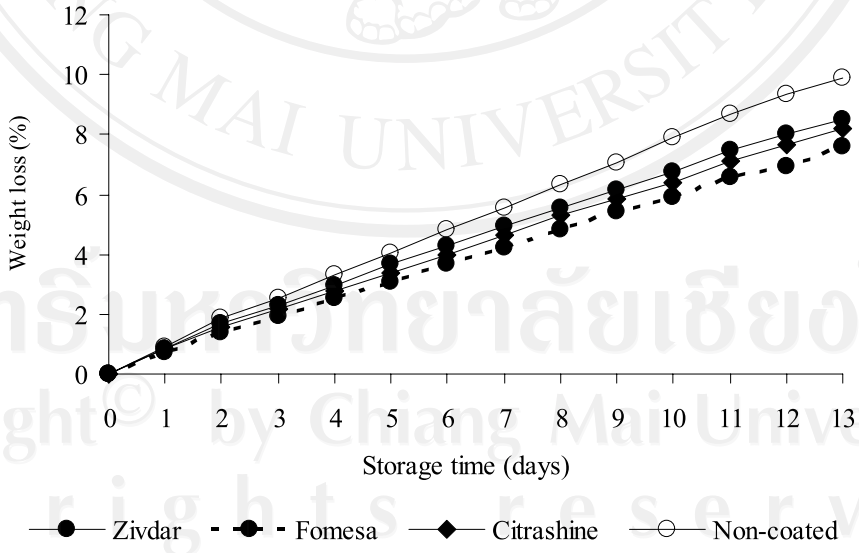

Figure 4.29 Effects of 3 commercial coatings on the weight loss of tangerine fruit stored at room temperature (24±3°C) and 59±6% relative humidity for 10 days

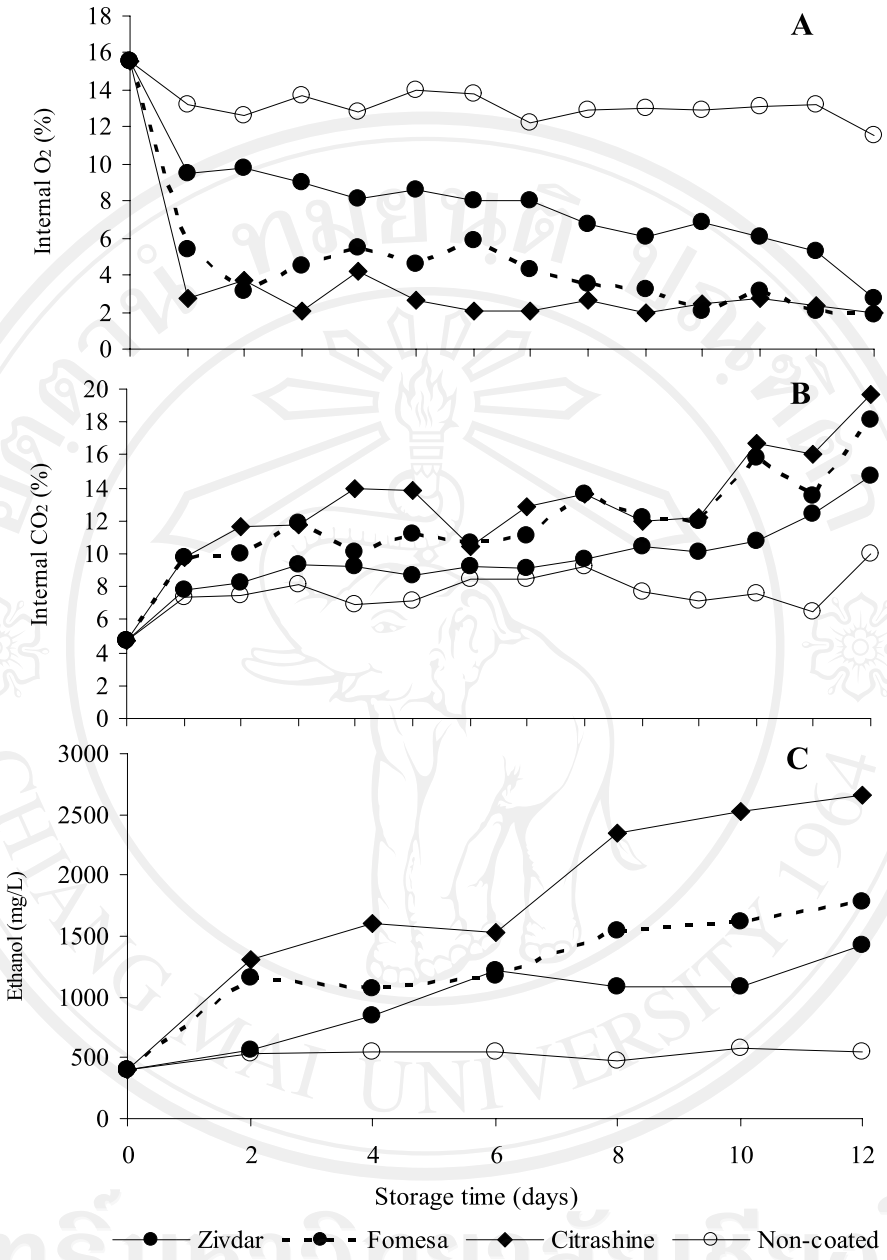

Figure 4.30 Effects of 3 commercial coatings on the (A) internal O_2, (B) internal CO_2 and (C) ethanol content of tangerine fruit stored at room temperature (24±3°C) and 59±6% relative humidity for 13 and 12 days

4.2.1.3 Ethanol content in juice

The statistical analysis showed that there was significant difference among the means of ethanol contents in juice of all treatments. Non-coated tangerine fruit had the lowest amount of ethanol content in juice (581.55±82.22 mg/l), followed by fruit coated with Zivdar (1,084.89±42.12 mg/l). Ethanol content in juice of fruit coated with zivdar was lower than fruit coated with Fomesa and Citrashine (1,613.30±109.29 and 2,518.72±28.08 mg/l, respectively). It was also found that ethanol content in juice of non-coated control fruit is quite stable during storage for 13 days. While, ethanol content in juice of fruit coated with Citrashine increased rapidly since the first day of storage and continuously increased at very high rate. Rate of increasing in ethanol contents of fruit coated with Zivdar is less than fruit coated with other coating materials (Table 4.8 and Figure 4.30).

4.2.1.4 Fermentative enzymes

4.2.1.4.1 Pyruvate decarboxylase activity (PDC activity)

After storage for 10 days, the results showed that there was no significant difference in PDC activity among fruit coated with Zivdar, Fomesa, Citrashine and non-coated fruit (Table 4.9). The PDC activity of fruit in all treatments increased during day 4 to day 8 of storage. On day 5 of storage, fruit coated with Citrashine had the highest enzyme activity (19.57±8.33 units/min/mg protein), which significant difference with Fomesa-, Zivdar- and non-coated fruit. Fruit coated with Zivdar, Fomesa and control fruit had the highest PDC activity on day 5, 8 and 8 of storage, respectively. In addition, the results showed that PDC activity of non-coated fruit was lower than PDC activity of coated fruit (Table A.34 and Figure 4.31).

4.2.1.4.2 Alcohol dehydrogenase activity (ADH activity)

After 10 days of storage, it was found that tangerine fruit coated with Citrashine had the highest ADH activity (10.11±5.60 units/min/mg protein), which significant difference from fruit coated with Zivdar, Fomesa and non-coated fruit (3.17±1.95, 2.87±1.89 and 3.54±1.04 units/min/mg protein, respectively) (Table 4.9). Based on Figure 4.31 and Table A.35, the results showed that during the storage period at 4 to 10 days activity of ADH enzyme in all treatments were quite variable. Activity of ADH enzyme of fruit coated with Citrashine increased at day 4 of storage

with the highest activity was 23.0±04.54 units/min/mg protein, then decreased during 5 to 10 days of storage and varied between 1.09±0.38 to 21.78±13.88 units/min/mg protein.

ADH activity of fruit coated with Fomesa clearly increased on day 4 and 5 of storage, and the activity was the highest on day 8 of storage (21.62±18.56 units/min/mg protein). While, the ADH activity of tangerine fruit coated with Zivdar slightly increased on day 3 until day 5, the decreasing noted relative constant. At day 5 of storage, fruit coated with Zivdar had the highest ADH activity (8.63±2.79 units/min/mg protein). During storage, ADH activity of non-coated fruit was less than coated fruit (Table A.35 and Figure 4.31).

Table 4.9 Pyruvate decarboxylase acitivity and alcohol dehydrogenase activity of tangerine fruit cv. 'Sai Nam Phueng' coated with 3 commercial coatings by commercial method during storage at room temperature (24±3°C) and 59±6% relative humidity for 10 days

Commercial coatings	**Pyruvate decarboxylase activity (units/min/mg protein)**	**Alcohol dehydrogenase activity (units/ min/ mg protein)**
Zivdar	1.06±0.16	3.17±1.95[b]
Fomesa	0.85±0.31	2.87±1.89[b]
Citrashine	1.54±0.68	10.11±5.60[a]
Non-coated	1.51±0.23	3.54±1.04[b]
$LSD_{0.05}$	1.18	1.18
C.V. (%)	20.12	20.12

Means followed by different superscript letters within a column are significantly different (P≤0.05)

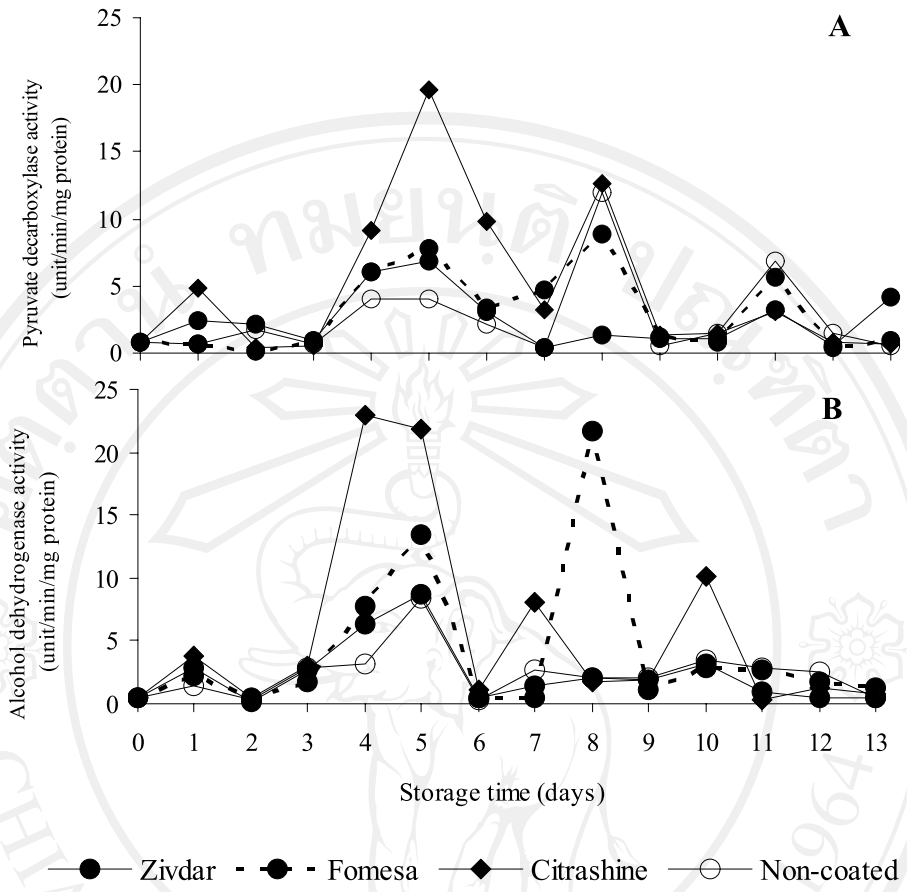

Figure 4.31 Effects of 3 commercial coatings on the (A) pyruvate decarboxylase activity and (B) alcohol dehydrogenase activity of tangerine fruit stored at room temperature (24±3°C) and 59±6% relative humidity for 13 days

4.2.1.5 Assessment of flavor and visual appearance

4.2.1.5.1 Flavor

The statistical analysis showed that the flavor score was decreased during 13 days of storage. Zivdar-coated and non-coated tangerine fruit had good eating quality and no flavor compared to fruit coated with Fomesa and Citrashine. Flavor score of fruit coated with Citrashine and Fomesa gradually decreased after storage for 3 days. Whereas flavor score of fruit coated with Zivdar and non-coated control fruit decreased after storage for 9 and 10 days, respectively (Table 4.10 and Figure 4.32).

Table 4.10 Flavor score, visual appearance score and peel color of tangerine fruit cv. 'Sai Nam Phueng' coated with 3 commercial coatings by commercial method during storage at room temperature (24±3°C) and 59±6% relative humidity for 10 days

Commercial coatings	Flavor (score)	Visual appearance (score)	Peel color		
			L*	chroma	hue angle
Zivdar	3.67±0.52[a]	3.67±0.52[a]	64.95±2.76	58.85±7.41	73.39±6.61
Fomesa	2.67±0.52[b]	3.67±0.52[a]	63.88±3.18	56.97±7.09	73.24±6.31
Citrashine	2.00±0.00[c]	3.67±0.52[a]	64.67±2.11	59.84±3.89	72.84±4.97
Non-coated	4.00±0.00[a]	2.67±0.52[b]	64.79±2.24	59.95±4.91	73.05±4.98
$LSD_{0.05}$	0.44	0.62	0.62	3.94	3.76
C.V. (%)	9.60	15.11	15.11	10.34	7.94

Means followed by different superscript letters within a column are significantly different (P≤0.05)

Evaluation of flavor by tasting, using a scale of 1 to 4 where 4 = excellent, 3 = slightly off-flavor, 2 = moderately off-flavor and 1 = extremely off-flavor. Fruit taste was rated "unacceptable" when the taste score was below three.

Evaluation of visual appearance (wilting and shriveling), using a scale of 1 to 5 where 5 = excellent, 4 = good, 3 = fair, 2 = poor and 1 = unusable. Fruit appearance was rated "unacceptable" when the score was below three.

4.2.1.5.2 Visual appearance

The results illustrated in Figure 4.32 revealed that there was significant decrease in visual appearance score of coated fruit with commercial coatings during storage period. However, the rate of decreasing in visual appearance score was significantly higher in non-coated control fruit as compared with coated fruit. The visual appearance score of fruit coated with Citrashine, Fomesa and Zivdar was not significant. Surface coatings also increased the glossy appearance of tangerine fruit (Table 4.10 and Figure 4.32).

Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with 3 commercial coatings during storage at room temperature (24±3°C) and 59±6% relative humidity for 0 and 10 days were shown in Figure 4.33.

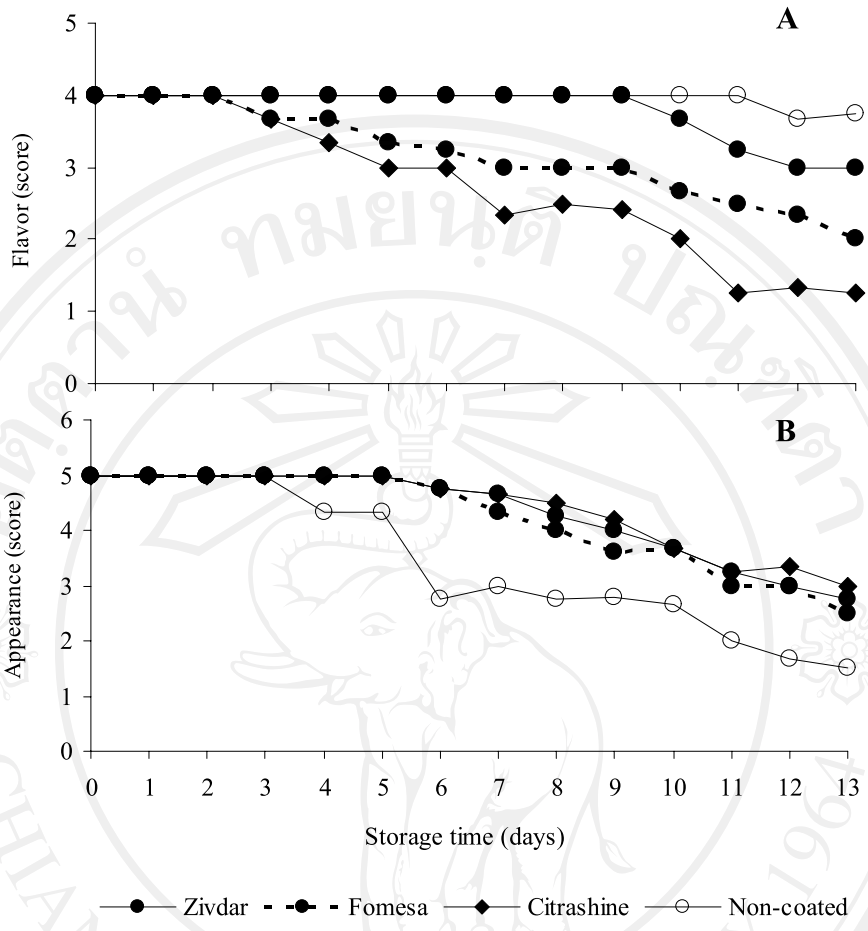

Figure 4.32 Effects of 3 commercial coatings on the (A) flavor score and (B) visual appearance score of tangerine fruit stored at room temperature (24±3°C) and 59±6% relative humidity for 13 days

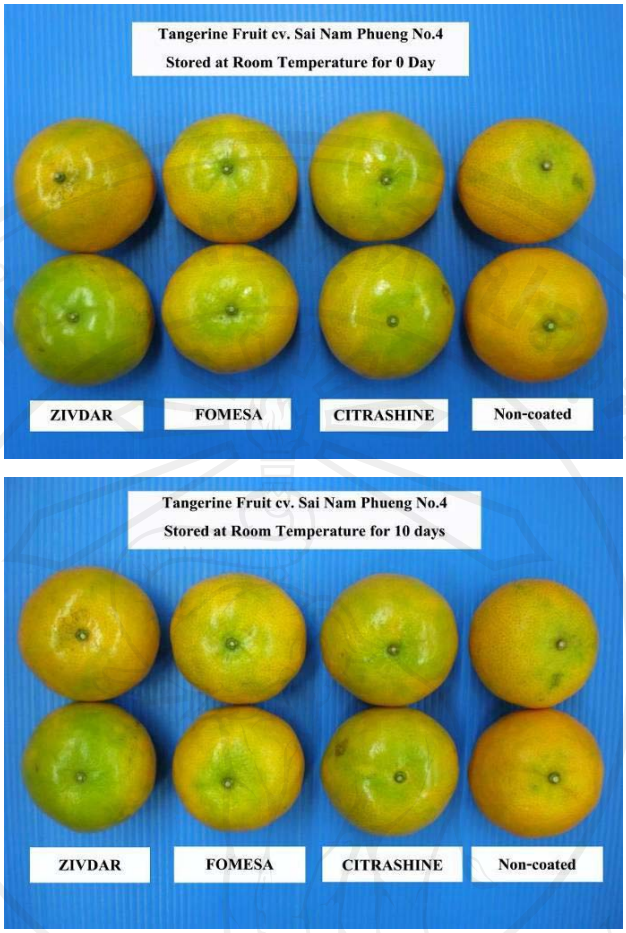

Figure 4.33 Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with 3 commercial coatings during storage at room temperature (24±3°C) and 59±6% relative humidity for 0 and 10 days

4.2.1.6 Peel color

4.2.1.6.1 L*

Figure 4.34 reveals that the L* value of commercial-coated tangerine fruit gradually decreased during storage. The L* values of the fruit in all treatments were not significantly different during 10 days of storage (Table 4.10 and Figure 4.34).

4.2.1.6.2 chroma

There were no differences in chroma values among treatments after 10 days of storage. The chroma values of tangerine fruit in all treatments relatively constant during storage (Table 4.10 and Figure 4.34).

4.2.1.6.3 hue angle (H°)

After 10 days of storage, the results showed that coating treatments did not have effect on hue angle. Hue angle of coated- and non-coated tangerine fruit slightly decreased during storage at room temperature for 13 days (Table 4.10 and Figure 4.34).

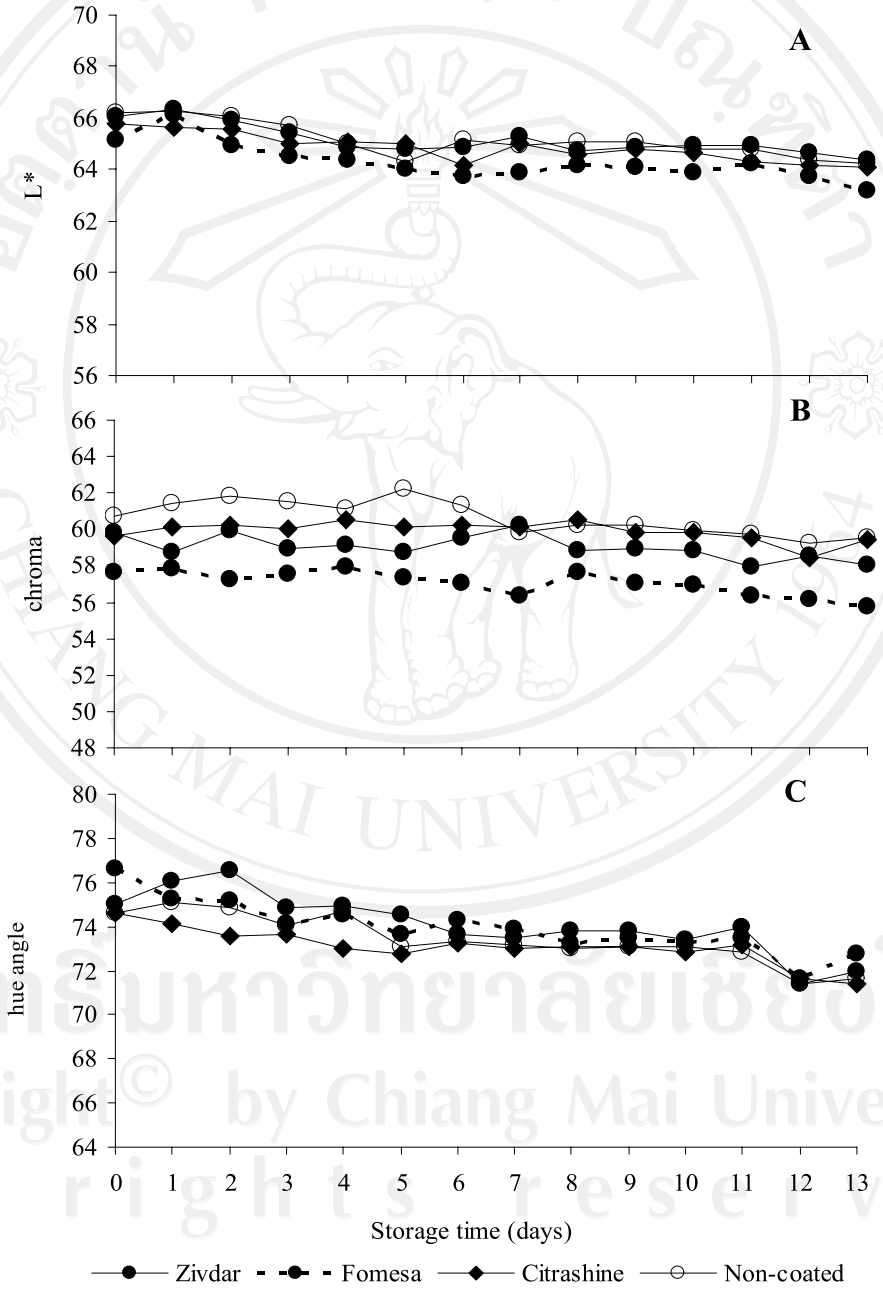

Figure 4.34 Effects of 3 commercial coatings on the (A) L*, (B) chroma and (C) hue angle of tangerine fruit stored at room temperature (24±3°C) and 59±6% relative humidity for 13 days

4.2.1.7 Total soluble solids (TSS)

Total soluble solids content of tangerine fruit were not significantly affected by coating treatments. The total soluble solids of fruit in all treatments were relatively constant throughout the storage period (Table 4.11 and Figure 4.35).

4.2.1.8 Titratable acidity (TA)

Commercial coatings had no effect on titratable acidity of tangerine fruit. Titratable acidity decreased in all treatments during the storage period (Table 4.11 and Figure 4.35).

4.2.1.9 TSS/TA ratio

The results indicated that there was no significant difference in TSS/TA ratio of coated- and non-coated tangerine fruit after storage for 10 days at room temperature. TSS/TA ratio increased in both coated- and non-treated fruit during storage period (Table 4.11 and Figure 4.35).

Table 4.11 Total soluble solids (TSS), titratable acidity (TA), TSS/TA ratio, pH and vitamin C content of tangerine fruit cv. 'Sai Nam Phueng' coated with 3 commercial coatings by commercial method during storage at room temperature (24±3°C) and 59±6% relative humidity for 10 days

Commercial coatings	TSS (%)	TA (%)	TSS/TA ratio	pH	Vitamin C content (mg/100 ml juice)
Zivdar	12.53±1.12	0.66±0.06	19.12±1.83	3.22±0.02	20.38±2.21
Fomesa	13.00±0.60	0.69±0.10	19.04±2.23	3.16±0.03	21.66±4.41
Citrashine	12.83±0.76	0.62±0.06	20.90±0.97	3.20±0.09	21.02±1.91
Non-coated	12.43±0.93	0.62±0.09	20.32±1.62	3.17±0.11	22.93±1.91
$LSD_{0.05}$	1.64	0.15	3.25	1.64	5.29
C.V. (%)	6.88	12.39	8.69	6.88	13.80

Means followed by different superscript letters within a column are significantly different (P≤0.05)

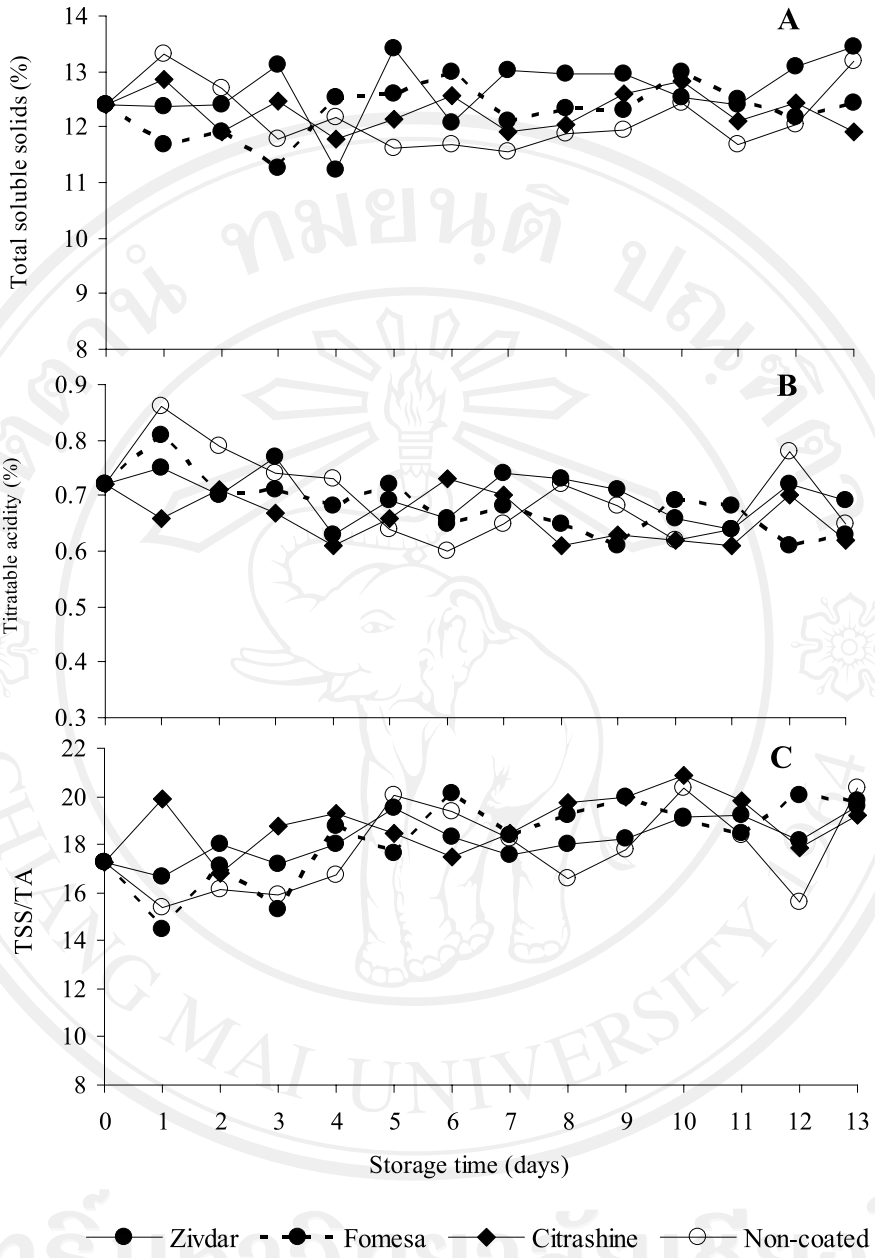

Figure 4.35 Effects of 3 commercial coatings on the (A) total soluble solids, (B) titratable acidity and (C) TSS/TA ratio of tangerine fruit stored at room temperature (24±3°C) and 59±6% relative humidity for 13 days

4.2.1.10 pH

The results showed that there was no significant difference between the pH value of coated and non-coated fruit. pH values of tangerine fruit slightly increased during storage at room temperature for 13 days (Table 4.11 and Figure 4.36).

4.2.1.11 Vitamin C

Vitamin C contents were not significantly different among the tangerine fruit coated with Fomesa, Citrashine, Zivdar and non-coated control. The results also found that vitamin C of tangerine fruit in all treatments slightly decreased during storage for 13 days at room temperature (Table 4.11 and Figure 4.36).

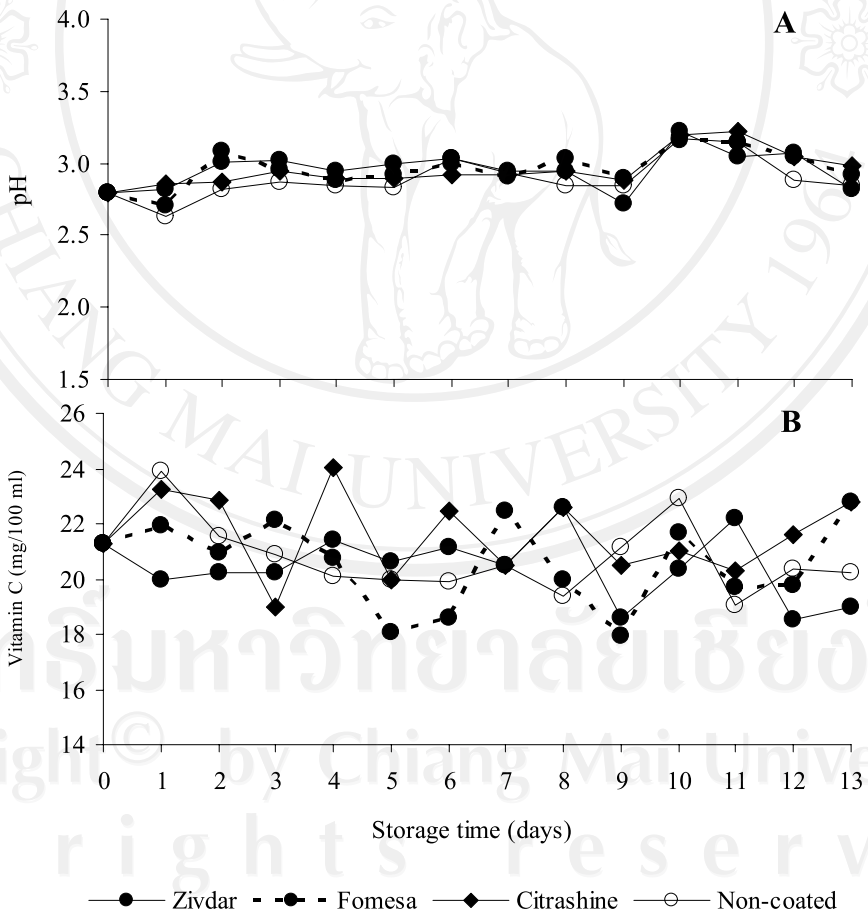

Figure 4.36 Effects of 3 commercial coatings on the (A) pH and (B) vitamin C of tangerine fruit stored at room temperature (24±3°C) and 59±6% relative humidity for 13 days

4.2.2 Effect of commercial coatings on the physico-chemical and physiological characters of tangerine fruit during storage at 5°C

Tangerine fruit cv. 'Sai Nam Phueng' were coated with 3 commercial coatings (Zivdar, Fomesa and Citrashine) by commercial methods and then stored at 5±2°C and 85±3% relative humidity for 41 days.

4.2.2.1 Weight loss

Weight losses of tangerine fruit were 5.39±0.89, 5.66±0.73 and 6.31±1.11% for fruit coated with Citrashine, Fomesa and Zivdar, respectively. Weight losses of coated fruit lower than non-coated control fruit during storage. Weight losses increased with storage time, nearly 9% after 46 days at 5°C for non-coated samples (Table 4.12 and Figure 4.37).

Weight losses of tangerine fruit were significantly reduced by commercial coatings. Reduction in weight loss over control was 27.84% by Citrashine, 24.23% by Fomesa and 15.53% by Zivdar.

4.2.2.2 Internal gases

4.2.2.2.1 Internal O_2

Coated tangerine had lower internal O_2 concentration than non-coated control. The lowest internal O_2 concentrations were found in tangerine fruit coated with Fomesa (4.11±1.39) and Citrashine (4.22±2.02%), while the highest concentrations were in control fruit (14.67±2.05%), followed by fruits coated with Zivdar (9.36±4.76). Fruit coated with Fomesa and Citrashine had the higher rate of decrease in internal O_2 concentration than fruit coated with Zivdar (Table 4.12 and Figure 4.38).

4.2.2.2.2 Internal CO_2

Internal CO_2 concentration was highest in tangerine coated with Fomesa (14.13±2.88%) followed by Citrashine (13.12±2.90%). Tangerine fruit coated with Zivdar was not significant different in internal CO_2 concentration from non-coated control fruit. Internal CO_2 concentration of fruit in all treatments increased during storage (Table 4.12 and Figure 4.38).

The results showed that coating treatments had higher internal CO_2 level and lower internal O_2 level than control. Zivdar coating also appeared to be the best effective on gas exchange between fruit and atmosphere. Coated fruit reached an internal gas composition around 4 or 10% O_2 and 12-18% CO_2 at the end of storage. Coatings with Citrashine and Fomesa modified the tangerine internal atmosphere more than those coated with Zivdar (Table 4.12 and Figure 4.38).

Table 4.12 Weight loss, internal O_2, internal CO_2 and ethanol content in juice of tangerine fruit cv. 'Sai Nam Phueng' coated with commercial coatings by commercial method during storage at 5±2°C and 85±3% relative humidity for 41 days

Commercial coatings	Weight loss (%)	Internal O_2 (%)	Internal CO_2 (%)	Ethanol content in juice (mg/l)
Zivdar	6.31±1.11^{b}	9.36±4.76^{b}	10.16±2.32^{bc}	514.37±7.02^{b}
Fomesa	5.66±0.73^{bc}	4.11±1.39^{c}	14.13±2.88^{a}	725.94±10.03^{ab}
Citrashine	5.39±0.89^{c}	4.22±2.02^{c}	13.12±2.90^{ab}	1089.91±394.05^{a}
Non-coated	7.47±1.85^{a}	14.67±2.05^{a}	6.75±1.67^{c}	462.23±121.33^{b}
$LSD_{0.05}$	0.77	6.36	4.38	388.18
C.V. (%)	19.72	52.20	25.38	29.54

Means followed by different superscript letters within a column are significantly different (P≤0.05)

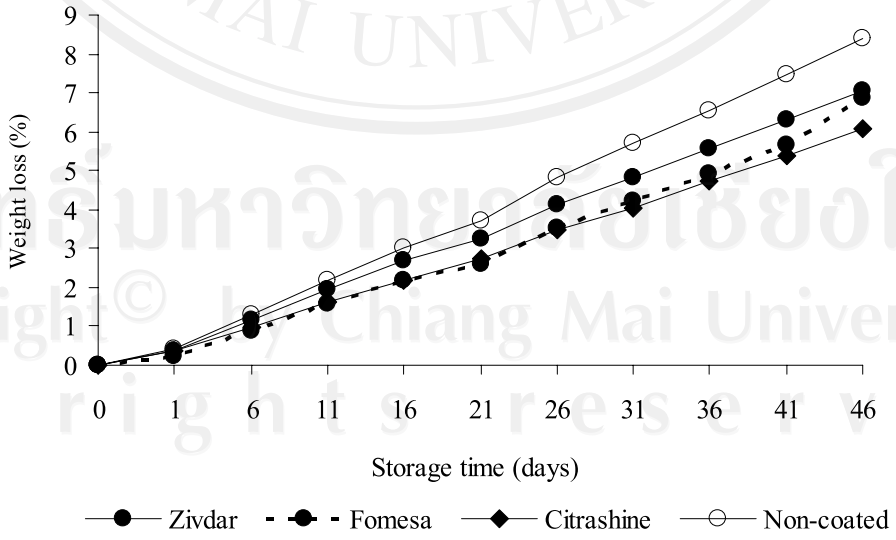

Figure 4.37 Effects of 3 commercial coatings on the weight loss of tangerine fruit stored at 5±2°C and 85±3% relative humidity for 46 days

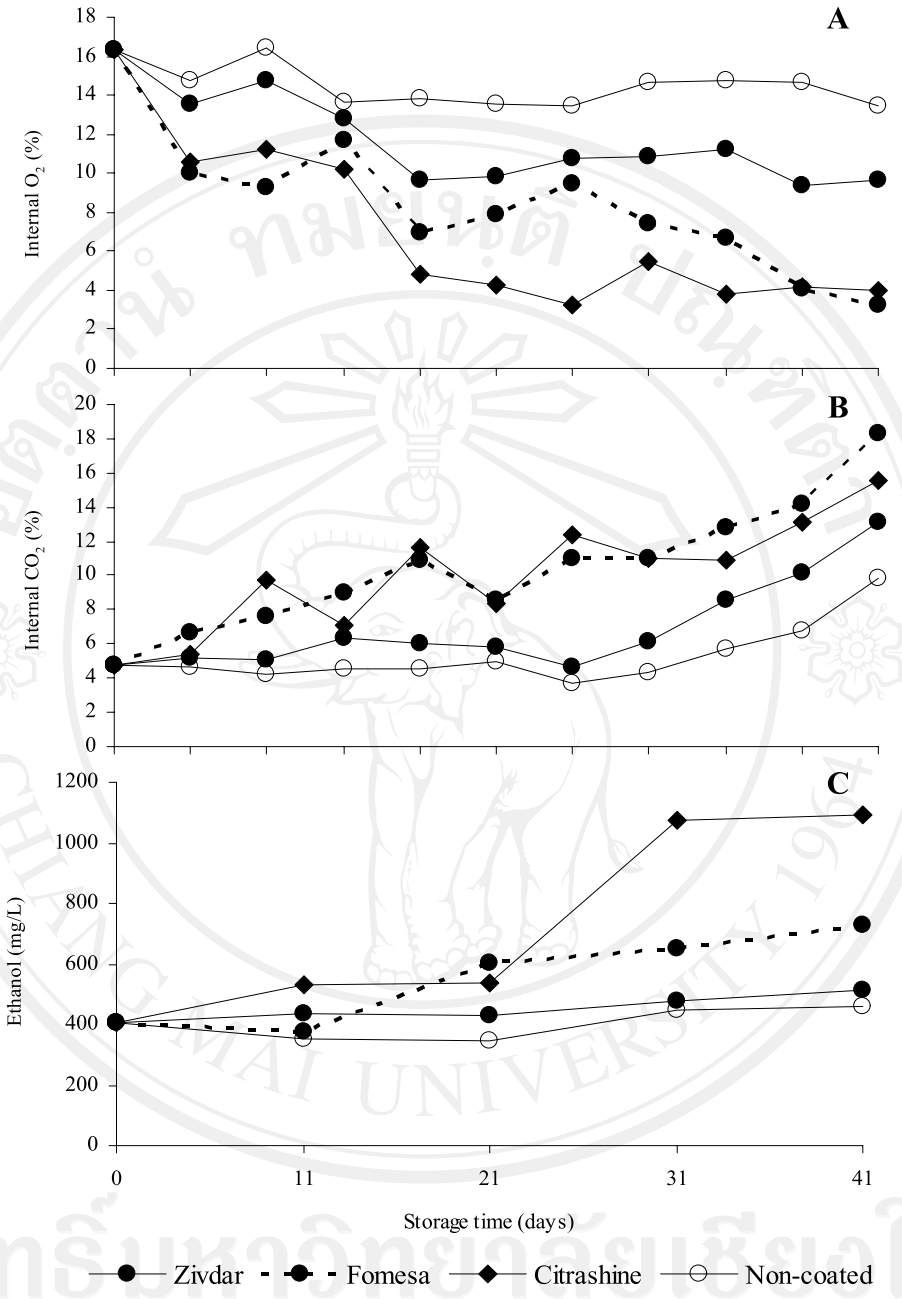

Figure 4.38 Effects of 3 commercial coatings on the (A) internal O_2, (B) internal CO_2 and (C) ethanol content of tangerine fruit stored at 5±2°C and 85±3% relative humidity for 46 and 41 days, respectively

4.2.2.3 Ethanol content in juice

Ethanol level was significantly higher in fruit coated with Citrashine (1,089.91±394.05 mg/L), followed by that coated with the Fomesa (725.94±10.03 mg/L). A similar level of ethanol content was obtained for the Zivdar-coated fruit (514.37±7.02 mg/L) and non-coated control fruit (462.23±121.33 mg/L). The results indicated that the amount of ethanol content of coated fruit increased with increase the storage period, while, the ethanol content of non-coated fruit with the relatively constant during storage (Table 4.12 and Figure 4.38).

4.2.2.4 Fermentative enzymes

4.2.2.4.1 Pyruvate decarboxylase activity (PDC activity)

Table 4.13 showed that tangerine fruit coated with Fomesa had higher PDC activity (1.02±0.82 units/min/mg protein) than fruit coated with Zivdar (0.42±0.13 units/min/mg protein), Citrashine (0.65±0.27 units/min/mg protein) and non-coated fruit (0.48±0.14 units/min/mg protein). Based on Figure 4.39 and Table A.50, the enzyme activities of the fruit in all treatments were high from the initial time, then decreased in all treatments. However, when considering the activity of enzyme, the results found that the correlation was relatively low compared to tangerine fruit stored at room temperature. The variable values of PDC activity about only 0.22 to 1.77 units/min/mg protein. This may be because of the analysis of enzyme activity of fruit stored at 5°C, made every 5 days. Based on the PDC activity of tangerine fruit storage at room temperature shows that enzyme activity has increased and decreased in the short period about 4-5 days (Table A.50 and Figure 4.39).

4.2.2.4.2 Alcohol dehydrogenase activity (ADH activity)

ADH activity of fruit coated with Zivdar (0.60±0.43 units/min/mg protein), Fomesa (0.38±0.21 units/min/mg protein), Citrashine (0.53±0.27 units/min/mg protein) and non-coated control (0.40±0.19 units/min/mg protein) were not significant different (Table 4.13). Figure 4.39 and Table A.51 showed that enzyme activity of tangerine fruit in all treatments were low for the duration of storage and there was no difference in all treatments. The variable values in the range of about 0.14 up to 1.01 units/min/mg protein.

Table 4.13 Pyruvate decarboxylase acitivity and alcohol dehydrogenase activity of tangerine fruit cv. 'Sai Nam Phueng' coated with commercial coatings by commercial method during storage at 5±2°C and 85±3% relative humidity for 41 days

Commercial coatings	Pyruvate decarboxylase activity (units/min/mg protein)	Alcohol dehydrogenase activity (units/ min/ mg protein)
Zivdar	0.42±0.13[b]	0.60±0.43
Fomesa	1.02±0.82[a]	0.38±0.21
Citrashine	0.65±0.27[b]	0.53±0.27
Non-coated	0.48±0.14[b]	0.40±0.19
$LSD_{0.05}$	0.83	0.66
C.V. (%)	28.99	33.42

Means followed by different superscript letters within a column are significantly different (P≤0.05)

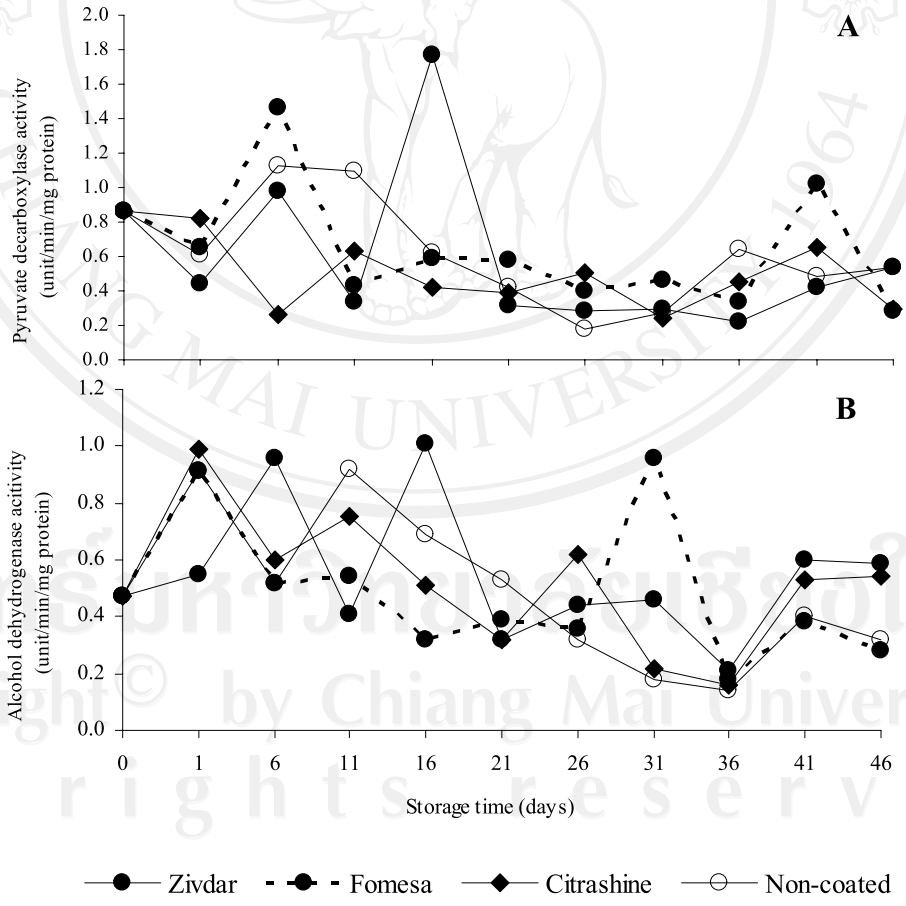

Figure 4.39 Effects of 3 commercial coatings on the (A) pyruvate decarboxylase activity and (B) alcohol dehydrogenase activity of tangerine fruit stored at 5±2°C and 85±3% relative humidity for 46 days

4.2.2.5 Assessment of flavor and visual appearance

4.2.2.5.1 Flavor

Regarding the presence of flavor, a significant build-up of bad odors in fruit coated with Citrashine (2.20±0.42 score) and Fomesa (2.20±0.79 score) after 41 days 5±2°C and 85±3% relative humidity was detected. In addition, a slight alteration of flavor and taste in fruit coated with Zivdar (3.40±0.52 score). Flavor score of non-coated fruit was 4.00±0.00, indicated that fruit had normal smell and taste. The results showed that fruit coated with Citrashine had smell and taste disorders faster than other treatments, followed by fruit coated with Fomesa, which smell and taste disorders clearly on day 16 and 26 of storage, respectively. The flavor of tangerine decreased with storage time, but it was considered within the range of acceptability for Zivdar-coated fruit after storage 46 days at 5°C (Table 4.14 and Figure 4.40).

4.2.2.5.2 Visual appearance

After storage for 41 days at 5°C, tangerine fruit coated with Citrashine and Fomesa showed the highest score for visual appearance (4.00±0.67 and 3.60±0.52, respectively), followed by those coated with Zivdar (3.00±0.67). Non-coated fruit had the lowest score for visual appearance (Table 4.14 and Figure 4.40).

The flavor and visual appearance scores significantly decreased along the storage period. Flavor scores were rates as acceptable quality on control and fruit coated with Zivdar, and of poor quality on fruit coated with Citrashine and Fomesa. The effect of Citrashine and Fomesa coatings maintaining tangerine good visual appearance could be related to its best weight loss control.

Visual appearance of tangerine fruit cv. ‘Sai Nam Phueng’ coated with 3 commercial coatings during storage at 5±2°C and 85±3% relative humidity for 0, 21 and 41 days were shown in Figure 4.41

Table 4.14 Flavor score, visual appearance score and peel color of tangerine fruit cv. 'Sai Nam Phueng' coated with commercial coatings by commercial method during storage at 5±2°C and 85±3% relative humidity for 41 days

Commercial coatings	Flavor (score)	Visual appearance (score)	Peel color		
			L*	chroma	hue angle
Zivdar	3.40±0.52^{b}	3.00±0.67^{b}	64.16±2.48	63.89±5.57	75.35±5.05^{a}
Fomesa	2.20±0.79^{c}	3.60±0.52^{a}	65.37±4.92	65.57±6.50	72.83±4.76^{ab}
Citrashine	2.20±0.42^{c}	4.00±0.67^{a}	63.48±2.54	62.76±6.54	76.29±7.72^{a}
Non-coated	4.00±0.00^{a}	2.20±0.42^{c}	64.26±2.76	68.10±7.00	71.20±5.35^{b}
$LSD_{0.05}$	0.47	0.52	2.10	4.05	3.68
C.V. (%)	17.51	18.04	5.12	9.87	7.91

Means followed by different superscript letters within a column are significantly different (P≤0.05)

Evaluation of flavor by tasting, using a scale of 1 to 4 where 4 = excellent, 3 = slightly off-flavor, 2 = moderately off-flavor and 1 = extremely off-flavor. Fruit taste was rated "unacceptable" when the taste score was below three.

Evaluation of visual appearance (wilting and shriveling), using a scale of 1 to 5 where 5 = excellent, 4 = good, 3 = fair, 2 = poor and 1 = unusable. Fruit appearance was rated "unacceptable" when the score was below three.

4.2.2.6 Peel color

4.2.2.6.1 L*

L* value of tangerine fruit coated with Fomesa, Zivdar, Citrashine and non-coated fruit were not significant different (Table 4.14). As can be observed in Figure 4.42, all the samples showed decreasing L* values with storage time.

4.2.2.6.2 chroma

No significant differences were found among the chroma of tangerines treated with different commercial coatings and non-coated fruit. The chroma values of fruit in all treatments tended to be constant throughout the storage period (Table 4.14 and Figure 4.42).

4.2.2.6.3 hue angle (H°)

Hue angle of non-coated tangerine fruit (71.20±5.35°) was less than fruit coated with Zivdar and Citrashine (75.35±5.05 and 76.29±7.72°, respectively), but not

different with Fomesa-coated fruit (72.83±4.76°). The hue angle of tangerine fruit slightly decrease during storage (Table 4.14 and Figure 4.42).

During storage important changes regarding the color parameters L* and hue angle occurred. There was a decreased in L* values which means a reduction of brightness, and a concomitant decline in hue angle, which represents and increase in yellow, indicating a loss of chlorophyll. The greatest changes in hue angle took place in non-coated fruit.

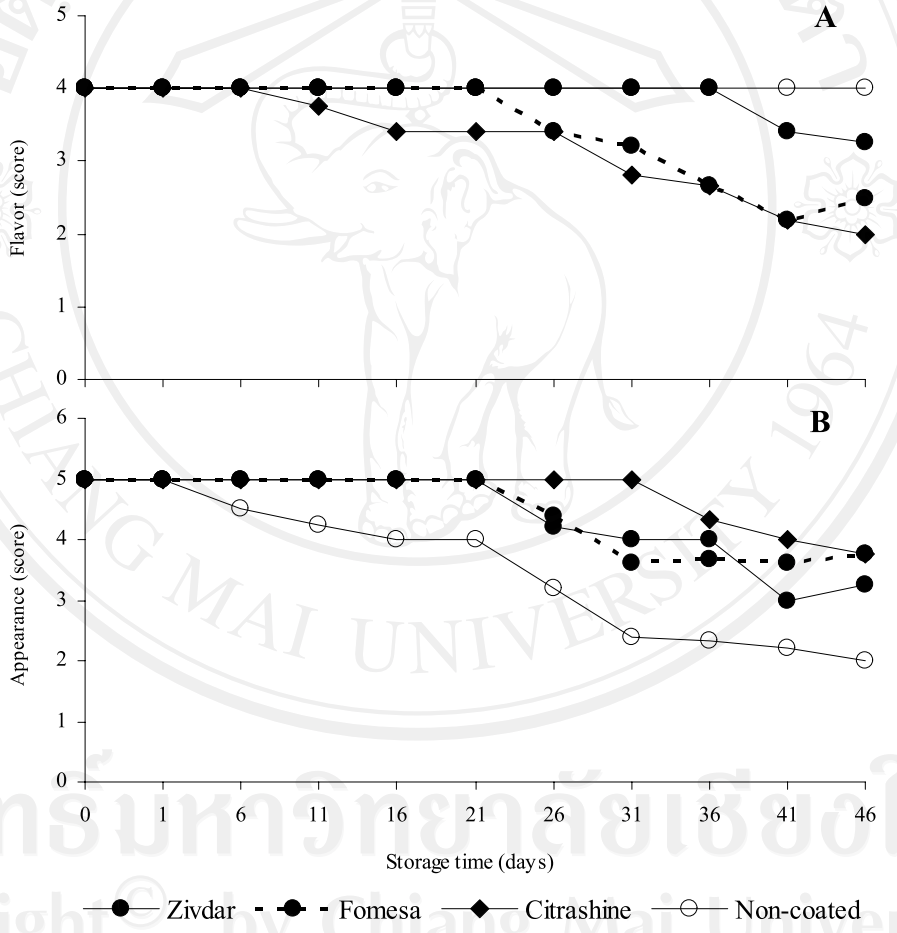

Figure 4.40 Effects of 3 commercial coatings on the (A) flavor score and (B) visual appearance score of tangerine fruit stored at 5±2°C and 85±3% relative humidity for 46 days

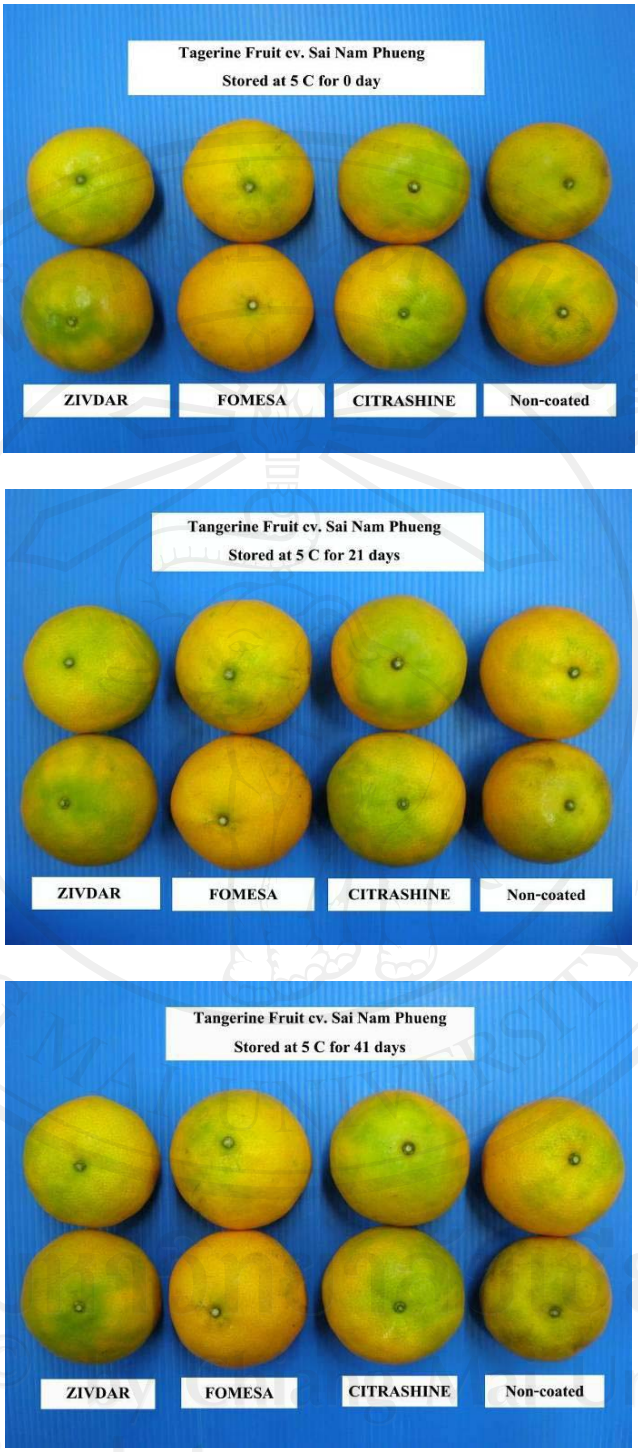

Figure 4.41 Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with 3 commercial coatings during storage at 5±2°C and 85±3% relative humidity for 0, 21 and 41 days

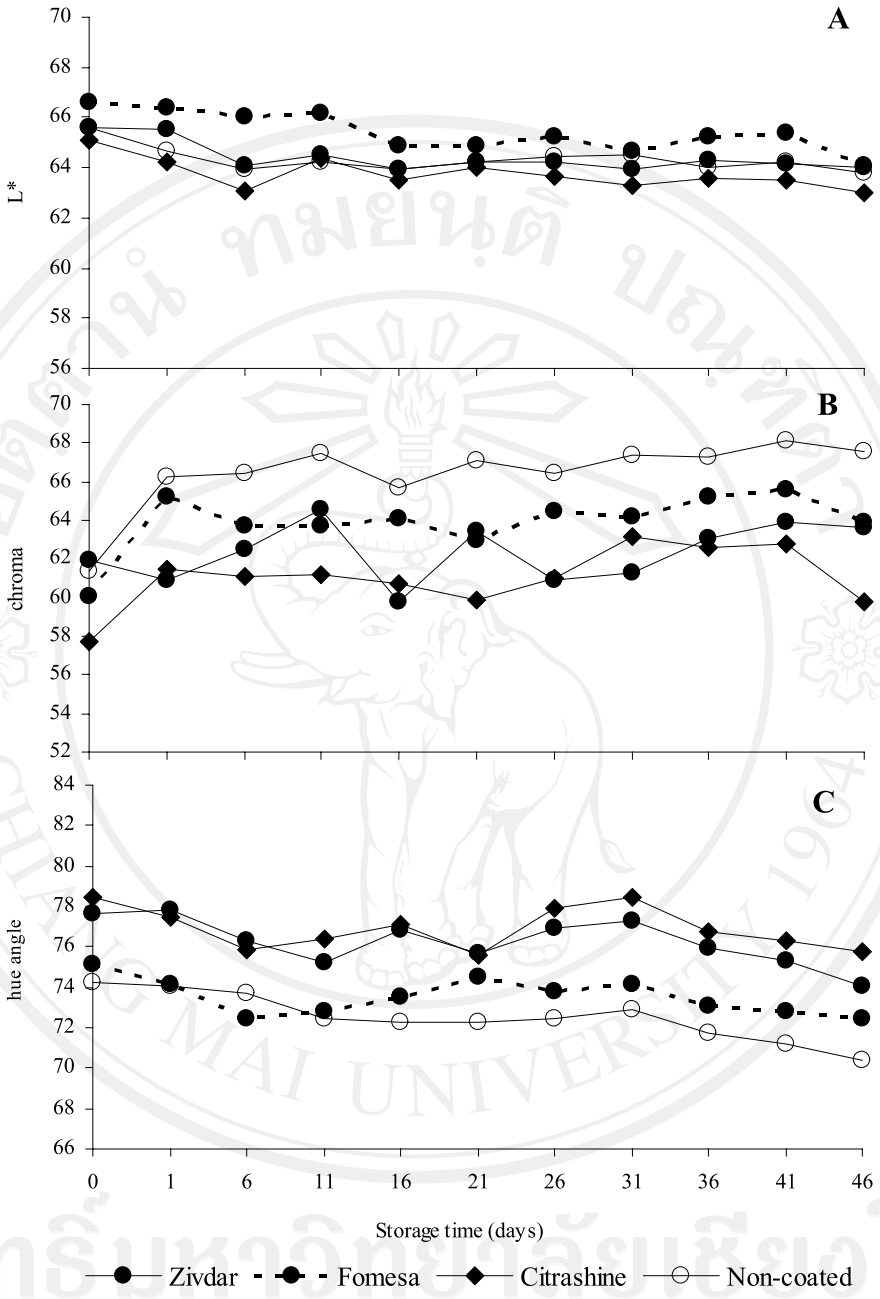

Figure 4.42 Effects of 3 commercial coatings on the (A) L*, (B) chroma and (C) hue angle of tangerine fruit stored at 5±2°C and 85±3% relative humidity for 46 days

4.2.2.7 Total soluble solids (TSS)

Coating treatments had no effect on total soluble solids of tangerine fruit. Total soluble solids of tangerine in all treatments were quite variable during storage (Table 4.15 and Figure 4.43).

4.2.2.8 Titratable acidity (TA)

The titratable acidity of tangerine fruit in all treatments decreased with the storage period. Differences with respect to coated treatments and non-coated control were not significant (Table 4.15 and Figure 4.43).

4.2.2.9 TSS/TA ratio

The results indicated that with increasing of maintenance period, TSS/TA ratio content of tangerine fruit increased in all treatments. Commercial coatings did not significantly influence on the TSS/TA ratio (Table 4.15 and Figure 4.43).

The progressive reduction of titratable acidity and the concomitant slight variations in total soluble solids led to a very important increase in the ratio.

Table 4.15 Total soluble solids (TSS), titratable acidity (TA), TSS/TA ratio, pH and vitamin C content of tangerine fruit cv. 'Sai Nam Phueng' coated with commercial coatings by commercial method during storage at 5±2°C and 85±3% relative humidity for 41 days

Commercial coatings	TSS (%)	TA (%)	TSS/TA ratio	pH	Vitamin C content (mg/100 ml juice)
Zivdar	12.43±0.12	0.66±0.02	18.90±0.56	3.04±0.03	18.87±1.89
Fomesa	12.00±0.78	0.66±0.03	18.10±0.81	3.03±0.03	17.61±2.18
Citrashine	13.00±0.46	0.66±0.03	19.65±1.31	3.03±0.04	18.24±1.09
Non-coated	11.83±0.61	0.66±0.02	18.00±1.23	3.03±0.01	20.75±1.89
$LSD_{0.05}$	1.03	0.04	1.93	0.05	3.40
C.V. (%)	4.46	3.03	5.50	0.87	9.58

Means followed by different superscript letters within a column are significantly different (P≤0.05)

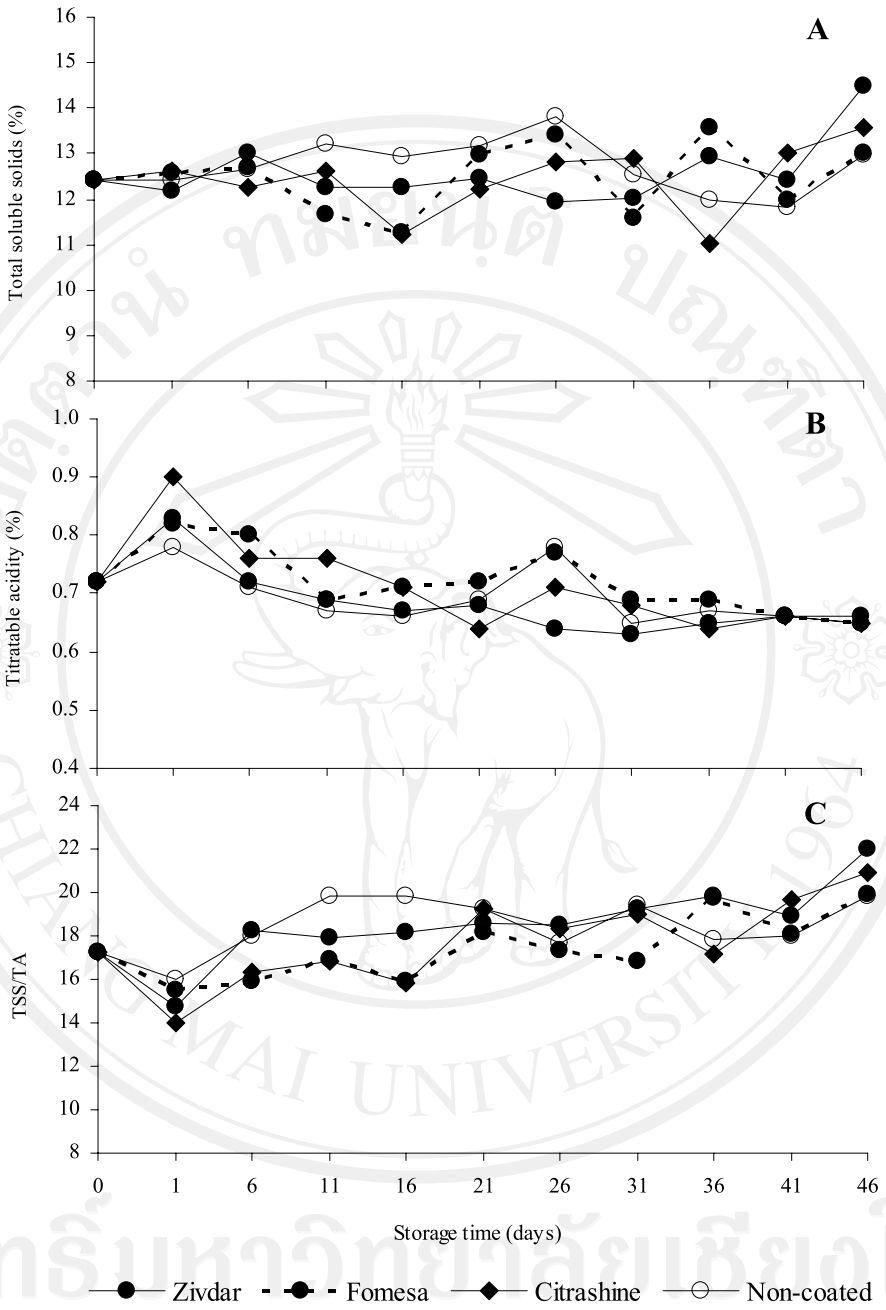

Figure 4.43 Effects of 3 commercial coatings on the (A) total soluble solids, (B) titratable acidity and (C) TSS/TA ratio of tangerine fruit stored at 5±2°C and 85±3% relative humidity for 46 days

4.2.2.10 pH

No significant differences on pH were observed in the various coated treatments and control fruit. The pH of coated and non-coated samples increased during storage (Table 4.15 and Figure 4.44).

4.2.2.11 Vitamin C

According to Table 4.15 it is clear that vitamin C of tangerine fruit was not affected significantly by commercial coatings during cold storage. Vitamin C of tangerine fruit showed a progressive decrease due to coatings with commercial waxes under cold storage period including control fruit (Figure 4.44).

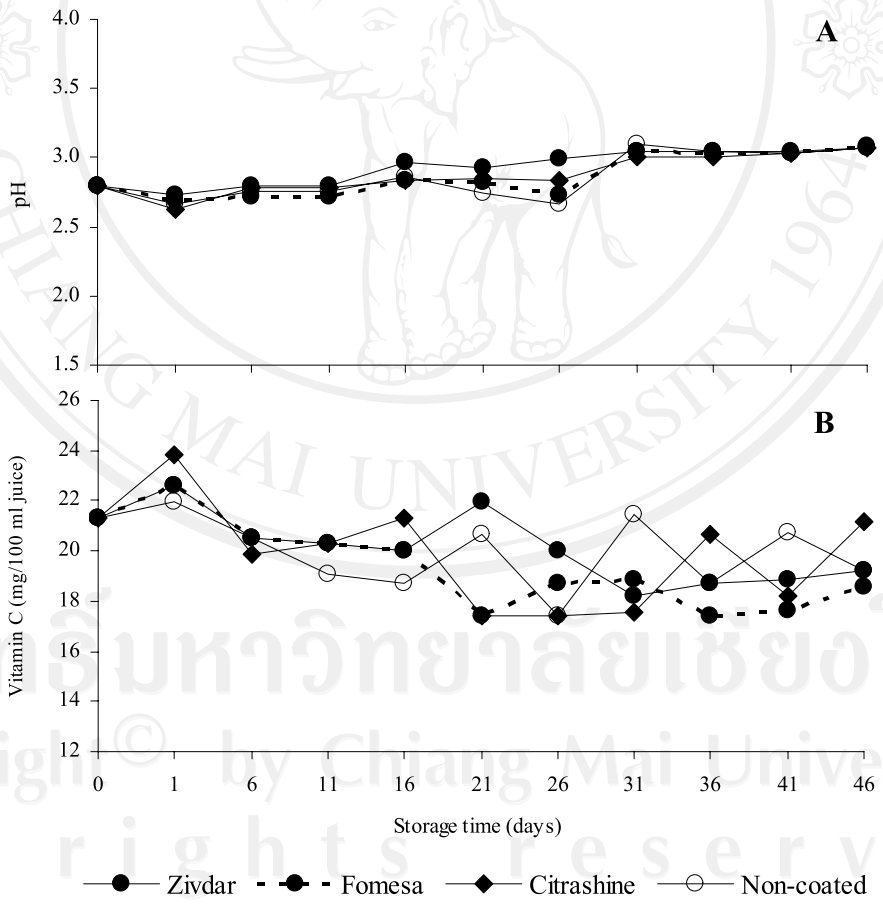

Figure 4.44 Effects of 3 commercial coatings on the (A) pH and (B) vitamin C of tangerine fruit stored at 5±2°C and 85±3% relative humidity for 46 days

4.3 Screening of developed coating materials for tangerine fruit cv. 'Sai Nam Phueng'

Tangerine fruit were coated with different developed coating materials which were divided into 5 experiments (Group A, B, C, D and E) as follows;

Group A

Tangerine fruit were coated with 4% zein, 8% zein, 12% zein, 18% polyethylene, 17% polyethylene + 1% shellac, 16% polyethylene + 2% shellac and non-coated fruit as control. Fruit were stored at room temperature (24±3°C) and 74±7% relative humidity for 12 days.

Group B

Tangerine fruit were coated with 18% carnauba, 17% carnauba + 1% shellac, 16% carnauba + 1.28% shellac, 18% polyethylene, 17% polyethylene + 1% shellac, 8% zein and non-coated as control. Fruit were stored at room temperature (21±3°C) and 72±6% relative humidity for 15 days.

Group C

Tangerine fruit were coated with 15% carnauba + 1% shellac, 14% carnauba + 1.54% shellac, 17.5% carnauba + 0.5% shellac, 15% polyethylene + 1% shellac, 14% polyethylene + 1.54% shellac, 17.5% polyethylene + 0.5% shellac and non-coated fruit as control. Fruit were stored at room temperature (22±3°C) and 73±6% relative humidity for 15 days.

Group D

Tangerine fruit were coated with 15% polyethylene + 2% zein, 16% polyethylene + 1% gum arabic, 19% polyethylene + 5% glycerine, 17.5% polyethylene + 0.5% shellac, 20% gum arabic, 8% zein, 2% chitosan (in citric acid), 20% polyethylene and non-coated fruit as control. Fruit were stored at room temperature (20±4°C) and 67±7% relative humidity for 12 days.

Group E

Tangerine fruit were coated with 6% candelilla + 14% polyethylene, 8% candelilla + 12% polyethylene, 10% candelilla + 10% polyethylene, 1% chitosan + 1% oleic acid, 1% chitosan + 2% oleic acid, 1% chitosan + 3% oleic acid, 1% chitosan, 20% candelilla and 20% polyethylene and non-coated fruit as control. Fruit were stored at room temperature (27±4°C) and 57±8% relative humidity for 9 days.

4.3.1 Weight loss

Group A

The results showed that non-coated fruit had the highest weight loss throughout the storage period for 12 days. Coating with 18% polyethylene, 17% polyethylene + 1% shellac and 17% polyethylene + 2% shellac was more effective in reducing weight loss than coating with 4%, 8% and 12% zein. However, fruit coated with 4%, 8% and 12% zein had lower weight loss than non-coated fruit. The decrease of weight losses were 47.42%, 46.50% and 54.31% in the fruit coated with 18% polyethylene, 17% polyethylene + 1% shellac and 17% polyethylene + 2% shellac, respectively (Table 4.16 and Figure 4.45).

Group B

Weight loss increased progressively reaching 10.73±1.77% in non-coated fruit at the end of the storage. In fruit coated with 17% carnauba + 1% shellac, 16% carnauba + 1.28% shellac and 17% polyethylene + 1% shellac, weight loss reduced to a low level, and after the 15 days of storage. They were about 5.53±0.67, 5.58±0.74 and 6.04±0.52%, respectively. Coated tangerine fruit with 8% zein, on the contrary, showed only a slight influence and at the end of the storage only 9.65±1.80% reduction of the initial weight was recorded (Table 4.17 and Figure 4.45).

Group C

Weight loss was significantly reduced by coating materials. Reduction in weight loss over control was 53.47% by 15% carnauba + 1% shellac, 50.08% by 14% carnauba + 1.54% shellac, 55.00% by 17.5% carnauba + 0.5% shellac, 40.68% by 15% polyethylene + 1% shellac, 46.78% by 14% polyethylene + 1.54% shellac and 50.68% by 17.5% polyethylene + 0.5% shellac. Considering weight loss only, the potential economic life of tangerine fruit was doubled by coating treatments, 17.5% carnauba + 0.5% shellac coating was the best with regard to weight loss (Table 4.18 and Figure 4.45).

Group D

Weight loss of tangerine fruit increased with storage time, increasing to nearly 11% after 12 days at room temperature for 20% gum arabic coated and non-coated fruit. Compared to the control, 20% polyethylene and 17.5% polyethylene + 0.5% shellac coatings reduced weight loss up to 52 and 45% respectively, while fruit coated

with 15% polyethylene + 2% zein, 16% polyethylene + 1% gum arabic, 19% polyethylene + 5% glycerine and 2% chitosan (in citric acid) coatings reduced weight loss around 27-36% (Table 4.19 and Figure 4.45).

Group E

Weight loss was lower throughout the storage period in coated fruit compared to non-coated control fruit. The fruit coated with 1% chitosan, 1% chitosan + 1% oleic acid, 1% chitosan + 2% oleic acid and 1% chitosan + 3% oleic acid resulted in higher weigh loss was 1.7 to 3.5 times greater than those coated with 6% candelilla + 14% polyethylene, 8% candelilla + 12% polyethylene, 10% candelilla + 10% polyethylene, 20% candelilla and 20% polyethylene. Tangerine fruit coated with 20% candelilla had the lowest weight loss, followed by 10% candelilla + 10% polyethylene, 8% candelilla + 12% polyethylene, 6% candelilla + 14% polyethylene and 20% polyethylene (Table 4.20 and Figure 4.45).

4.3.2 Assessment of flavor and visual appearance.

4.3.2.1 Flavor

Group A

The results showed that tangerine fruit coated with 18% polyethylene, 17% polyethylene + 1% shellac and 17% polyethylene + 2% shellac had less of flavor score than fruit coated with zein solution. Sensory evaluation showed a significant difference in flavor score after 10 days of storage between fruit coated with 4% zein and other coating treatments. Non-coated control fruit had the highest flavor score during storage for 12 days at room temperature.

The results indicated that tangerine fruit coated with 18% polyethylene, 17% polyethylene + 1% shellac and 17% polyethylene + 2% shellac had greater abnormal smell and taste than fruit coated zein coatings. Non-coated fruit had no abnormal smell and taste throughout the duration of storage (Table 4.21 and Figure 4.46).

Group B

The presence of flavor, a significant build-up of bad smell and taste in fruit coated with 16% carnauba + 1.28% shellac and 17% polyethylene + 1% shellac during storage at room temperature were detected, while no significant differences were found in non-coated fruit. In addition, a slight alteration of flavor and taste in

fruit coated with 18% Carnauba, 18% polyethylene and 8% zein were perceived after 15 days of storage. The results demonstrated that panelist found more acceptable in flavor of control fruit throughout the storage period (Table 4.22 and Figure 4.46).

Group C

During storage for 15 days, the results showed that there was a statistically significant difference in smell and taste evaluations between coated and non-coated fruit. Fruit coated with 17.5% polyethylene + 0.5% shellac was the most acceptable by panelist. By the assessment of flavor from 12 to 15 days of storage were varied in the range of 3.00 to 3.25 scores, which means that citrus fruit had a little abnormal odor and taste. While, tangerine fruit coated with other coatings had the moderate and large of smell and taste disorders. Tangerine fruit coated with 15% carnauba + 1% shellac, 14% carnauba + 1.54% shellac and 17.5% carnauba + 0.5% shellac had the abnormal smell and taste greater than other treatments. The non-coated fruit with the normally odor and taste occur throughout the storage period (Table 4.23 and Figure 4.46).

Group D

After 15 days at room temperature, the smell and taste of non-coated fruit was better than all coating treatments. Fruit coated with 17.5% polyethylene + 0.5% shellac, 8% zein and 19% polyethylene + 5% glycerine had moderately acceptable, while 20% gum arabic, polyethylene 15%+ 2% zein and 2% chitosan (in citric acid) had poor flavor, which was associated with strong off-flavor, compared to all others treatments (Table 4.24 and Figure 4.46).

Group E

The results showed that a slightly loss of taste and aroma was noted in fruit coated with 8% candelilla + 12% polyethylene form the 5th day of storage. The loss of taste and the strange aromas in fruit coated with 1% chitosan, 10% candelilla + 10% polyethylene and 20% candelilla, were considered to be unacceptable before other treatments. The non-coated fruit maintained the best taste and aroma, and was acceptable for consumption during storage for 9 days (Table 4.25 and Figure 4.46).

4.3.2.2 Visual appearance

Group A

The results of visual appearance of tangerines are presented in Table 4.26 from which it appears that 17% polyethylene + 1% shellac and 17% polyethylene + 2% shellac helped to maintain external appearance of tangerine fruit during storage at room temperature, a panel of judges gave a maximum scores to the fruit. The results also showed that 17% polyethylene + 1% shellac and 17% polyethylene + 2% shellac preserved these external characteristics, followed by 18% polyethylene, 12% and 8% zein, while 4% zein was less effective (Table 4.26 and Figure 4.47).

Group B

The visual appearance of tangerine fruit decreased with storage time, but it was considered within the range of acceptability for fruit coated with 16% carnauba + 1.28% shellac, followed by 17% carnauba + 1% shellac, 17% polyethylene + 1% shellac, and 18% polyethylene treatments after storage for 15 days at room temperature. Non-coated tangerine fruit were evaluated with the lowest visual appearance score throughout the storage period (Table 4.27 and Figure 4.47).

Group C

The evaluation of visual appearance score of tangerine fruit in all treatments continuously decreased during storage. The score of visual appearance in control fruit reduced before coated fruit, and decreased at the higher rate, means that non-coated fruit begin to shrink before coated fruit. Fruit coated with 14% polyethylene + 1.54% shellac, 17.5% carnauba + 0.5% shellac, 15% carnauba + 1% shellac and 14% carnauba + 1.54% shellac could slow down of shrivel symptoms better than other treatments (Table 4.28 and Figure 4.47).

Group D

During storage at room temperature, there were no differences found between the visual appearance of fruit coated with 20% gum arabic and non-coated tangerine fruit. Under prolonged storage, 17.5% polyethylene + 0.5% shellac coating was the most effective on maintain visual appearance compared to control, followed by 20% polyethylene and 19% polyethylene + 5% glycerine coatings. All other coatings had the less effective on visual appearance (Table 4.29 and Figure 4.47).

Group E

The highest score of visual appearance was recorded in tangerine fruit coated with 6% candelilla + 14% polyethylene, 8% candelilla + 12% polyethylene, 10% candelilla + 10% polyethylene, 20% candelilla and 20% polyethylene and the lowest score was found in non-coated fruit. The results also showed that there was no significant difference in visual appearance of chitosan, chitosan + oleic acid coatings and control fruit during storage for 9 days at room temperature (Table 4.30 and Figure 4.47).

Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with developed coatings Group A, B, C, D and E during storage at room temperature were shown in Figure 4.48 to 4.52.

Table 4.16 Weight loss of tangerine fruit coated with developed coatings (Group A) during storage at room temperature (24±3°C) and 74±7% relative humidity for 12 days

Coating treatments	Storage time (days)						
	0	1	2	3	4	5	6
4% zein	0.00±0.00	0.95±0.21^{b}	1.82±0.40^{b}	2.57±0.52^{b}	3.29±0.66^{b}	3.96±0.79^{b}	4.57±0.89^{a}
8% zein	0.00±0.00	1.05±0.22^{a}	1.77±0.40^{b}	2.41±0.55^{b}	3.04±0.70^{bc}	3.64±0.84^{bc}	4.14±0.96^{b}
12% zein	0.00±0.00	0.89±0.16^{b}	1.67±0.29^{b}	2.40±0.39^{b}	2.96±0.51^{c}	3.53±0.61^{c}	4.00±0.70^{b}
18% polyethylene	0.00±0.00	0.66±0.08^{c}	1.13±0.14^{c}	1.50±0.19^{c}	1.93±0.24^{d}	2.35±0.28^{d}	2.66±0.33^{c}
17% polyethylene + 1% shellac	0.00±0.00	0.62±0.05^{c}	1.11±0.08^{c}	1.56±0.12^{c}	2.01±0.16^{d}	2.40±0.19^{d}	2.77±0.23^{c}
16% polyethylene + 2% shellac	0.00±0.00	0.59±0.06^{c}	1.02±0.10^{c}	1.41±0.13^{c}	1.75±0.17^{d}	2.07±0.21^{d}	2.36±0.24^{c}
non-coated	0.00±0.00	1.14±0.21^{a}	2.04±0.39^{a}	2.82±0.50^{a}	3.70±0.76^{a}	4.50±0.76^{a}	5.20±0.87^{a}
LSD $_{0.05}$	-	18.59	19.28	18.47	18.47	18.37	18.34
C.V. (%)	-	0.10	0.18	0.24	0.31	0.37	0.42

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.16 (Continued) Weight loss of tangerine fruit coated with developed coatings (Group A) during storage at room temperature (24±3°C) and 74±7% relative humidity for 12 days

Coating treatments	Storage time (days)					
	7	8	9	10	11	12
4% zein	5.08±0.98^{b}	5.48±1.05^{b}	6.01±1.17^{b}	7.02±2.42^{a}	7.15±1.40^{b}	7.66±1.50^{b}
8% zein	4.59±1.06^{c}	5.02±1.15^{bc}	5.47±1.26^{bc}	5.89±1.36^{b}	6.41±1.49^{c}	6.84±1.59^{c}
12% zein	4.47±0.81^{c}	4.90±0.89^{c}	5.34±0.99^{c}	5.77±1.08^{b}	6.42±1.20^{c}	6.91±1.29^{c}
18% polyethylene	3.06±0.34^{de}	3.32±0.38^{de}	3.63±1.18^{de}	3.97±3.45^{c}	4.32±0.50^{d}	4.58±0.54^{d}
17% polyethylene + 1% shellac	3.08±0.26^{d}	3.38±0.29^{d}	3.70±0.33^{d}	4.01±0.36^{c}	4.38±0.41^{d}	4.66±0.44^{d}
16% polyethylene + 2% shellac	2.61±0.28^{e}	2.84±0.31^{e}	3.10±0.35^{e}	3.36±0.38^{c}	3.71±0.43^{d}	3.98±0.45^{d}
non-coated	5.85±0.97^{a}	6.36±1.06^{a}	7.01±1.17^{a}	7.55±1.32^{a}	8.20±1.42^{a}	8.71±1.52^{a}
LSD $_{0.05}$	18.26	18.22	18.44	23.47	18.72	18.76
C.V. (%)	0.47	0.51	0.56	0.79	0.68	0.73

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.17 Weight loss of tangerine fruit coated with developed coatings (Group B) during storage at room temperature (21±3°C) and 72±6% relative humidity for 15 days

Coating treatments	Storage time (days)								
	0	1	2	3	4	5	6	7	8
18% carnauba	0.00±0.00	0.70±0.10^{cd}	1.26±0.17^{bc}	1.73±0.22^{bc}	2.15±0.28^{bc}	2.53±0.33^{bc}	2.93±0.39^{bc}	3.36±0.46^{bc}	3.76±0.52^{cd}
17% carnauba + 1% shellac	0.00±0.00	0.62±0.05^{de}	1.10±0.10^{d}	1.49±0.21^{d}	1.89±0.18^{d}	2.20±0.23^{d}	2.56±0.28^{d}	2.92±0.32^{d}	3.25±0.37^{e}
16% carnauba + 1.28% shellac	0.00±0.00	0.58±0.06^{e}	1.04±0.10^{d}	1.44±0.14^{d}	1.81±0.19^{d}	2.10±0.23^{d}	2.49±0.28^{d}	2.85±0.33^{d}	3.19±0.38^{e}
18% polyethylene	0.00±0.00	0.73±0.06^{c}	1.35±0.12^{b}	1.86±0.17^{b}	2.34±0.23^{b}	2.73±0.27^{b}	3.22±0.33^{b}	3.64±0.38^{b}	4.14±0.44^{c}
17% polyethylene + 1% shellac	0.00±0.00	0.64±0.06^{de}	1.15±0.08^{cd}	1.60±0.10^{cd}	1.99±0.13^{cd}	2.34±0.15^{cd}	2.73±0.20^{cd}	3.13±0.22^{cd}	3.51±0.26^{de}
8% zein	0.00±0.00	1.14±0.24^{a}	2.07±0.35^{a}	2.84±0.47^{a}	3.41±0.59^{a}	3.88±0.73^{a}	4.52±0.80^{a}	5.09±0.92^{a}	5.69±1.03^{b}
non-coated	0.00±0.00	1.06±0.18^{b}	1.95±0.32^{a}	2.69±0.44^{a}	3.42±0.56^{a}	4.00±0.66^{a}	4.75±0.77^{a}	5.38±0.90^{a}	6.11±1.00^{a}
$LSD_{0.05}$	-	0.08	0.13	0.18	0.22	0.27	0.31	0.36	0.40
C.V. (%)	-	16.20	14.40	14.62	14.50	15.03	14.82	15.04	16.44

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.17 (continued) Weight loss of tangerine fruit coated with developed coatings (Group B) during storage at room temperature (21±3°C) and 72±6% relative humidity for 15 days

Coating treatments	Storage time (days)						
	9	10	11	12	13	14	15
18% carnauba	4.13±0.58^{cd}	4.53±0.63^{c}	4.88±0.69^{cd}	5.30±0.76^{cd}	5.71±0.83^{cd}	6.10±0.89^{cd}	6.48±0.95^{cd}
17% carnauba + 1% shellac	3.59±0.42^{e}	3.89±0.45^{d}	4.19±0.49^{e}	4.53±0.54^{e}	4.89±0.58^{e}	5.21±0.63^{e}	5.53±0.67^{e}
16% carnauba + 1.28% shellac	3.53±0.42^{e}	3.87±0.47^{d}	4.19±0.53^{e}	4.53±0.59^{e}	4.92±0.64^{e}	5.25±0.69^{e}	5.58±0.74^{e}
18% polyethylene	4.58±0.49^{c}	4.99±0.55^{c}	5.41±0.60^{c}	5.85±0.67^{c}	6.31±0.71^{c}	6.72±0.76^{c}	7.13±0.81^{c}
17% polyethylene + 1% shellac	3.87±0.29^{de}	3.90±0.30^{d}	4.61±0.37^{de}	4.98±0.41^{de}	5.38±0.45^{de}	5.72±0.49^{de}	6.04±0.52^{de}
8% zein	6.25±1.15^{b}	6.79±1.25^{b}	7.34±1.35^{b}	7.93±1.48^{b}	8.56±1.59^{b}	9.09±1.73^{b}	9.65±1.80^{b}
non-coated	7.05±1.26^{a}	7.41±1.22^{a}	8.00±1.34^{a}	8.75±1.46^{a}	9.46±1.57^{a}	10.11±1.68^{a}	10.73±1.77^{a}
$LSD_{0.05}$	0.47	0.49	0.54	0.59	0.64	0.69	0.72
C.V. (%)	15.86	15.40	15.47	15.61	16.27	15.75	15.65

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.18 Weight loss of tangerine fruit coated with developed coatings (Group C) during storage at room temperature (22±3°C) and 73±6% relative humidity for 15 days

Coating treatments	Storage time (days)								
	0	1	2	3	4	5	6	7	8
15% carnauba + 1% shellac	0.00±0.00	0.50±0.05^{c}	1.00±0.19^{b}	1.42±0.25^{d}	1.84±0.20^{cd}	2.21±0.24^{cd}	2.61±0.28^{cd}	3.03±0.33^{d}	3.21±0.33^{e}
14% carnauba + 1.54% shellac	0.00±0.00	0.53±0.18^{c}	1.02±0.20^{b}	1.47±0.22^{c}	1.94±0.26^{cd}	2.34±0.29^{cd}	2.75±0.33^{cd}	3.21±0.37^{cd}	3.59±0.40^{cd}
17.5% carnauba + 0.5% shellac	0.00±0.00	0.48±0.07^{c}	0.93±0.16^{b}	1.32±0.21^{c}	1.75±0.26^{d}	2.09±0.31^{db}	2.47±0.36^{d}	2.87±0.40^{d}	3.22±0.40^{de}
15% polyethylene + 1% shellac	0.00±0.00	0.65±0.23^{b}	1.25±0.23^{a}	1.76±0.24^{b}	2.34±0.26^{b}	2.79±0.29^{c}	3.32±0.32^{b}	3.83±0.36^{b}	4.30±0.40^{b}
14% polyethylene + 1.54% shellac	0.00±0.00	0.48±0.27^{c}	0.99±0.12^{b}	1.50±0.17^{c}	2.30±0.21^{c}	2.46±0.25^{cd}	2.91±0.29^{c}	3.40±0.33^{c}	3.81±0.37^{c}
17.5% polyethylene + 0.5% shellac	0.00±0.00	0.49±0.10^{c}	0.96±0.18^{b}	1.41±0.23^{c}	1.86±0.34^{c}	2.26±0.41^{cd}	2.68±0.47^{c}	3.13±0.53^{cd}	3.52±0.59^{cd}
non-coated	0.00±0.00	0.91±0.18^{a}	1.90±0.37^{a}	2.76±0.53^{a}	3.74±0.69^{a}	4.53±0.83^{a}	5.42±0.98^{a}	6.39±1.21^{a}	7.15±1.23^{a}
$LSD_{0.05}$	0.00	0.09	0.14	0.18	0.22	0.27	0.31	0.37	0.39
C.V. (%)	-	24.52	19.14	17.95	16.00	15.82	15.52	15.85	14.97

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.18 (continued) Weight loss of tangerine fruit coated with developed coatings (Group C) during storage at room temperature (22±3°C) and 73±6% relative humidity for 15 days

Coating treatments	Storage time (days)						
	9	10	11	12	13	14	15
15% carnauba + 1% shellac	3.38±0.37^{e}	3.70±0.40^{e}	4.36±0.48^{d}	4.68±0.52^{d}	4.91±0.55^{d}	5.20±0.58^{d}	5.49±0.64^{d}
14% carnauba + 1.54% shellac	3.94±0.43^{cd}	4.27±0.46^{cd}	4.61±0.50^{cd}	5.00±0.54^{cd}	5.27±0.57^{c}	5.51±0.61^{cd}	5.89±0.65^{cd}
17.5% carnauba + 0.5% shellac	3.53±0.48^{de}	3.84±0.52^{de}	4.16±0.56^{d}	4.50±0.61^{d}	4.74±0.65^{d}	5.02±0.69^{d}	5.31±0.74^{d}
15% polyethylene + 1% shellac	4.68±0.44^{b}	5.11±0.47^{b}	5.51±0.52^{b}	5.97±0.56^{b}	6.26±0.59^{b}	6.62±0.63^{b}	7.00±0.67^{b}
14% polyethylene + 1.54% shellac	4.18±0.41^{c}	4.54±0.45^{c}	4.94±0.49^{c}	5.32±0.53^{c}	5.60±0.56^{c}	5.91±0.61^{c}	6.28±0.64^{c}
17.5% polyethylene + 0.5% shellac	3.83±0.65^{cd}	4.18±0.74^{cd}	4.56±0.76^{cd}	4.78±0.98^{cd}	5.19±0.86^{cd}	5.49±0.92^{cd}	5.82±0.97^{cd}
non-coated	7.86±1.34^{a}	8.56±1.45^{a}	9.26±1.57^{a}	10.06±1.69^{a}	10.53±1.77^{a}	11.16±1.88^{a}	11.80±1.99^{a}
$LSD_{0.05}$	0.42	0.46	0.50	0.55	0.56	0.60	0.63
C.V. (%)	14.91	14.90	14.75	15.15	14.71	14.81	14.82

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.19 Weight loss of tangerine fruit coated with developed coatings (Group D) during storage at room temperature (20±4°C) and 67±7% relative humidity for 12 days

Coating treatments	Storage time (days)						
	0	1	2	3	4	5	6
15% polyethylene + 2% zein	0.00±0.00	0.76±0.09^{bc}	1.37±0.18^{bc}	2.07±0.28^{cd}	2.67±0.33^{d}	3.24±0.42^{d}	4.39±0.51^{d}
16% polyethylene + 1% gum arabic	0.00±0.00	0.78±0.11^{bc}	1.42±0.21^{b}	2.13±0.28^{bcd}	3.39±0.49^{b}	3.49±0.47^{cd}	4.75±0.64^{cd}
19% polyethylene + 5% glycerine	0.00±0.00	0.76±0.12^{bc}	1.36±0.20^{bc}	2.02±0.29^{cd}	2.63±0.35^{d}	3.20±0.42^{d}	4.73±0.60^{d}
17.5% polyethylene + 0.5% shellac	0.00±0.00	0.68±0.23^{c}	1.22±0.27^{cd}	1.83±0.34^{cd}	2.32±0.36^{e}	2.81±0.39^{e}	3.76±0.47^{e}
20% gum arabic	0.00±0.00	1.05±0.21^{a}	1.94±0.27^{a}	3.01±0.39^{a}	3.88±0.53^{a}	4.79±0.62^{a}	6.42±0.84^{a}
8% zein	0.00±0.00	0.82±0.13^{b}	1.49±0.26^{b}	2.33±0.39^{b}	3.04±0.48^{c}	4.34±0.66^{b}	5.56±0.83^{b}
2% chitosan (in Citric acid)	0.00±0.00	0.83±0.18^{b}	1.51±0.34^{b}	2.28±0.50^{bc}	2.98±0.64^{c}	3.63±0.77^{c}	4.94±1.03^{c}
20% polyethylene	0.00±0.00	0.56±0.09^{d}	1.06±0.16^{d}	1.56±0.24^{e}	2.04±0.30^{e}	2.50±0.35^{e}	3.34±0.47^{e}
non-coated	0.00±0.00	1.01±0.18^{a}	2.01±0.33^{a}	3.07±0.48^{a}	4.03±0.59^{a}	4.94±0.75^{a}	6.73±1.00^{a}
LSD 0.05	0.10	0.16	0.23	0.29	0.35	0.41	0.46
C.V. (%)	19.50	17.14	16.26	15.57	15.32	15.23	14.94

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.19 (continued) Weight loss of tangerine fruit coated with developed coatings (Group D) during storage at room temperature (20±4°C) and 67±7% relative humidity for 12 days

Coating treatments	Storage time (days)					
	7	8	9	10	11	12
15% polyethylene + 2% zein	4.39±0.51^{d}	4.57±0.61^{d}	5.33±0.62^{d}	5.80±0.70^{c}	6.37±0.74^{cd}	6.89±0.81^{c}
16% polyethylene + 1% gum arabic	4.75±0.64^{cd}	5.19±0.71^{c}	5.79±0.80^{cd}	6.32±0.88^{bc}	6.89±0.96^{bc}	7.46±1.06^{bc}
19% polyethylene + 5% glycerine	4.73±0.60^{cd}	5.24±0.66^{c}	5.76±0.73^{cd}	5.76±0.73^{c}	6.21±0.82^{d}	6.78±0.90^{c}
17.5% polyethylene + 0.5% shellac	3.76±0.47^{e}	4.13±0.50^{de}	4.52±0.54^{e}	4.97±0.58^{d}	5.34±0.62^{e}	5.87±0.66^{d}
20% gum arabic	6.42±0.84^{a}	7.06±0.87^{a}	7.85±0.92^{a}	8.57±1.02^{a}	9.45±1.10^{a}	10.29±1.17^{a}
8% zein	5.56±0.73^{b}	6.10±1.04^{b}	6.74±1.03^{b}	6.74±1.03^{b}	7.33±1.12^{b}	8.01±1.21^{b}
2% chitosan (in Citric acid)	4.94±1.03^{c}	5.44±1.12^{c}	5.99±1.24^{c}	6.59±1.37^{b}	7.16±1.49^{b}	7.75±1.59^{b}
20% polyethylene	3.34±0.47^{e}	3.67±0.50^{e}	4.02±0.56^{e}	4.51±0.81^{d}	4.78±0.67^{e}	5.18±0.73^{d}
non-coated	6.73±1.00^{a}	7.44±1.08^{a}	8.20±1.24^{a}	9.01±1.31^{a}	9.77±1.42^{a}	10.67±1.55^{a}
LSD 0.05	0.46	0.51	0.56	0.61	0.65	0.70
C.V. (%)	14.94	15.13	14.82	14.99	14.77	14.66

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.20 Weight loss of tangerine fruit coated with developed coatings (Group E) during storage at room temperature (27±4°C) and 57±8% relative humidity for 9 days

Coating treatments	Storage time (days)									
	0	1	2	3	4	5	6	7	8	9
6%CA + 14%PE	0.00±0.00	0.86±0.11^{d}	1.62±0.21^{d}	2.36±0.32^{d}	2.97±0.41^{d}	3.55±0.49^{d}	4.13±0.57^{d}	4.83±0.78^{d}	5.57±0.78^{d}	6.35±0.92^{d}
8%CA + 12%PE	0.00±0.00	0.70±0.14^{e}	1.34±0.27^{e}	1.93±0.42^{e}	2.41±0.56^{e}	2.88±0.66^{e}	3.42±0.76^{e}	4.64±1.05^{e}	4.64±1.05^{e}	5.28±1.23^{e}
10%CA + 10%PE	0.00±0.00	0.64±0.12^{e}	1.22±0.21^{e}	1.77±0.30^{e}	2.24±0.39^{e}	2.67±0.47^{e}	3.14±0.56^{e}	4.28±0.76^{e}	4.28±0.76^{e}	4.83±0.85^{e}
1%CH + 1%OA	0.00±0.00	1.22±0.26^{c}	2.49±0.47^{c}	3.60±0.68^{c}	4.59±0.87^{c}	5.42±1.03^{c}	6.44±1.21^{c}	8.89±1.57^{c}	8.89±1.57^{c}	10.16±1.74^{c}
1%CH + 2%OA	0.00±0.00	1.31±0.19^{c}	2.74±0.35^{b}	3.88±0.49^{bc}	5.01±0.62^{b}	5.87±0.74^{bc}	7.07±0.87^{b}	9.71±1.06^{b}	9.71±1.06^{b}	10.95±1.15^{bc}
1%CH + 3%OA	0.00±0.00	1.50±0.22^{b}	2.77±0.39^{b}	4.06±0.55^{b}	5.07±0.70^{b}	6.12±0.84^{b}	7.19±1.00^{b}	9.79±1.33^{b}	9.79±1.33^{b}	11.14±1.47^{b}
1%CH	0.00±0.00	1.33±0.23^{c}	2.68±0.33^{bc}	3.88±0.48^{bc}	4.93±0.60^{bc}	5.84±0.73^{bc}	7.06±1.04^{b}	9.48±1.14^{bc}	9.48±1.14^{bc}	10.84±1.26^{bc}
20%CA	0.00±0.00	0.41±0.07^{f}	0.79±0.15^{f}	1.12±0.22^{f}	1.42±0.28^{f}	1.70±0.34^{f}	2.03±0.40^{f}	2.77±0.55^{f}	2.77±0.55^{f}	3.15±0.62^{f}
20%PE	0.00±0.00	0.89±0.24^{d}	1.69±0.45^{d}	2.42±0.65^{d}	3.02±0.83^{d}	3.56±1.00^{d}	4.22±1.19^{d}	5.68±1.64^{d}	5.68±1.64^{d}	6.43±1.87^{d}
Non-coated	0.00±0.00	1.67±0.33^{a}	3.31±0.57^{a}	4.68±0.77^{a}	5.92±0.97^{a}	6.93±1.14^{a}	8.31±1.32^{a}	11.23±1.70^{a}	11.23±1.70^{a}	12.67±1.79^{a}
$LSD_{0.05}$	-	0.13	0.23	0.33	0.41	0.49	0.59	0.66	0.86	0.84
C.V. (%)	-	19.26	17.62	17.45	17.50	17.59	17.73	17.24	16.92	16.54

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05 CA = candelilla PE = polyethylene CH = chitosan OA = oleic acid

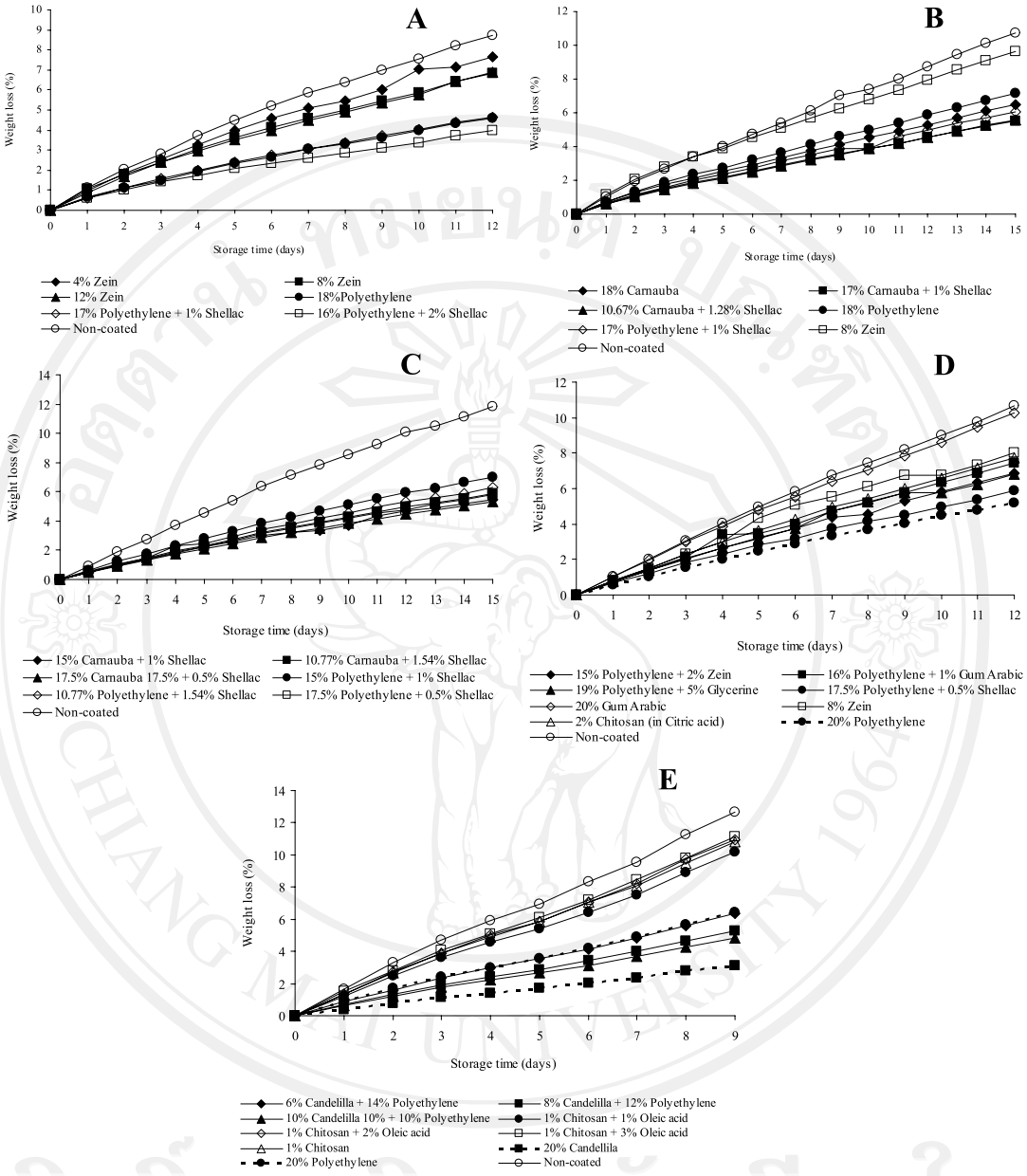

Figure 4.45 Effects of developed coatings (A) group A, (B) group B, (C) group C, (D) group D and (E) group E on the weight loss of tangerine fruit stored at room temperature

Table 4.21 Flavor score of tangerine fruit coated with developed coatings (Group A) during storage at room temperature (24±3°C) and 74±7% relative humidity for 12 days

Coating treatments	Storage time (days)						
	0	1	2	3	4	5	6
4% zein	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00^{a}
8% zein	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	3.67±0.52^{a}
12% zein	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00^{a}
18% polyethylene	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00^{a}
17% polyethylene + 1% shellac	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	3.00±0.89^{b}
16% polyethylene + 2% shellac	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	3.67±0.52^{a}
non-coated	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00^{a}
$LSD_{0.05}$	-	-	-	-	-	-	0.51
C.V. (%)	-	-	-	-	-	-	11.60

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.21 (Continued) Flavor score of tangerine fruit coated with developed coatings (Group A) during storage at room temperature (24±3°C) and 74±7% relative humidity for 12 days

Coating treatments	Storage time (days)					
	7	8	9	10	11	12
4% zein	4.00±0.00^{a}	4.00±0.00^{a}	3.67±0.52^{ab}	4.00±0.00^{a}	3.00±0.00^{a}	3.33±0.52^{ab}
8% zein	4.00±0.00^{a}	3.50±0.58^{ab}	2.67±1.03^{cd}	3.33±0.52^{a}	3.50±0.58^{a}	2.67±0.52^{bc}
12% zein	3.50±0.58^{b}	3.50±0.58^{ab}	3.00±1.55^{bc}	2.33±0.52^{b}	3.50±0.58^{a}	2.33±1.03^{cd}
18% polyethylene	4.00±0.00^{a}	2.00±0.00^{d}	2.00±0.89^{de}	3.33±0.52^{a}	2.00±1.15^{b}	2.67±1.37^{bc}
17% polyethylene + 1% shellac	3.50±0.58^{b}	3.00±1.15^{bc}	3.67±0.52^{ab}	1.33±0.52^{c}	1.50±0.58^{b}	1.67±0.52^{de}
16% polyethylene + 2% shellac	3.00±0.00^{c}	2.50±0.58^{cd}	1.33±0.52^{e}	2.33±1.37^{b}	1.50±0.58^{b}	1.33±0.52^{e}
non-coated	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	3.50±0.58^{a}	4.00±0.00^{a}
$LSD_{0.05}$	0.45	0.85	1.00	0.76	0.96	0.99
C.V. (%)	8.31	17.96	29.29	21.92	24.77	32.12

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.22 Flavor score of tangerine fruit coated with developed coatings (Group B) during storage at room temperature (21±3°C) and 72±6% relative humidity for 15 days

Coating treatments	Storage time (days)								
	0	1	2	3	4	5	6	7	8
18% carnauba	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	3.50±0.58^{a}
17% carnauba + 1% shellac	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	3.50±0.58^{ab}	3.50±0.53^{b}	3.50±0.58^{a}
16% carnauba+1.28% shellac	4.00±0.00	4.00±0.00	4.00±0.00	3.33±0.52^{b}	3.00±0.89^{c}	3.50±0.58^{b}	3.50±0.58^{ab}	2.50±0.53^{c}	2.50±0.58^{b}
18% polyethylene	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00^{a}	3.67±0.52^{ab}	4.00±0.00^{a}	4.00±0.00^{a}	3.50±0.53^{b}	4.00±0.00^{a}
17% polyethylene + 1% shellac	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00^{a}	3.00±0.00^{c}	3.40±0.58^{b}	3.00±1.15^{b}	3.25±0.46^{b}	1.50±0.58^{c}
8% zein	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00^{a}	3.33±1.03^{bc}	4.00±0.00^{a}	3.50±0.58^{a}	3.50±0.53^{b}	4.00±0.00^{a}
non-coated	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{ab}	4.00±0.00^{a}	4.00±0.00^{a}
$LSD_{0.05}$	-	-	-	0.23	0.65	0.45	0.85	0.44	0.64
C.V. (%)	-	-	-	4.99	15.46	8.00	15.85	12.71	13.28

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.22 (continued) Flavor score of tangerine fruit coated with developed coatings (Group B) during storage at room temperature (21±3°C) and 72±6% relative humidity for 15 days.

Coating treatments	Storage time (days)						
	9	10	11	12	13	14	15
18% carnauba	3.00±0.00^{b}	3.33±0.52^{ab}	3.00±0.00^{b}	4.00±0.00^{a}	2.67±1.03^{c}	3.33±0.52^{bc}	3.00±0.00^{b}
17% carnauba + 1% shellac	3.50±0.58^{ab}	3.67±0.52^{ab}	3.75±0.46^{a}	3.33±0.52^{a}	3.33±0.52^{b}	3.00±0.00^{cd}	2.00±0.00^{c}
16% carnauba+1.28% shellac	1.50±0.58^{c}	2.33±1.37^{c}	3.00±1.07^{b}	2.00±0.89^{b}	2.33±0.52^{c}	2.67±1.03^{d}	1.00±0.00^{e}
18% polyethylene	3.00±0.00^{b}	4.00±0.00^{a}	4.00±0.00^{a}	3.33±1.03^{a}	3.67±0.52^{ab}	3.67±0.52^{ab}	3.00±0.00^{b}
17% polyethylene + 1% shellac	1.50±0.58^{c}	3.00±0.59^{bc}	1.75±1.39^{c}	2.00±0.89^{b}	1.00±0.00^{d}	1.00±0.00^{e}	1.50±0.58^{d}
8% zein	3.50±0.58^{ab}	3.67±0.52^{ab}	4.00±0.00^{a}	3.67±0.52^{a}	4.00±0.00^{a}	3.33±0.52^{bc}	3.00±0.00^{b}
non-coated	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}
$LSD_{0.05}$	0.64	0.82	0.69	0.79	0.60	0.60	0.32
C.V. (%)	15.28	20.52	20.41	21.19	17.21	17.21	8.73

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.23 Flavor score of tangerine fruit coated with developed coatings (Group C) during storage at room temperature (22±3°C) and 73±6% relative humidity for 15 days

Coating treatments	Storage time (days)								
	0	1	2	3	4	5	6	7	8
15% carnauba + 1% shellac	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	3.33±1.03^{a}	3.25±0.46^{c}	3.33±0.52^{b}	2.67±1.03^{b}
14% carnauba + 1.54% shellac	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	2.33±0.52^{b}	3.75±0.46^{b}	3.67±0.52^{ab}	3.67±0.52^{a}
17.5% carnauba + 0.5% shellac	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	3.33±1.03^{a}	4.00±0.00^{a}	3.67±0.52^{ab}	2.67±0.52^{b}
15% polyethylene + 1% shellac	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}
14% polyethylene + 1.54% shellac	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}
17.5% polyethylene + 0.5% shellac	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	3.67±0.52^{a}	4.00±0.00^{a}	4.00±0.00^{a}	3.67±0.52^{a}
non-coated	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}
$LSD_{0.05}$	-	-	-	-	-	0.72	0.25	0.40	0.60
C.V. (%)	-	-	-	-	-	17.52	6.41	8.87	14.66

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.23 (continued) Flavor score of tangerine fruit coated with developed coatings (Group C) during storage at room temperature (22±3°C) and 73±6% relative humidity for 15 days

Coating treatments	Storage time (days)						
	9	10	11	12	13	14	15
15% carnauba + 1% shellac	3.00±0.00^{b}	1.67±0.52^{c}	2.50±1.73^{c}	1.00±0.00^{d}	1.50±0.58^{d}	1.50±0.58^{d}	1.25±0.46^{e}
14% carnauba + 1.54% shellac	4.00±0.00^{a}	3.67±0.52^{ab}	3.50±0.58^{ab}	2.33±0.52^{c}	2.00±1.15^{cd}	1.50±0.58^{d}	1.00±0.00^{e}
17.5% carnauba + 0.5% shellac	3.50±0.58^{ab}	3.33±0.52^{b}	3.00±1.15^{bc}	2.67±0.52^{bc}	2.00±1.15^{cc}	1.50±0.58^{d}	1.25±0.46^{e}
15% polyethylene + 1% shellac	3.50±0.58^{ab}	3.67±0.52^{ab}	3.00±1.15^{bc}	3.00±0.00^{b}	2.75±0.00^{bc}	2.00±0.00^{c}	2.25±0.46^{cd}
14% polyethylene + 1.54% shellac	3.50±0.58^{ab}	4.00±0.00^{a}	3.00±0.00^{a}	3.00±0.89^{b}	2.00±0.00^{cc}	2.00±0.00^{c}	2.00±0.76^{d}
17.5% polyethylene + 0.5% shellac	4.00±1.15^{b}	4.00±0.00^{a}	4.00±1.15^{a}	3.33±1.03^{ab}	3.00±1.15^{ab}	3.00±1.15^{b}	3.25±0.89^{b}
non-coated	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}
$LSD_{0.05}$	0.85	0.46	1.50	0.69	1.16	0.85	0.54
C.V. (%)	16.49	11.23	31.15	20.16	24.48	21.84	24.14

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.24 Flavor score of tangerine fruit coated with developed coatings (Group D) during storage at room temperature (20±4°C) and 67±7% relative humidity for 12 days

Coating treatments	Storage time (days)						
	0	1	2	3	4	5	6
15% polyethylene + 2% zein	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}
16% polyethylene + 1% gum arabic	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	3.67±0.52^{a}	3.33±0.52^{c}	3.33±0.52^{b}
19% polyethylene + 5% glycerine	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	3.67±0.52^{ab}
17.5% polyethylene + 0.5% shellac	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.52^{a}	4.00±0.00^{a}	4.00±0.00^{a}
20% gum arabic	4.00±0.00	3.25±0.46^{b}	2.25±0.89^{b}	1.33±0.52^{b}	1.00±0.00^{b}	1.00±0.00^{d}	1.00±0.00^{c}
8% zein	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}
2% chitosan (in citric acid)	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	3.67±0.52^{a}	3.67±0.52^{b}	3.33±0.52^{b}
20% polyethylene	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	3.67±0.52^{a}	4.00±0.00^{a}	3.67±0.52^{a}
non-coated	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}
LSD 0.05	-	0.15	0.30	0.20	0.40	0.28	0.40
C.V. (%)	-	3.94	7.76	4.65	9.78	6.85	9.99

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.24 (continued) Flavor score of tangerine fruit coated with developed coatings (Group D) during storage at room temperature (20±4°C) and 67±7% relative humidity for 12 days

Coating treatments	Storage time (days)					
	7	8	9	10	11	12
15% polyethylene + 2% zein	4.00±0.00^{a}	3.25±0.46^{bc}	3.50±0.53^{a}	3.00±0.89^{bcd}	2.67±0.52^{bc}	1.67±0.52^{de}
16% polyethylene + 1% gum arabic	4.00±0.00^{a}	3.00±0.76^{c}	3.50±0.93^{a}	2.67±1.03^{cd}	2.33±0.52^{cd}	2.67±0.52^{bc}
19% polyethylene + 5% glycerine	4.00±0.00^{a}	3.75±0.46^{ab}	3.75±0.46^{a}	3.33±0.52^{abc}	3.00±0.00^{b}	2.67±1.03^{bc}
17.5% polyethylene+0.5% shellac	4.00±0.00^{a}	4.00±0.00^{a}	3.50±0.53^{a}	3.67±0.53^{ab}	3.67±0.52^{a}	2.00±0.89^{cd}
20% gum arabic	1.00±0.00^{c}	1.25±0.46^{d}	1.00±0.00^{c}	1.00±0.00^{e}	1.00±0.00^{e}	1.00±0.00^{e}
8% zein	4.00±0.00^{a}	3.75±0.46^{ab}	3.50±0.53^{a}	3.67±0.52^{ab}	2.67±0.52^{bc}	3.00±0.89^{ab}
2% chitosan (in citric acid)	3.50±0.58^{b}	3.25±1.39^{bc}	2.75±0.89^{b}	2.33±1.03^{d}	2.00±0.89^{d}	1.67±1.03^{de}
20% polyethylene	4.00±0.00^{a}	3.00±0.76^{c}	3.50±0.53^{a}	3.00±0.00^{bcd}	2.67±0.52^{bc}	2.67±1.37^{bc}
non-coated	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	3.67±0.52^{a}
LSD 0.05	0.39	0.66	0.58	0.75	0.57	0.98
C.V. (%)	7.66	20.33	17.92	20.95	17.53	36.14

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.25 Flavor score of tangerine fruit coated with developed coatings (Group E) during storage at room temperature (27±4°C) and 57±8% relative humidity for 9 days

Coating treatments	Storage time (days)									
	0	1	2	3	4	5	6	7	8	9
6%CA + 14%PE	4.00±0.00	4.00±0.00	3.50±0.58^{b}	4.00±0.00^{a}	2.50±0.58^{c}	2.67±1.03^{c}	3.50±0.58^{ab}	3.50±0.58^{ab}	2.00±0.00^{b}	2.50±0.58^{bc}
8%CA + 12%PE	4.00±0.00	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	3.67±0.52^{ab}	4.00±0.00^{a}	3.50±0.58^{ab}	4.00±0.00^{a}	3.00±0.00^{ab}
10%CA + 10%PE	4.00±0.00	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	3.00±0.00^{b}	3.00±0.89^{bc}	3.50±0.58^{ab}	2.50±0.58^{c}	3.00±1.15^{ab}	2.00±1.15^{bc}
1%CH + 1%OA	4.00±0.00	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	3.33±1.03^{abc}	3.50±0.58^{ab}	4.00±0.00^{a}	2.50±1.73^{b}	2.50±1.73^{bc}
1%CH + 2%OA	4.00±0.00	4.00±0.00	3.50±0.58^{b}	3.33±1.03^{b}	3.50±0.58^{b}	3.00±0.00^{bc}	3.00±1.15^{bc}	3.00±1.15^{bc}	2.00±1.15^{b}	3.00±1.15^{ab}
1%CH + 3%OA	4.00±0.00	4.00±0.00	3.50±0.58^{b}	3.00±0.89^{bc}	4.00±0.00^{a}	2.67±1.03^{c}	2.00±0.00^{d}	3.50±0.58^{ab}	3.00±1.15^{ab}	2.50±1.73^{bc}
1%CH	4.00±0.00	4.00±0.00	4.00±0.00^{a}	3.33±0.52^{b}	1.50±0.58^{d}	3.67±0.52^{ab}	3.50±0.58^{ab}	3.00±1.15^{bc}	3.00±1.15^{ab}	1.50±0.58^{c}
20%CA	4.00±0.00	4.00±0.00	4.00±0.00^{a}	2.67±0.52^{c}	3.00±0.00^{b}	3.00±0.89^{bc}	3.50±0.58^{ab}	2.50±0.58^{c}	2.00±1.15^{b}	2.00±0.00^{bc}
20%PE	4.00±0.00	4.00±0.00	4.00±0.00^{a}	3.33±0.52^{b}	4.00±0.00^{a}	3.00±0.00^{bc}	2.50±0.58^{cd}	3.00±0.00^{bc}	2.00±0.00^{b}	2.50±0.58^{bc}
Non-coated	4.00±0.00	4.00±0.00	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}
$LSD_{0.05}$	-	-	0.46	0.60	0.46	0.85	0.83	0.95	1.42	1.42
C.V. (%)	-	-	8.21	14.48	9.44	22.82	17.49	20.25	35.75	38.56

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05 CA = candelilla PE = polyethylene CH = chitosan OA = oleic acid

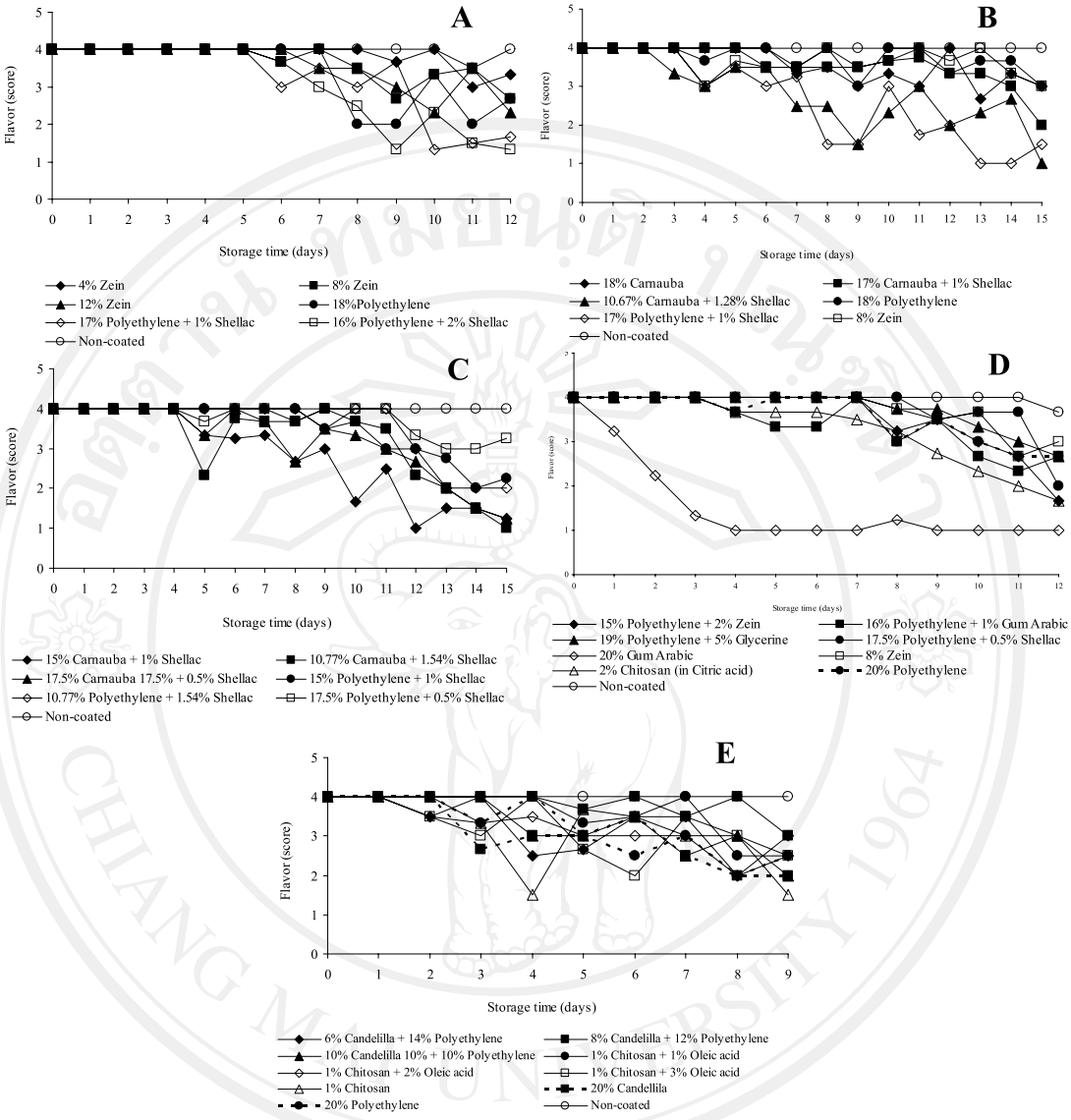

Figure 4.46 Effects of development coatings (A) group A, (B) group B, (C) group C, (D) group D and (E) group E on the flavor score of tangerine fruit stored at room temperature

Table 4.26 Visual appearance score of tangerine fruit coated with developed coatings (Group A) during storage at room temperature (24±3°C) and 74±7% relative humidity for 12 days

Coating treatments	Storage time (days)						
	0	1	2	3	4	5	6
4% zein	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	4.50±0.58^{b}	4.50±0.58^{b}	4.00±0.00^{d}
8% zein	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	4.67±0.52^{b}
12% zein	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
18% polyethylene	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
17% polyethylene + 1% shellac	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
16% polyethylene + 2% shellac	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
non-coated	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	4.00±0.00^{c}	4.00±0.00^{c}	4.33±0.52^{c}
$LSD_{0.05}$	-	-	-	-	4.56	4.56	4.86
C.V. (%)	-	-	-	-	0.32	0.32	0.32

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.26 (Continued) Visual appearance score of tangerine fruit coated with developed coatings (Group A) during storage at room temperature (24±3°C) and 74±7% relative humidity for 12 days

Coating treatments	Storage time (days)					
	7	8	9	10	11	12
4% zein	2.50±0.58^{c}	3.00±1.15^{bc}	2.00±0.00^{c}	1.67±0.52^{d}	1.00±0.00^{d}	1.00±0.00^{c}
8% zein	4.00±0.00^{b}	4.00±1.15^{ab}	3.33±0.52^{b}	3.00±0.00^{c}	2.00±0.00^{c}	1.33±0.52^{c}
12% zein	4.00±0.00^{b}	4.00±1.15^{ab}	3.00±0.00^{b}	3.00±0.00^{c}	2.00±0.00^{c}	1.33±0.52^{c}
18% polyethylene	5.00±0.00^{a}	4.50±0.58^{a}	4.33±0.52^{a}	4.00±0.00^{b}	3.50±0.58^{b}	2.67±0.52^{b}
17% polyethylene + 1% shellac	5.00±0.00^{a}	4.50±0.58^{a}	4.33±0.52^{a}	5.00±0.00^{a}	4.50±0.58^{a}	3.33±0.52^{a}
16% polyethylene + 2% shellac	5.00±0.00^{a}	4.50±0.58^{a}	4.67±0.52^{a}	5.00±0.00^{a}	4.50±0.58^{a}	3.33±0.52^{a}
non-coated	2.50±0.58^{c}	2.50±0.58^{c}	2.00±0.89^{c}	1.00±0.00^{e}	1.00±0.00^{d}	1.00±0.00^{c}
$LSD_{0.05}$	7.58	22.63	15.27	6.03	14.30	21.82
C.V. (%)	0.45	1.28	0.60	0.23	0.56	0.51

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.27 Visual appearance score of tangerine fruit coated with developed coatings (Group B) during storage at room temperature (21±3°C) and 72±6% relative humidity for 15 days

Coating treatments	Storage time (days)								
	0	1	2	3	4	5	6	7	8
18% carnauba	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
17% carnauba + 1% shellac	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
16% carnauba + 1.28% shellac	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
18% polyethylene	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
17% polyethylene+1% shellac	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	4.75±0.46^{ab}	5.00±0.00^{a}
8% zein	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	4.50±0.58^{b}	4.75±0.46^{ab}	4.00±0.00^{b}
non-coated	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	4.50±0.58	4.00±0.00^{c}	3.72±0.46^{b}	4.00±0.00^{b}
$LSD_{0.05}$	-	-	-	-	-	0.45	0.32	0.37	0.34
C.V. (%)	-	-	-	-	-	6.35	4.70	7.79	8.04

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.27 (continued) Visual appearance score of tangerine fruit coated with developed coatings (Group B) during storage at room temperature (21±3°C) and 72±6% relative humidity for 15 days

Coating treatments	Storage time (days)						
	9	10	11	12	13	14	15
18% carnauba	4.00±0.00^{ab}	3.67±0.52^{ab}	4.00±0.00^{a}	3.67±0.52^{ab}	4.00±0.00^{a}	3.67±0.52^{ab}	2.50±0.58^{c}
17% carnauba + 1% shellac	4.00±0.00^{ab}	3.67±0.52^{ab}	3.75±0.46^{ab}	4.00±0.00^{a}	3.33±0.52^{ab}	4.00±0.00^{a}	3.00±0.00^{b}
16% carnauba + 1.28% shellac	4.58±0.58^{a}	4.00±0.00^{a}	3.75±0.46^{ab}	3.00±0.89^{b}	3.33±1.03^{ab}	3.67±0.52^{ab}	3.50±0.58^{a}
18% polyethylene	4.00±0.00^{ab}	4.00±0.00^{a}	3.50±0.53^{b}	3.33±1.03^{ab}	3.33±1.03^{ab}	3.67±0.52^{ab}	3.00±0.00^{b}
17% polyethylene+1% shellac	4.00±0.00^{ab}	3.00±0.89^{bc}	4.00±0.00^{a}	4.00±0.00^{a}	4.00±0.00^{a}	3.33±0.52^{b}	3.00±0.00^{b}
8% zein	3.50±0.58^{b}	3.00±0.89^{bc}	2.75±0.89^{c}	3.00±0.89^{b}	2.67±0.52^{bc}	1.67±0.52^{c}	2.00±0.00^{d}
non-coated	2.50±0.58^{c}	2.33±0.52^{c}	2.25±0.46^{d}	1.33±0.52^{c}	2.00±0.00^{c}	1.00±0.00^{d}	1.00±0.00^{e}
$LSD_{0.05}$	0.56	0.69	0.50	0.79	0.72	0.51	0.45
C.V. (%)	9.99	17.32	14.43	21.19	19.06	14.55	12.00

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.28 Visual appearance score of tangerine fruit coated with developed coatings (Group C) during storage at room temperature (22±3°C) and 73±6% relative humidity for 15 days

Coating treatments	Storage time (days)								
	0	1	2	3	4	5	6	7	8
15% carnauba + 1% shellac	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
14% carnauba + 1.54% shellac	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
17.5% carnauba + 0.5% shellac	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
15% polyethylene + 1% shellac	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	4.00±0.00^{c}
14% polyethylene + 1.54% shellac	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
17.5% polyethylene + 0.5% shellac	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	4.67±0.52^{b}
non-coated	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	4.00±0.00^{b}	4.00±0.00^{b}	4.00±0.00^{b}	2.67±0.52^{d}
LSD $_{0.05}$	-	-	-	-	-	0.00	0.00	0.00	0.32
C.V. (%)	-	-	-	-	-	0.34	0.44	0.40	6.17

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.28 (continued) Visual appearance score of tangerine fruit coated with developed coatings (Group C) during storage at room temperature (22±3°C) and 73±6% relative humidity for 15 days

Coating treatments	Storage time (days)						
	9	10	11	12	13	14	15
15% carnauba + 1% shellac	5.00±0.00^{a}	4.00±0.00^{b}	3.00±0.00^{ab}	3.00±0.00^{a}	2.50±0.58^{a}	2.00±0.00^{c}	2.00±0.00^{bc}
14% carnauba + 1.54% shellac	5.00±0.00^{a}	4.00±0.00^{b}	3.50±0.58^{a}	3.00±0.00^{a}	3.00±0.00^{a}	2.00±0.00^{c}	1.75±0.46^{c}
17.5% carnauba + 0.5% shellac	5.00±0.00^{a}	5.00±0.00^{a}	3.50±0.58^{a}	3.00±0.00^{a}	3.00±0.00^{a}	3.00±0.00^{a}	2.50±0.53^{ab}
15% polyethylene + 1% shellac	4.00±0.00^{b}	4.33±0.52^{b}	3.00±0.00^{ab}	2.67±0.52^{b}	2.50±0.58^{a}	2.00±0.00^{c}	2.00±0.76^{bc}
14% polyethylene + 1.54% shellac	4.00±0.00^{b}	4.33±0.52^{b}	2.50±0.58^{b}	3.00±0.00^{a}	3.00±0.00^{a}	2.50±0.58^{b}	2.75±0.89^{a}
17.5% polyethylene + 0.5% shellac	4.00±0.00^{b}	4.00±0.00^{b}	3.00±0.00^{ab}	2.67±0.52^{b}	2.50±0.58^{a}	2.00±0.00^{c}	2.00±0.76^{bc}
non-coated	2.50±0.58^{c}	2.67±0.52^{c}	1.00±0.00^{c}	1.00±0.00^{c}	1.00±0.00^{b}	1.00±0.00^{d}	1.00±0.00^{d}
LSD $_{0.05}$	0.32	0.40	0.56	0.32	0.56	0.32	0.59
C.V. (%)	5.18	7.67	13.57	10.54	15.12	10.53	27.49

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.29 Visual appearance score of tangerine fruit coated with developed coatings (Group D) during storage at room temperature (20±4°C) and 67±7% relative humidity for 12 days

Coating treatments	Storage time (days)						
	0	1	2	3	4	5	6
15% polyethylene + 2% zein	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	4.33±0.52^{b}	4.00±0.00^{c}	3.33±0.52^{de}
16% polyethylene + 1% gum arabic	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	4.33±0.52^{b}	4.00±0.00^{c}	3.67±0.52^{cd}
19% polyethylene + 5% glycerine	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	4.67±0.52^{ab}	4.33±0.52^{b}	4.00±0.00^{bc}
17.5% polyethylene + 0.5% shellac	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	4.67±0.52^{a}
20% gum arabic	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	4.33±0.52^{b}	4.00±0.00^{c}	3.67±0.52^{cd}
8% zein	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	4.33±0.52^{b}	4.00±0.00^{c}	4.33±0.52^{ab}
2% chitosan (in citric acid)	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	4.00±0.00^{bc}	4.00±0.00^{c}	3.00±0.89^{e}
20% polyethylene	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	4.33±0.52^{ab}
non-coated	5.00±0.00	5.00±0.00	5.00±0.00	4.96±0.52	3.67±0.52^{c}	4.00±0.00^{c}	2.33±0.52^{f}
LSD 0.05	-	-	-	0.20	0.49	0.20	0.63
C.V. (%)	-	-	-	3.47	9.57	4.04	14.70

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.29 (continued) Visual appearance score of tangerine fruit coated with developed coatings (Group D) during storage at room temperature (20±4°C) and 67±7% relative humidity for 12 days

Coating treatments	Storage time (days)					
	7	8	9	10	11	12
15% polyethylene + 2% zein	2.50±0.58^{b}	2.75±0.46^{cd}	2.75±0.89^{de}	2.00±0.00^{d}	2.33±0.52^{bc}	1.33±0.52^{cd}
16% polyethylene + 1% gum arabic	3.00±0.00^{b}	2.75±0.46^{cd}	2.50±0.53^{ef}	2.67±0.52^{bc}	2.33±0.52^{bc}	1.67±0.52^{bc}
19% polyethylene + 5% glycerine	4.00±0.00^{a}	3.25±0.46^{b}	3.50±0.53^{b}	3.00±0.00^{b}	2.67±0.52^{b}	2.00±0.00^{b}
17.5% polyethylene + 0.5% shellac	4.00±0.00^{a}	3.75±0.46^{a}	3.88±0.52^{a}	3.67±0.52^{a}	3.33±0.52^{a}	3.00±0.00^{a}
20% gum arabic	2.50±0.58^{b}	2.25±0.46^{ef}	2.00±0.00^{g}	1.00±0.00^{e}	1.00±0.00^{d}	1.00±0.00^{d}
8% zein	4.00±0.00^{a}	2.50±0.53^{de}	3.00±0.00^{cd}	2.00±0.00^{d}	2.00±0.00^{c}	2.00±0.00^{b}
2% chitosan (in citric acid)	3.00±1.15^{b}	3.00±0.76^{bc}	2.75±0.46^{de}	2.33±0.52^{cd}	2.33±0.52^{bc}	1.33±0.52^{cd}
20% polyethylene	4.00±0.00^{a}	4.00±0.00^{a}	3.50±0.05^{b}	3.00±0.00^{b}	2.67±0.52^{b}	2.33±0.52^{b}
non-coated	2.50±0.58^{b}	2.00±0.00^{f}	2.25±0.46^{fg}	2.00±0.00^{d}	1.33±0.52^{d}	1.00±0.00^{d}
LSD 0.05	0.74	0.46	0.48	0.35	0.53	0.40
C.V. (%)	14.54	15.87	16.46	11.84	20.49	15.59

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05

Table 4.30 Visual appearance score of tangerine fruit coated with developed coatings (Group E) during storage at room temperature (27±4°C) and 57±8% relative humidity for 9 days

Coating treatments	Storage time (days)									
	0	1	2	3	4	5	6	7	8	9
6%CA + 14%PE	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	4.00±0.00^{c}	4.00±0.00^{a}	3.50±0.58^{a}	3.00±0.00^{a}
8%CA + 12%PE	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	4.00±0.00^{c}	4.00±0.00^{a}	3.00±0.00^{a}	3.00±0.00^{a}
10%CA + 10%PE	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	4.00±0.00^{c}	4.00±0.00^{a}	3.50±0.58^{a}	2.50±0.58^{a}
1%CH + 1%OA	5.00±0.00	5.00±0.00	4.50±0.58^{b}	4.00±0.00^{cd}	4.00±0.00^{b}	3.67±0.52^{c}	3.00±0.00^{d}	3.00±0.00^{c}	1.50±0.58^{bc}	1.00±0.00^{b}
1%CH + 2%OA	5.00±0.00	5.00±0.00	4.50±0.58^{b}	3.67±0.52^{d}	3.50±0.58^{c}	3.00±0.00^{d}	3.00±0.00^{d}	2.00±0.00^{e}	1.50±0.58^{bc}	1.00±0.00^{b}
1%CH + 3%OA	5.00±0.00	5.00±0.00	5.00±0.00^{a}	4.67±0.52^{ab}	3.50±0.58^{c}	3.33±0.52^{cd}	3.00±0.00^{d}	3.00±0.00^{c}	1.50±0.58^{bc}	1.50±0.58^{b}
1%CH	5.00±0.00	5.00±0.00	4.50±0.58^{b}	4.33±0.52^{bc}	3.50±0.58^{c}	3.33±0.52^{cd}	3.00±0.00^{d}	2.00±0.00^{e}	2.00±0.00^{b}	1.00±0.00^{b}
20%CA	5.00±0.00	5.00±0.00	5.00±0.00^{a}	4.67±0.52^{ab}	5.00±0.00^{a}	4.50±0.58^{b}	4.50±0.58^{b}	2.50±0.58^{d}	3.50±0.58^{a}	3.00±1.15^{a}
20%PE	5.00±0.00	5.00±0.00	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	3.50±0.58^{b}	3.50±0.58^{a}	3.00±0.00^{a}
Non-coated	5.00±0.00	5.00±0.00	4.00±0.00^{c}	3.67±0.52^{d}	3.00±0.00^{d}	2.00±0.00^{e}	2.00±0.00^{e}	1.00±0.00^{f}	1.00±0.00^{c}	1.00±0.00^{b}
$LSD_{0.05}$	-	-	0.46	0.42	0.44	0.38	0.26	0.37	0.70	0.65
C.V. (%)	-	-	6.66	8.11	7.29	8.14	5.14	8.91	19.71	22.36

The text that follows the average difference indicates that the difference significant confidence level at P≤0.05 CA = candelilla PE = polyethylene CH = chitosan OA = oleic acid

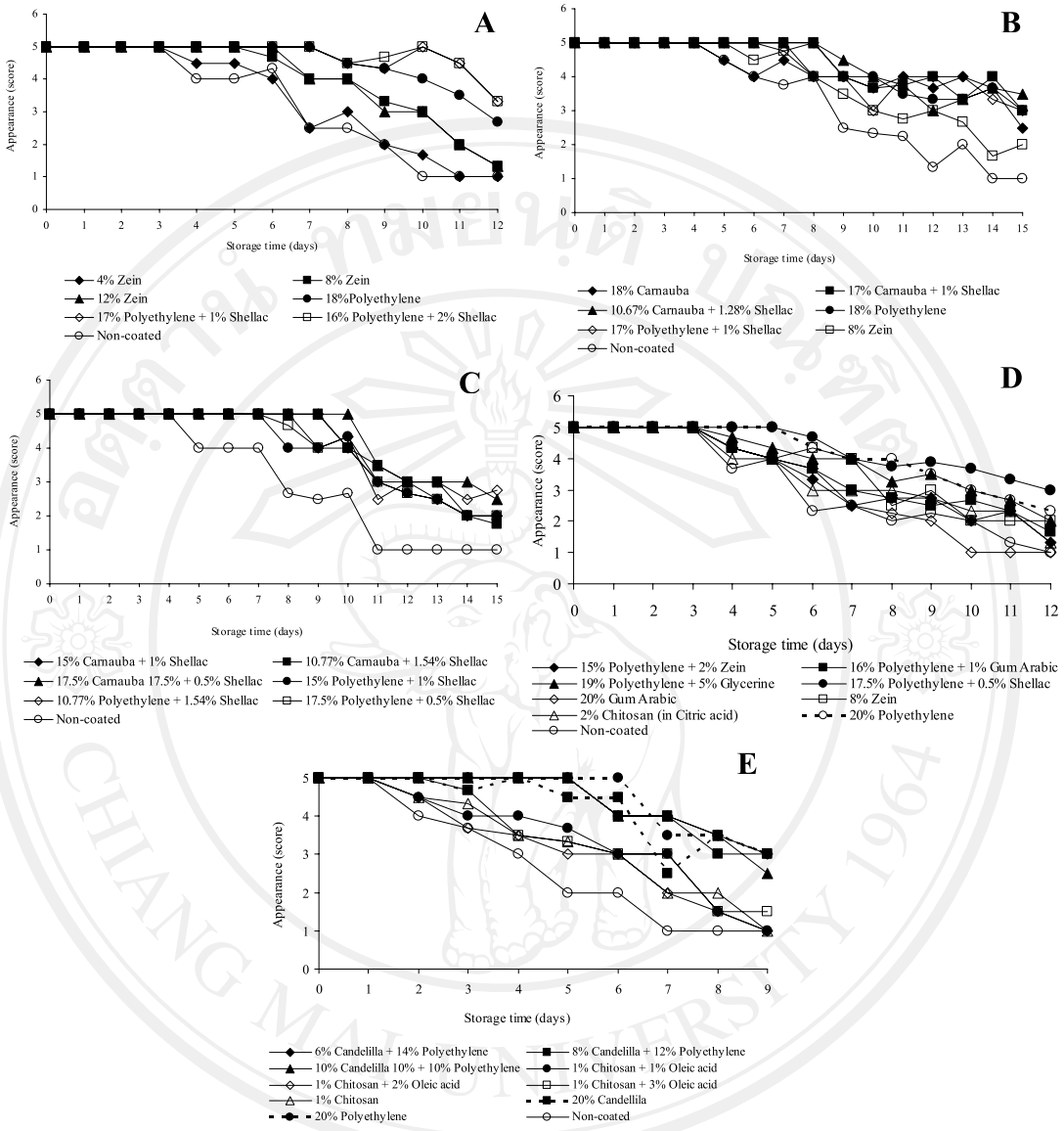

Figure 4.47 Effects of developed coatings (A) group A, (B) group B, (C) group C, (D) group D and (E) group E on the visual appearance score of tangerine fruit stored at room temperature

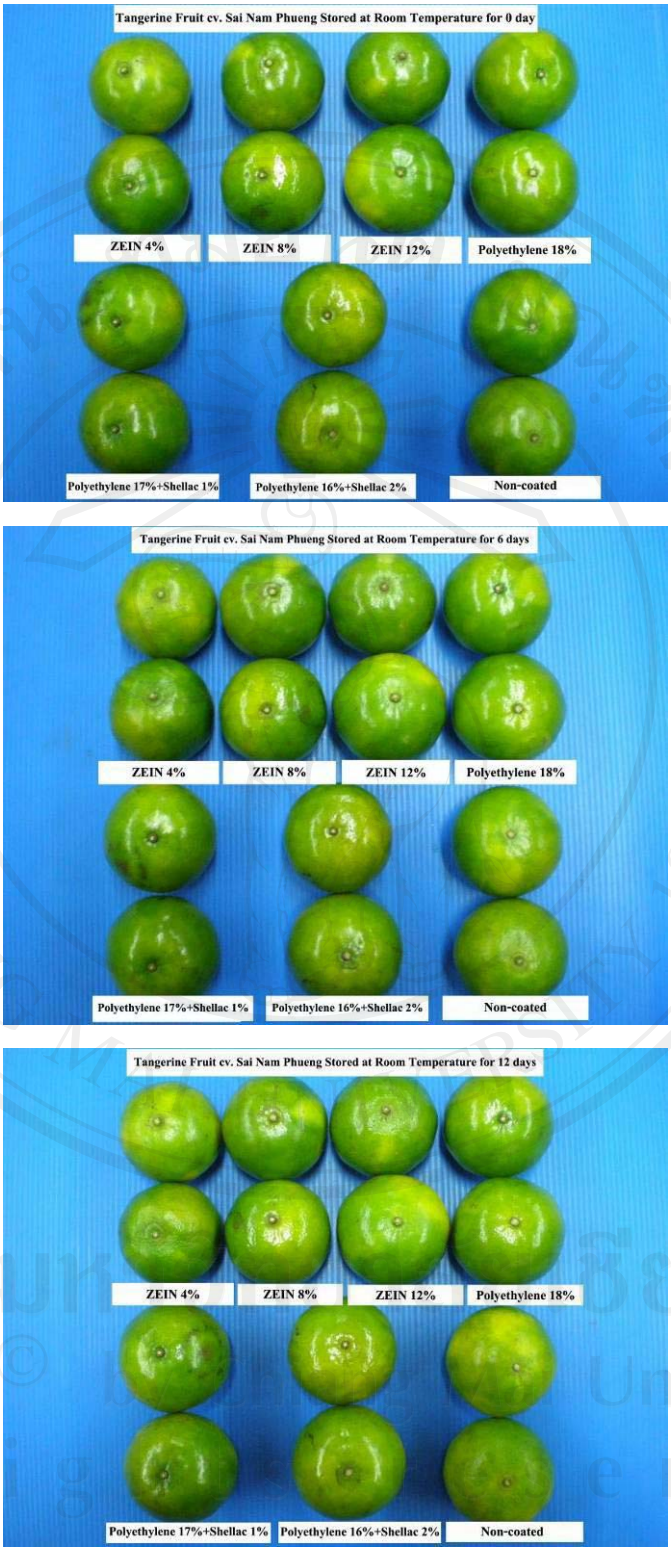

Figure 4.48 Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with developed coatings (Group A) during storage at room temperature (24±3°C) and 74±7% relative humidity for 0, 6 and 12 days

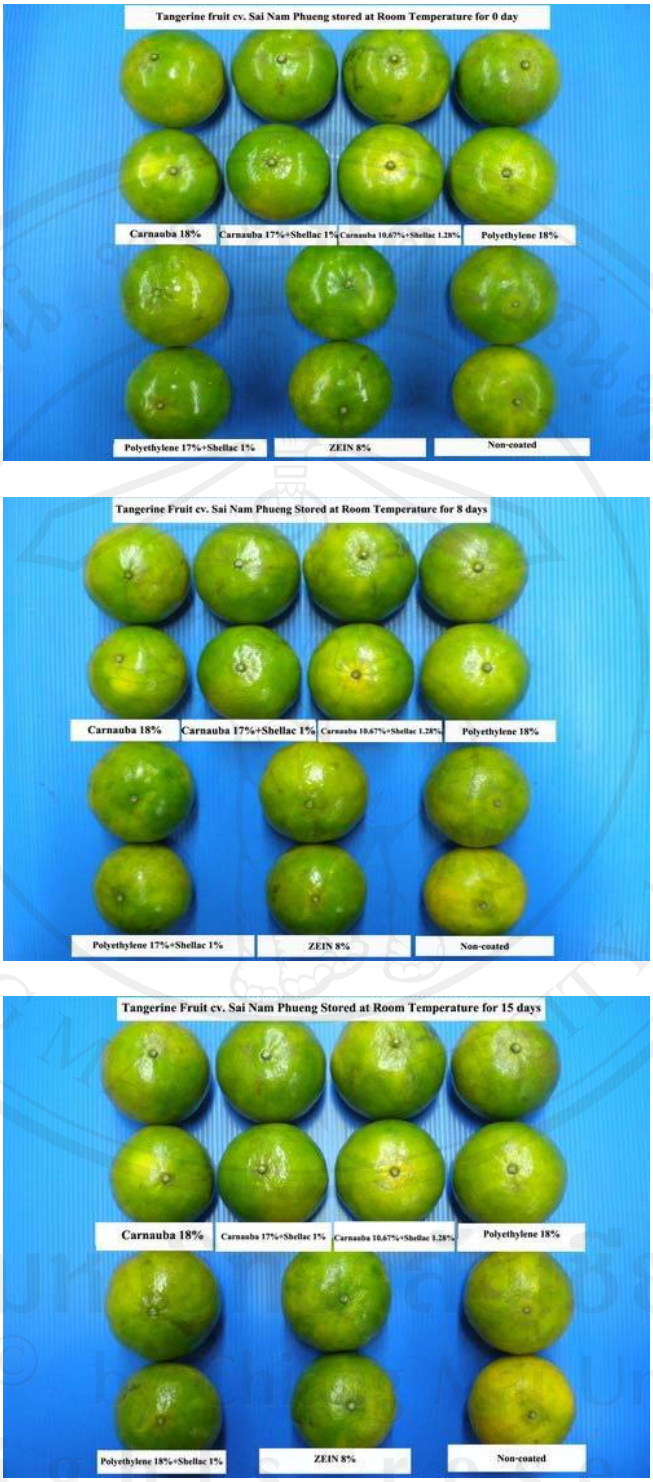

Figure 4.49 Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with developed coatings (Group B) during storage at room temperature (21±3°C) and 72±6% relative humidity for 0, 8 and 15 days

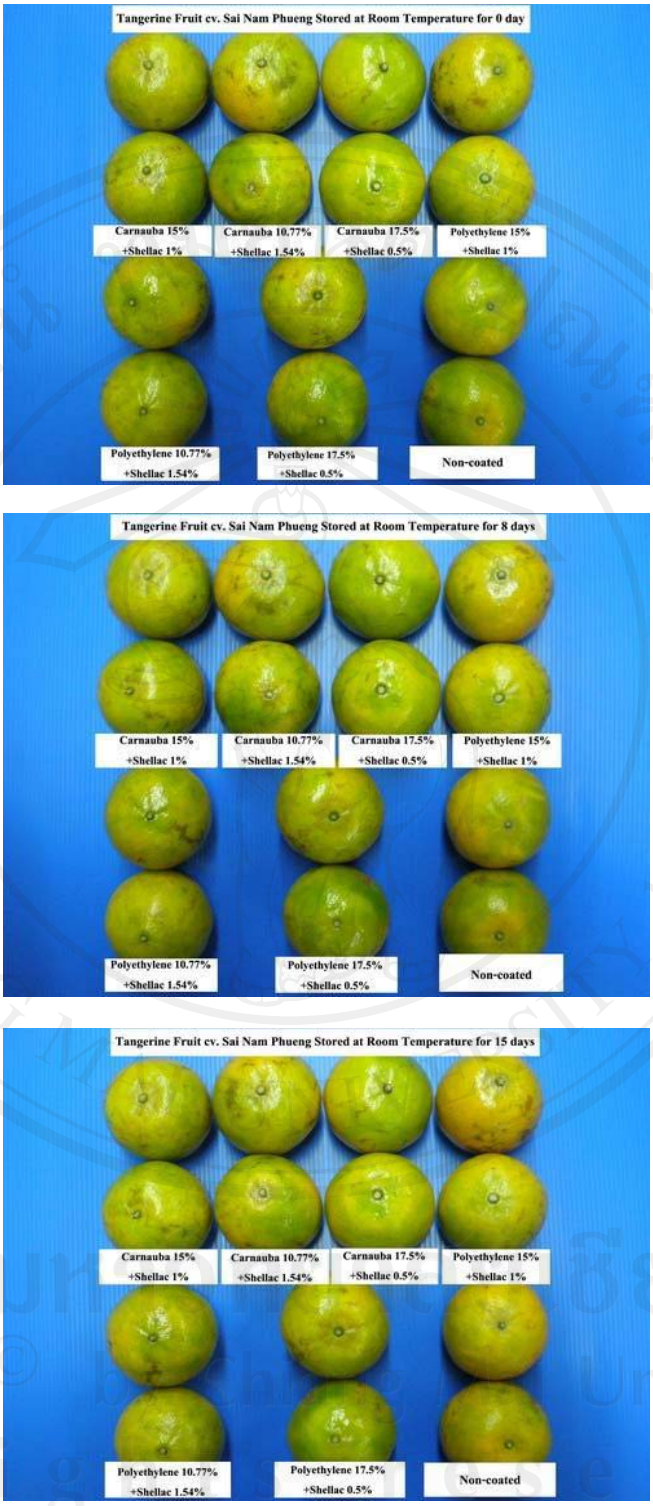

Figure 4.50 Visual appearance score of tangerine fruit cv. Sai 'Nam Phueng' coated with developed coatings (Group C) during storage at room temperature (22±3°C) and 73±6% relative humidity for 0, 8 and 15 days

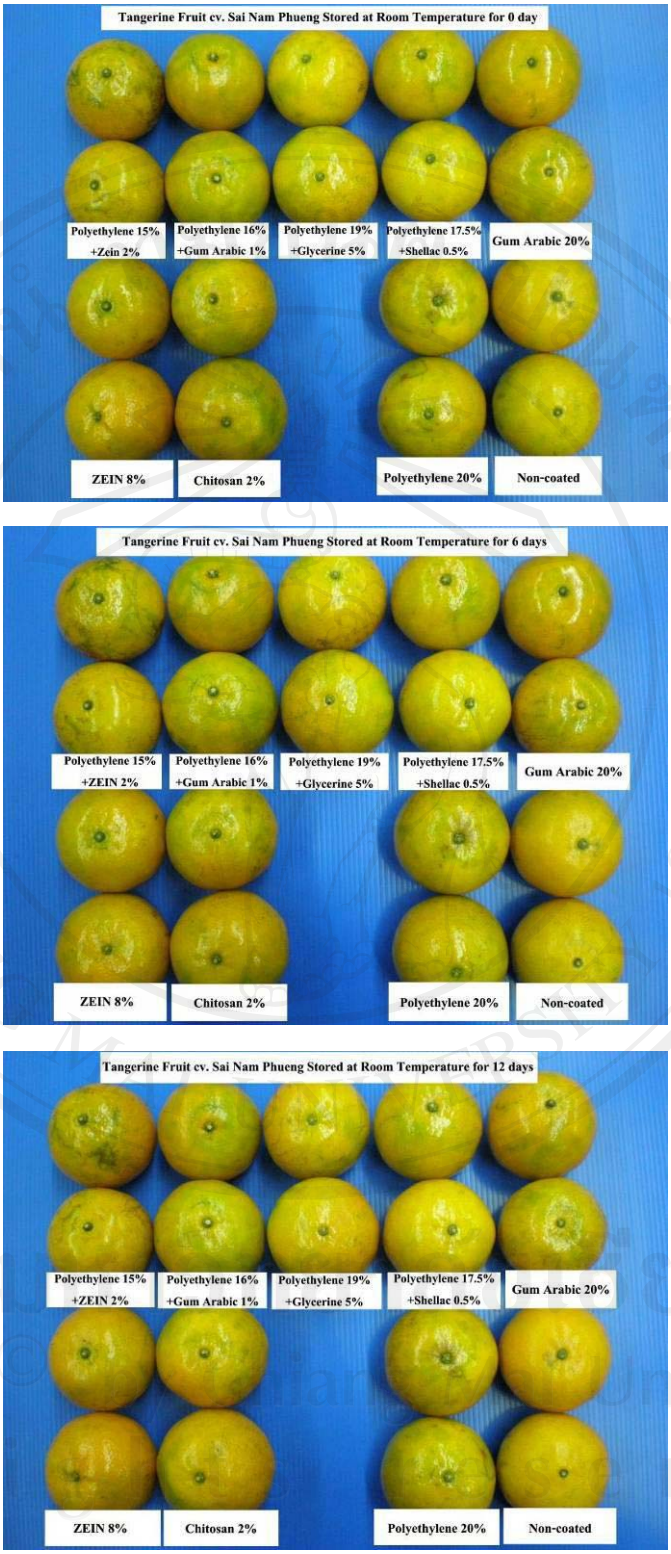

Figure 4.51 Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with developed coatings (Group D) during storage at room temperature (20±4°C) and 67±7% relative humidity for 0, 6 and 12 days

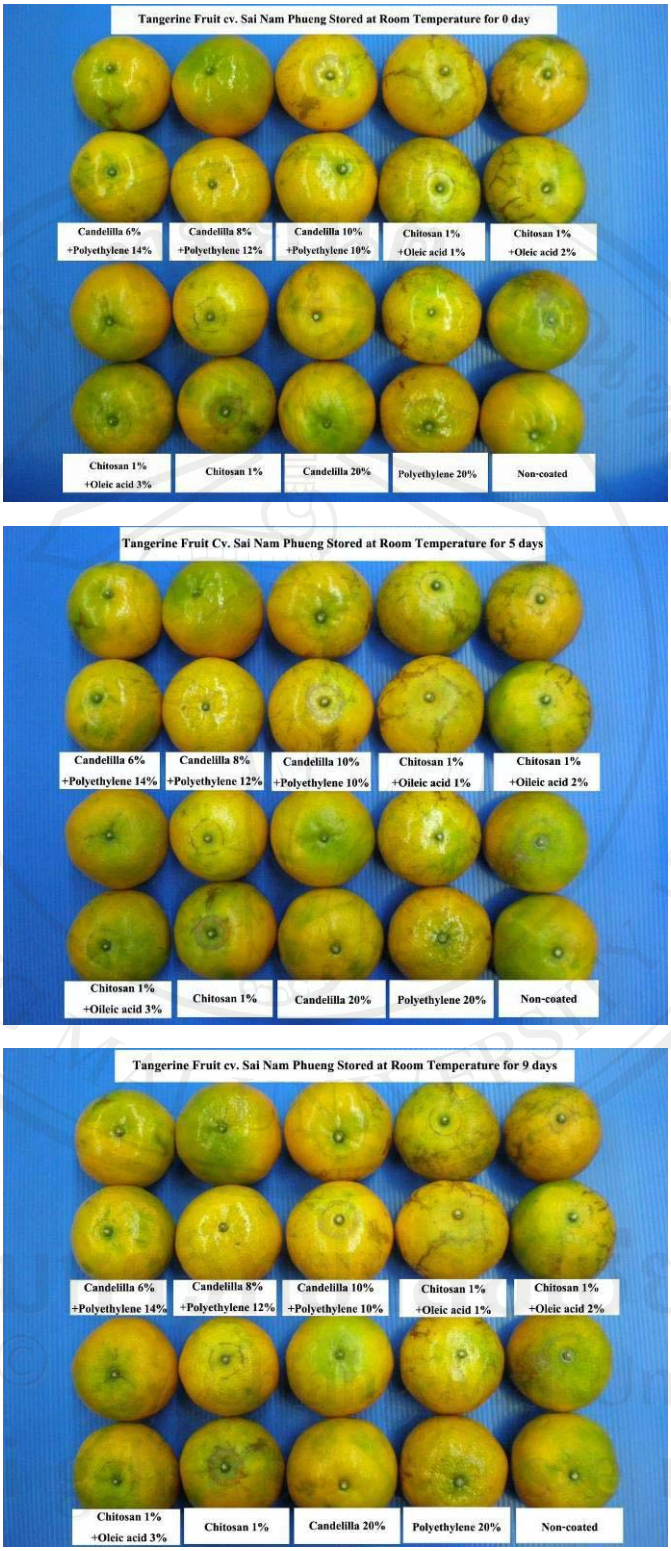

Figure 4.52 Visual appearance score of tangerine fruit cv. 'Sai Nam Phueng' coated with developed coatings (Group E) during storage at room temperature (27±4°C) and 57±8% relative humidity for 0, 5 and 9 days

4.4 Effect of 4 developed coating materials and commercial coating (Zivdar) on the physico-chemical and physiological characters of tangerine fruit

The study of physical, chemical and physiological properties of tangerine fruit cv. 'Sai Nam Phueng' coated with 4 developed coating materials and commercial coating (Zivdar) during storage at room temperature (27±3°C) and 56±11% relative humidity for 11 days.

Component of coatings:

- Formulation A : 8% candelilla microemulsion + 12% commercial polyethylene
- Formulation B : 17.5% commercial polyethylene + 0.5% shellac in ethanol
- Formulation C : 17.5% commercial polyethylene + 0.5% shellac microemulsion
- Formulation D : 17.5% polyethylene microemulsion + 0.5% shellac microemulsion
- Zivdar : 18% w/v waxes (shellac, polyethylene wax and imazalil)

4.4.1 Weight loss

Tangerine fruit coated with formulation A had the lowest weight loss (5.00±0.31%). There was no significant difference in weight loss among fruit coated with formulation B (6.38±0.59%), C (6.51±0.43%), D (6.94±0.69), and Zivdar (6.60±0.51%) (Table 4.31). As shown in Fig 4.53 there is a considerable increase in weight loss over the storage period in all treatments. Non-coated fruit had higher weight loss than coated treatments approximately 2 times.

The formulation A significantly reduced weight loss of coated tangerines after storage at room temperature, which indicates the effectiveness of this coating as a moisture barrier. Coated tangerine fruit with coating formulation B, C, D and Zivdar reduced weight loss approximately 45-50% compared with non-coated control (Table 4.31). At the end of storage period, weight loss of all coating treatments were around 5.60-7.79% (Table A.62).

4.4.2 Internal gases

4.4.2.1 Internal O_2

The internal O_2 concentration of tangerine fruit coated with formulation A, B, C, D and Zivdar were not significant difference (4.34±1.53, 3.95±1.54, 4.63±1.46,

5.75±2.08 and 4.85±1.74%, respectively). There was a similar trend in the reduction of internal O_2 concentration in all coated treatments. Internal O_2 of coated fruit decreased rapidly at the first day of storage then gradually decreased until day 5 of storage after that were relatively constant throughout the storage period. The control treatment was found to be significantly higher each other throughout the observation period. Internal O_2 concentration of control fruit was decreased continuously, but decreased in the lower rate than that of coated treatments (Table 4.31 and Figure 4.54).

Table 4.31 Weight loss, internal O_2, internal CO_2, acetaldehyde and ethanol content in juice of tangerine fruit cv. 'Sai Nam Phueng' coated with 4 developed coatings and Zivdar during storage at room temperature (27±3°C) and 56±11% relative humidity for 11 days

Treatments	Weight loss (%)	Internal O_2 (%)	Internal CO_2 (%)	Acetaldehyde content (mg/l)	Ethanol content (mg/l)
Formulation A	5.00±0.31^{d}	4.34±1.53^{b}	14.89±2.80^{a}	not detected	1,337.57±360.90^{a}
Formulation B	6.38±0.59^{c}	3.95±1.54^{b}	12.96±1.19^{a}	not detected	1,481.28±271.91^{a}
Formulation C	6.51±0.43^{bc}	4.63±1.46^{b}	13.58±1.87^{a}	not detected	1,124.33±299.63^{ab}
Formulation D	6.94±0.69^{b}	5.75±2.08^{b}	14.17±1.59^{a}	not detected	786.10±318.85^{b}
Zivdar	6.60±0.51^{bc}	4.85±1.74^{b}	14.88±1.30^{a}	not detected	1,005.35±257.77^{ab}
Non-coated	12.64±1.43^{a}	9.29±3.48^{a}	8.11±1.41^{b}	not detected	209.23±15.05^{c}
$LSD_{0.05}$	0.47	2.73	2.40	-	493.60
C.V. (%)	10.26	38.29	13.50	-	28.02

Means followed by different superscript letters within a column are significantly different (P≤0.05)

4 developed coating materials:

- Formulation A : 8% candelilla microemulsion + 12% commercial polyethylene
- Formulation B : 17.5% commercial polyethylene + 0.5% shellac in ethanol
- Formulation C : 17.5% commercial polyethylene + 0.5% shellac microemulsion
- Formulation D : 17.5% polyethylene microemulsion + 0.5% shellac microemulsion

4.4.2.2 Internal CO_2

On day 11, there was a significant difference between coated and non-coated tangerine fruit. Non-coated fruit had the lowest internal CO_2 of 9.29±3.48%, while, there were no significant differences among internal CO_2 concentration of tangerine fruit coated with coating formulation A, B, C, D and Zivdar which was 14.89±2.80, 12.96±1.19, 13.58±1.87, 14.17±1.59 and 14.88±1.30%, respectively. Internal CO_2

concentration progressively increased during storage. Non-coated fruit had the increase rate of internal CO_2 slower than coated fruit (Table 4.31 and Figure 4.54).

The results showed that coated fruit reach an internal gas composition around 3-6% O_2 and 14-18% CO_2 at the end of storage, whereas control fruit had an internal gas composition around 10% O_2 and 5% CO_2 (Table A.63 and Table A.64).

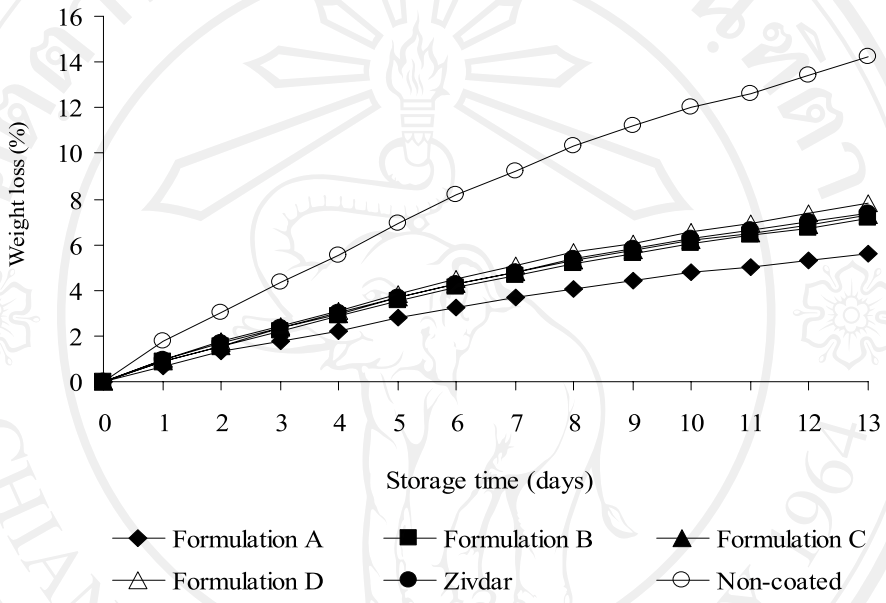

Figure 4.53 Effects of 4 developed coating materials and Zivdar on the weight loss of tangerine fruit stored at room temperature (27±3°C) and 56±11% relative humidity for 13 days

4.4.3 Fermentative products

4.4.3.1 Acetaldehyde content in juice

The results indicated that amounts of acetaldehyde in tangerine fruit coated with coating formulation A, B, C, D, Zivdar and control fruit were not detected after storage for 10 days at room temperature (Table 4.31).

4.4.3.2 Ethanol content in juice

The results demonstrated that non-coated control had the lowest ethanol content in juice (209.23±15.05 mg/l). Ethanol content was significantly lower in juice from fruit coated with formulation D (786.10±318.85 mg/l) than in juice from

formulation A (1,337.57±360.90 mg/l) and B (1,481.28±271.91 mg/l). There were not significant differences coated fruit among formulation D, formulation C (1,124.33±299.63 mg/l) and Zivdar (1,005.35±257.77 mg/l). The results indicated that ethanol concentration differed greatly in coated treatments throughout the whole storage period with respect to the non-coated one. The ethanol content in juice of tangerines increased over time for all coated treatments. The ethanol content of fruit coated with formulation D increased at lower rate than other coatings, while, ethanol content of non-coated control fruit relatively constant throughout the storage period (Table 4.31 and Figure 4.54).

The amount of ethanol found in the core of tangerines as a function of the various coatings. Ethanol levels in juice increased 3.76, 5.37, 6.39, 7.08 and 4.80 fold in juice of tangerine fruit coated with formulation D, C, A, B and Zivdar, respectively, as compared with control fruit.

4.4.4 Fermentative enzymes

4.4.4.1 Pyruvate decarboxylase activity (PDC activity)

PDC activity in fruit coated with coating formulation A and C with was 3.07±0.35 and 3.09±1.89 units/min/mg protein, respectively, which does not significant different with PDC activity of fruit coated with coating formulation B, D and Zivdar is equal to 2.72±0.44, 2.04±0.50 and 2.36±0.77 units/min/mg protein, respectively. The enzyme activity of non-coated control was 1.08±0.66 units/min/mg protein (Table 4.32). Based on Figure 4.55 and Table A.66 shows that the first five days of storage, the activity of PDC enzyme of tangerine fruit in all treatments increased in rate is relatively low, and more clearly on the 6th day of storage. PDC activity of fruit coated with coating formulation A (10.01±2.91 units/min/mg protein) rising before the other treatments on day 7 of storage. Tangerine fruit coated with other coatings and non-coated fruit had the highest PDC activity on day 8 of storage. Tangerine fruit coated with coating formulation A had the higher enzyme activity than other treatments. Moreover, the results indicated that control fruit had the lowest PDC activity during storage (Table A.66 and Figure 4.55).

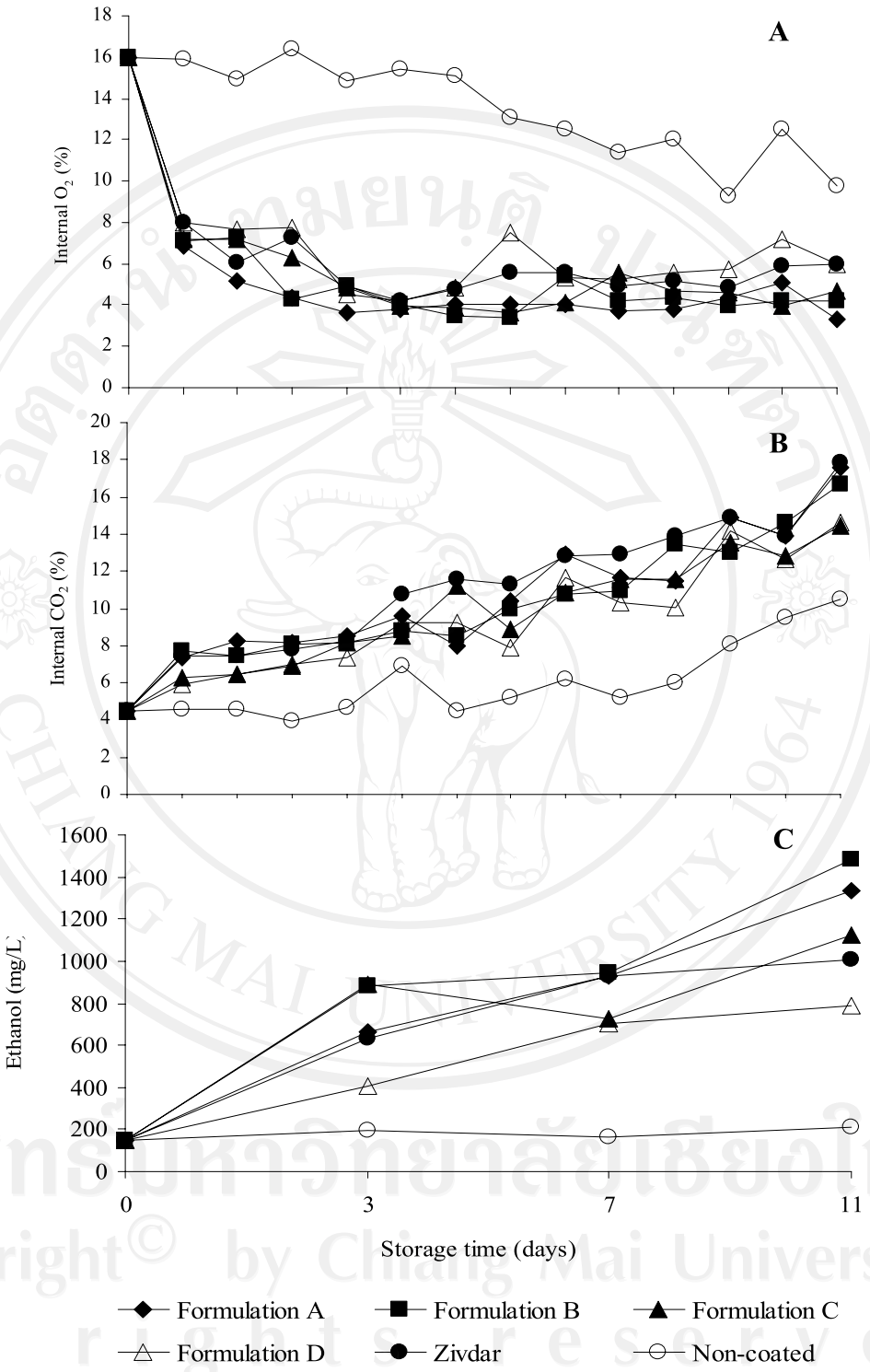

Figure 4.54 Effects of 4 developed coating materials and Zivdar on the (A) internal O_2, (B) internal CO_2 and (C) ethanol content of tangerine fruit stored at room temperature (27±3°C) and 56±11% relative humidity for 13 and 11 days, respectively

4.4.4.2 Alcohol dehydrogenase activity (ADH activity)

ADH activity of fruit coated with Zivdar was higher than enzyme activity of fruit coated with coating formulation A, B, C and non-coated fruit, which were 1.65±0.95, 1.61±0.18, 3.52±1.94 and 1.44±1.25 units/min/mg protein, respectively. However, no significant difference with enzyme activity of fruit coated with coating formulation D (Table 4.32). Table A.67 and Figure 4.55 showed that during storage for 13 days, ADH activity of tangerine fruit coated with different coatings were increased and then decreased. Tangerine fruit coated with coating formulation A had the highest ADH activity and clearly increased on day 7 of storage, which is equal to 5.96±2.37 units/min/mg protein, after that the activity decreased. Tangerine fruit coated with coating formulation B, C, D and Zivdar an increase of enzyme activity and the highest activity behind fruit coated with coating formulation A, which on day 8-13 of storage depending on the type of coating. The ADH activity of non-coated fruit increased continuously compared to the initial activity. However, the rate of increase was very low when compared with coated fruit (Table A.67 and Figure 4.55).

Table 4.32 Pyruvate decarboxylase activity and alcohol dehydrogenase activity of tangerine fruit cv. 'Sai Nam Phueng' coated with 4 developed coatings and Zivdar during storage at room temperature (27±3°C) and 56±11% relative humidity for 11 days

Treatments	Pyruvate decarboxylase activity (units/min/mg protein)	Alcohol dehydrogenase activity (units/min/mg protein)
Formulation A	3.07±0.35^{a}	1.65±0.95^{cd}
Formulation B	2.72±0.44^{ab}	1.61±0.18^{cd}
Formulation C	3.09±1.89^{a}	3.52±1.94^{bc}
Formulation D	2.04±0.^{ab}	4.31±0.99^{ab}
Zivdar	2.36±0.77^{ab}	5.70±0.76^{a}
Non-coated	1.08±0.66^{b}	1.44±1.25^{d}
$LSD_{0.05}$	1.64	2.03
C.V. (%)	38.77	37.53

Means followed by different superscript letters within a column are significantly different (P≤0.05)

4 developed coating materials:

- Formulation A : 8% candelilla microemulsion + 12% commercial polyethylene
- Formulation B : 17.5% commercial polyethylene + 0.5% shellac in ethanol
- Formulation C : 17.5% commercial polyethylene + 0.5% shellac microemulsion
- Formulation D : 17.5% polyethylene microemulsion + 0.5% shellac microemulsion

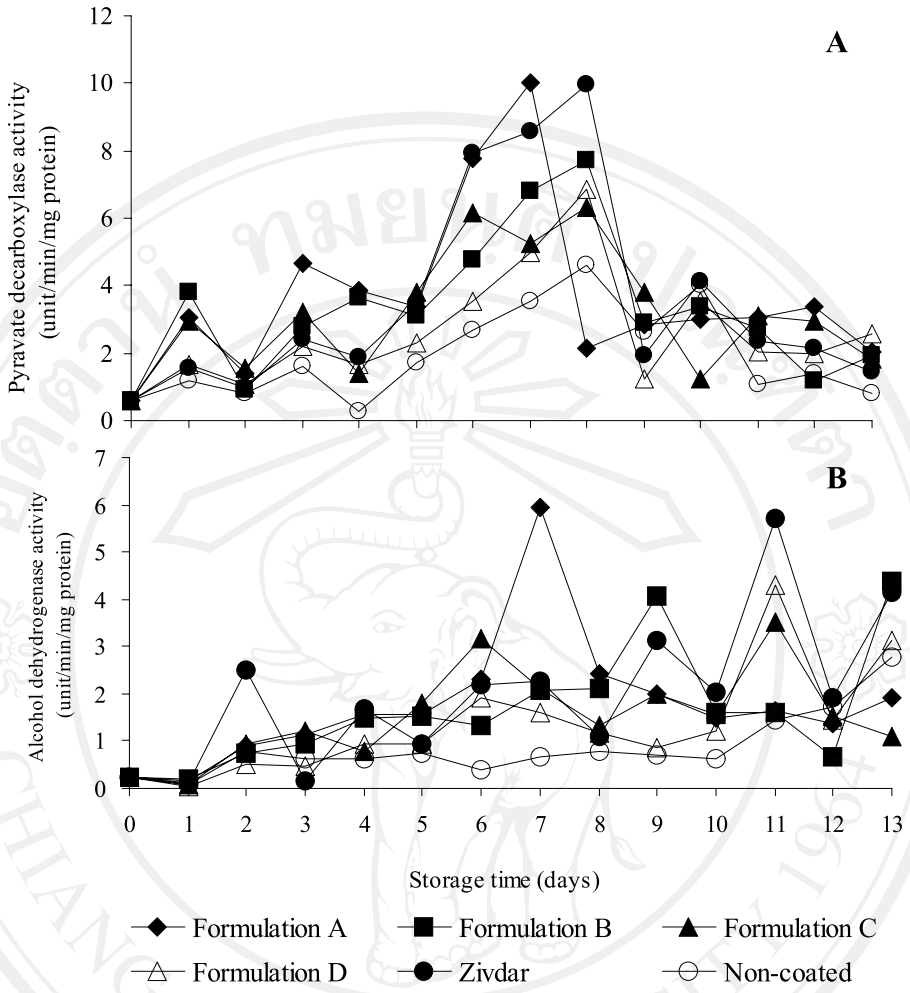

Figure 4.55 Effects of 4 developed coating materials and Zivdar on the (A) pyruvate decarboxylase activity and (B) alcohol dehydrogenase activity of tangerine fruit stored at room temperature (27±3°C) and 56±11% relative humidity for 13 days

4.4.5 Assessment of flavor and visual appearance

4.4.5.1 Flavor

The flavor score of coated tangerine fruit decreased concurrently with the storage period, but differently depending on the treatment. Formulation A and Zivdar coating noticeably reduced the flavor score of the fruit (3.00±0.89 and 3.33±0.52, respectively), as compared with formulation B (4.00±0.00), C (4.00±0.00), D (4.00±0.00) and control (4.00±0.00) (Table 4.33 and Figure 4.56).

Based on the assessment scores of flavor throughout the storage time for 13 days showed that flavor score of non-coated control fruit was 4.00±0.00, means that non-coated fruit had the normal flavors. The tangerines coated with formulation B, C and D had similar or slightly lower flavor scores than those non-coated control after 13 days of storage. However, the flavor scores of all coated fruit still acceptable (with scores of near or higher than 3 compared to the initial score of 4). This means that coated fruit had a little unusual flavor during storage. The rapid decrease in flavor scores was noticeable for the tangerine fruit coated with formulation A after 7 days of storage. Unlike, the flavor score of the tangerines coated with formulation B, C and D which gradually declined. Formulation D-coated fruit developed the smell and taste disorders later than other treatments, followed by fruit coated with formulation B, C and Zivdar (Table 4.33 and Figure 4.56).

The flavor score of tangerine fruit decreased with storage time, but it was considered within the range of acceptability for all treatments until 11 days of storage at room temperature.

4.4.5.2 Visual appearance

The results showed that visual appearance scores depended on the type of coatings applied. Tangerine fruit coated with formulation A had the highest score (4.00±0.00), followed by fruit coated with formulation B (3.33±0.52), C (3.33±0.52 score), D (3.00±0.00) and Zivdar (3.00±0.00). While, non-coated tangerine fruit had the lowest visual appearance score of 1.00±0.00. Non-coated fruit began to show clearly shrivel from the 5^{th} day of storage and more shrivel from the 10^{th} day of storage. For the coated fruit in all treatments began to show slightly shrivel about 8 days of storage. The decrease in visual appearance scores was in accordance with the decrease in weight loss and fruit firmness against storage time. The decreased of

visual appearance score of coated fruit occur later than visual appearance score of non-coated control fruit (Table 4.33 and Figure 4.56).

Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with 4 developed coating materials and Zivdar during storage at room temperature (27±3°C) and 56±11% relative humidity for 0, 7 and 13 days were shown in Figure 4.57.

Table 4.33 Flavor score, visual appearance score and peel color of tangerine fruit cv. 'Sai Nam Phueng' coated with 4 developed coatings and Zivdar during storage at room temperature (27±3°C) and 56±11% relative humidity for 11 days

Treatments	Flavor (score)	Visual appearance (score)	Peel color		
			L*	chroma	hue angle
Formulation A	3.00±0.89^{b}	4.00±0.00^{a}	49.13±3.69	39.96±5.50^{b}	113.19±3.61^{b}
Formulation B	4.00±0.00^{a}	3.33±0.52^{b}	48.39±2.87	38.42±4.38^{bc}	113.68±3.14^{ab}
Formulation C	4.00±0.00^{a}	3.33±0.52^{b}	47.51±2.28	37.42±3.47^{bc}	114.48±2.88^{ab}
Formulation D	4.00±0.00^{a}	3.00±0.00^{b}	47.15±2.74	36.91±3.96^{c}	115.38±2.12^{a}
Zivdar	3.33±0.52^{b}	3.00±0.00^{b}	47.92±2.11	36.94±3.59^{c}	114.03±3.01^{ab}
Non-coated	4.00±0.00^{a}	1.00±0.00^{c}	49.05±3.42	42.77±4.62^{a}	109.88±4.63^{c}
$LSD_{0.05}$	0.50	0.35	1.82	2.70	2.09
C.V. (%)	11.33	10.13	6.03	11.12	2.93

Means followed by different superscript letters within a column are significantly different (P≤0.05)

4 developed coating materials:

- Formulation A : 8% candelilla microemulsion + 12% commercial polyethylene
- Formulation B : 17.5% commercial polyethylene + 0.5% shellac in ethanol
- Formulation C : 17.5% commercial polyethylene + 0.5% shellac microemulsion
- Formulation D : 17.5% polyethylene microemulsion + 0.5% shellac microemulsion

Evaluation of flavor by tasting, using a scale of 1 to 4 where 4 = excellent, 3 = slightly off-flavor, 2 = moderately off-flavor and 1 = extremely off-flavor. Fruit taste was rated "unacceptable" when the taste score was below three.

Evaluation of visual appearance (wilting and shriveling), using a scale of 1 to 5 where 5 = excellent, 4 = good, 3 = fair, 2 = poor and 1 = unusable. Fruit appearance was rated "unacceptable" when the score was below three.

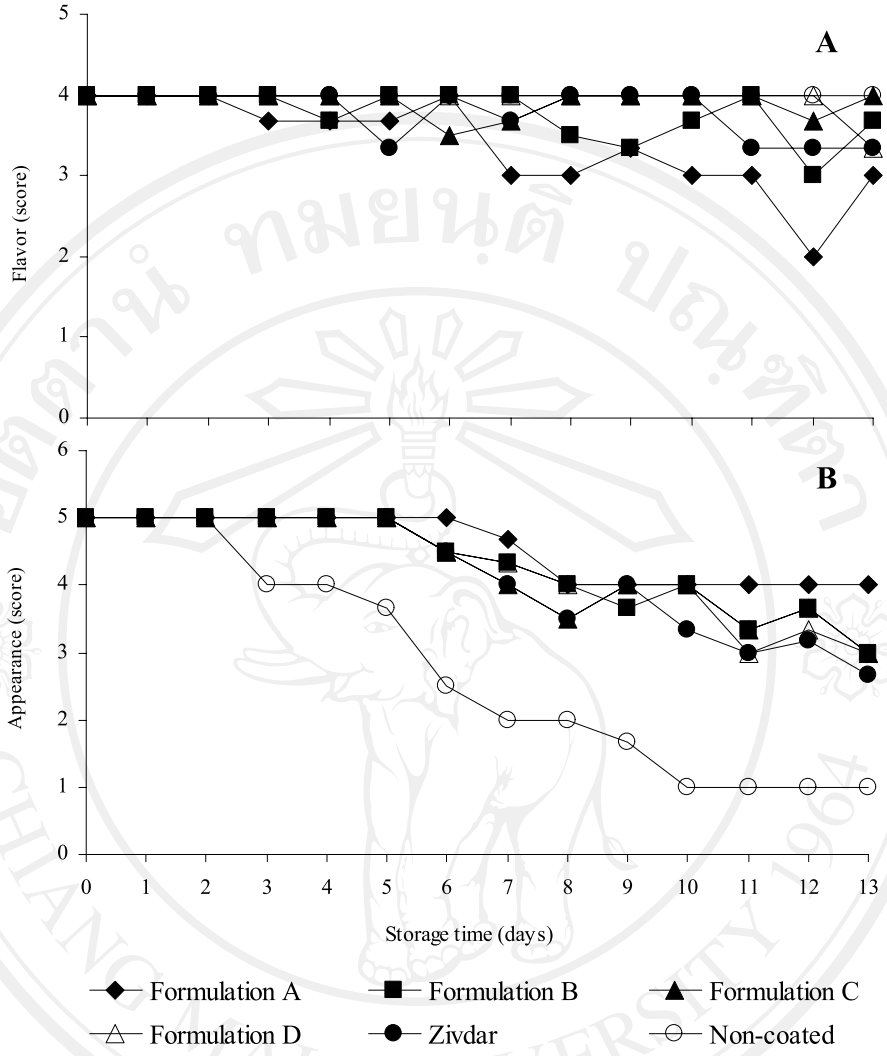

Figure 4.56 Effects of 4 developed coating s and Zivdar on the (A) flavor score and (B) visual appearance score of tangerine fruit stored at room temperature (27±3°C) and 56±11% relative humidity for 13 days

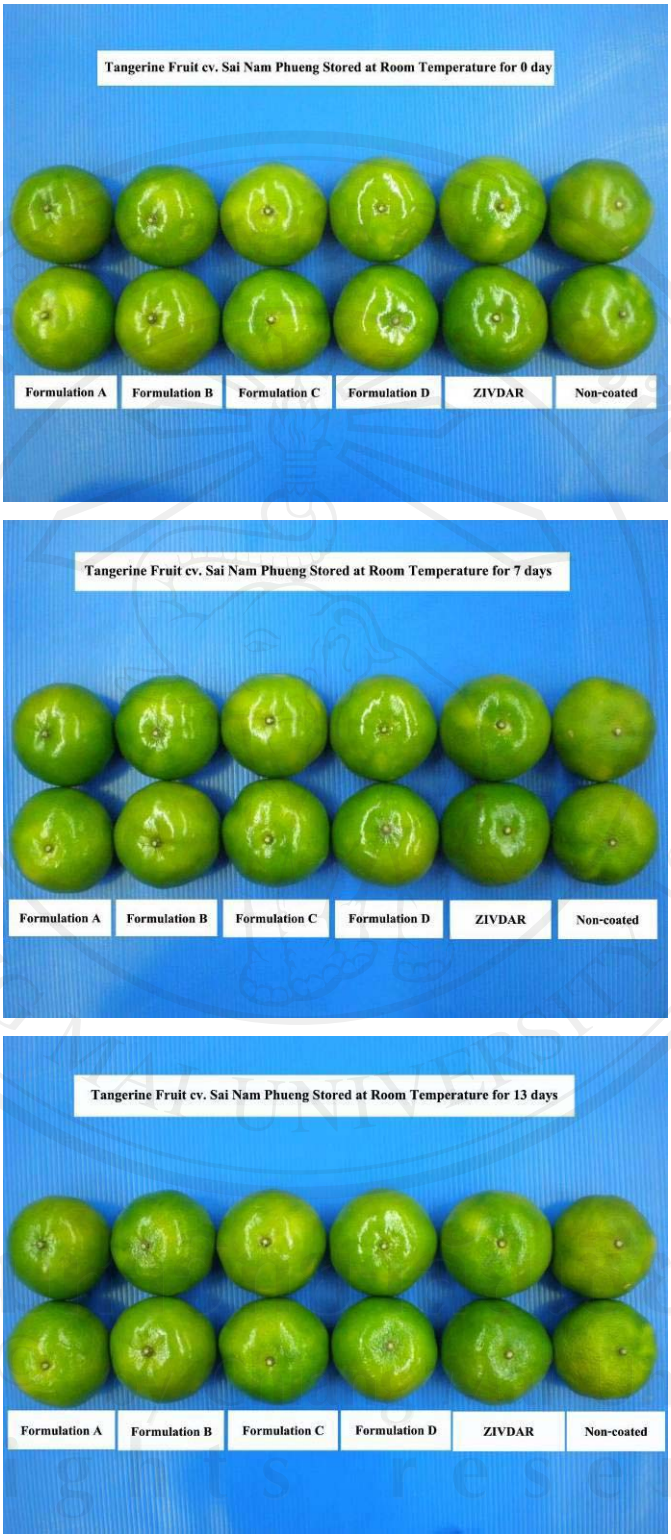

Figure 4.57 Visual appearance of tangerine fruit cv. 'Sai Nam Phueng' coated with 4 developed coating materials and Zivdar during storage at room temperature (27±3°C) and 56±11% relative humidity for 0, 7 and 13 days

4.4.6 Peel color

4.4.6.1 L*

The L* color value of all treatments tended to decrease during storage for 13 days, with no difference among fruit coated with formulation A, B, C, D, Zivdar and non-coated fruit (Table 4.33 and Figure 4.58).

4.4.6.2 chroma

Chroma values of tangerine fruit differed significantly during the storage period. Data indicated that at day 11, non-coated fruit had higher chroma value of peel color (42.77±4.62). The results also showed that fruit coated with formulation A, B, C, D and Zivdar did not differ significantly in chroma values (39.96±5.50, 38.42±4.38, 37.42±3.47, 36.91±3.96 and 36.94±3.59, respectively). The chroma value of coated fruit slightly decreased at the end of storage, while chroma value of control fruit increasing when compared to the initial value (Table 4.33 and Figure 4.58).

4.4.6.3 hue angle (H°)

The changes in hue angle were significant different between non-coated control and coated treatments. Non-coated fruit had lower hue angle (109.88±4.63°) after storage for 11 days. Fruit coated with formulation D tended to have slightly higher hue angle than those coated with formulation A (115.38±2.12 and 113.19±3.61°, respectively), but did not significant with formulation B, C and Zivdar treatments. The hue angle of tangerine fruit in all treatments decreased during storage, and hue angle of control decreased rapidly than coated treatments (Table 4.33 and Figure 4.58).

The results showed that coating treatments can delay the degradation of color. Color changes were evaluated in terms of hue angle and chroma values. Hue angles denote the color of the sample that a hue angle of 0°, 360° = purple, 90° = yellow, 180° = blue-green and 270° = blue. Chroma values indicate color saturation or intensity. Higher numbers indicate a more vivid color, whereas lower numbers correspond to dull colors.

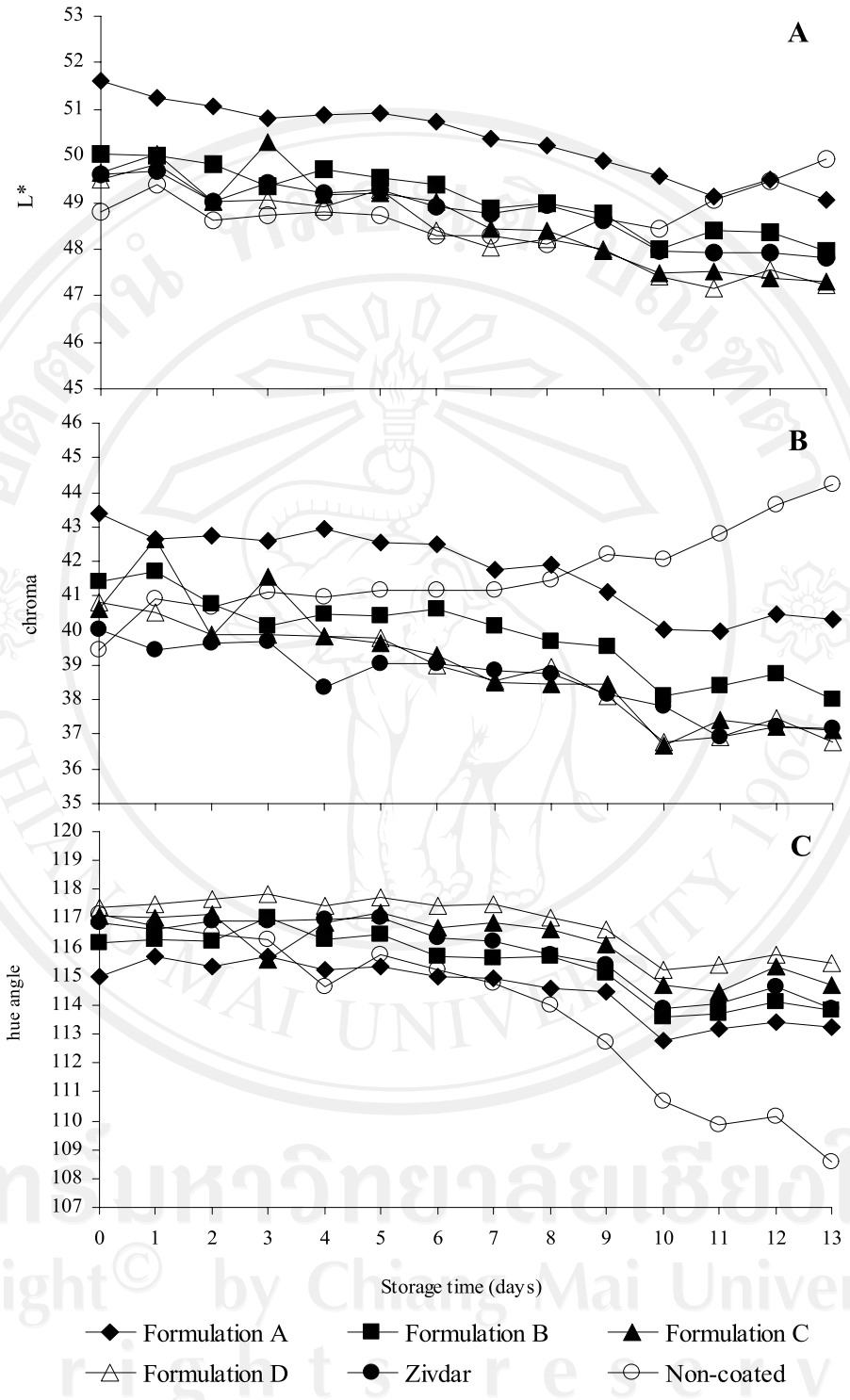

Figure 4.58 Effects of 4 developed coating materials and Zivdar on the (A) L*, (B) chroma and (C) hue angle of tangerine fruit stored at room temperature (27±3°C) and 56±11% relative humidity for 13 days

4.4.7 Total soluble solids (TSS)

There was no difference in total soluble solids (range 11.63-12.37%) among treatments after storage for 11 days. Total soluble solids of tangerine fruit in all treatments slightly increased during storage for 13 days (Table 4.34 and Figure 4.59).

4.4.8 Titratable acidity (TA)

Titratable acidity of tangerine fruit in all treatments was relatively constant during storage. The difference in titratable acidity during storage is quite negligible. The mean values recorded for tangerine coated with formulation A, B, C, D, Zivdar, and non-coated control where 0.88±0.01, 0.82±0.15, 0.88±0.09, 0.90±0.08, 0.87±0.08 and 1.10 ± 0.12% as citric acid, respectively (Table 4.34 and Figure 4.59).

4.4.9 TSS/TA ratio

TSS/TA ratio varied between 11.74 and 14.63, however, the changes were not consistent among the tangerine coated with formulation A (13.78±0.53), B (14.63±2.65), C (13.53±2.35), D (13.03±1.54), Zivdar (14.29±1.33) and non-coated fruit (11.74±0.98). The concomitant slight variations in TSS/TA ratio of tangerine fruit in all treatments between 10.64±0.04 to 16.56±1.75 during storage for 13 days (Table 4.34 and Figure 4.59).

4.4.10 pH

There were no obvious differences between the coating treatments for pH values of tangerine fruit. Comparison the pH of treatment mean values showed slightly increasing in all treatments during storage (Table 4.34 and Figure 4.60).

4.4.10 Vitamin C

There was no significant difference in vitamin C content among coated treatments and non-coated control. Vitamin C contents of fruit in all treatments were relatively constant throughout the storage period (Table 4.34 and Figure 4.60).

Table 4.34 Total soluble solids (TSS), titratable acidity (TA), TSS/TA ratio, pH and vitamin C content of tangerine fruit cv. 'Sai Nam Phueng' coated with 4 developed coatings and Zivdar during storage at room temperature (27±3°C) and 56±11% relative humidity for 11 days

Treatments	TSS (%)	TA (%)	TSS/TA ratio	pH	Vitamin C content (mg/100 ml juice)
Formulation A	12.10±0.44	0.88±0.01	13.78±0.53	3.24±0.03	20.50±1.87
Formulation B	11.73±0.21	0.82±0.15	14.63±2.65	3.32±0.16	20.50±0.00
Formulation C	11.73±0.85	0.88±0.09	13.53±2.35	3.24±0.02	20.49±3.23
Formulation D	11.63±0.40	0.90±0.08	13.03±1.54	3.22±0.13	21.12±1.07
Zivdar	12.37±0.31	0.87±0.08	14.29±1.33	3.22±0.09	22.36±3.23
Non-coated	11.83±0.38	1.10±0.12	11.74±0.98	3.06±0.07	23.60±2.15
$LSD_{0.05}$	0.85	0.17	3.07	0.17	3.98
C.V. (%)	4.00	10.85	12.79	2.95	10.45

Means followed by different superscript letters within a column are significantly different (P≤0.05)

4 developed coating materials:

- Formulation A : 8% candelilla microemulsion + 12% commercial polyethylene
- Formulation B : 17.5% commercial polyethylene + 0.5% shellac in ethanol
- Formulation C : 17.5% commercial polyethylene + 0.5% shellac microemulsion
- Formulation D : 17.5% polyethylene microemulsion + 0.5% shellac microemulsion

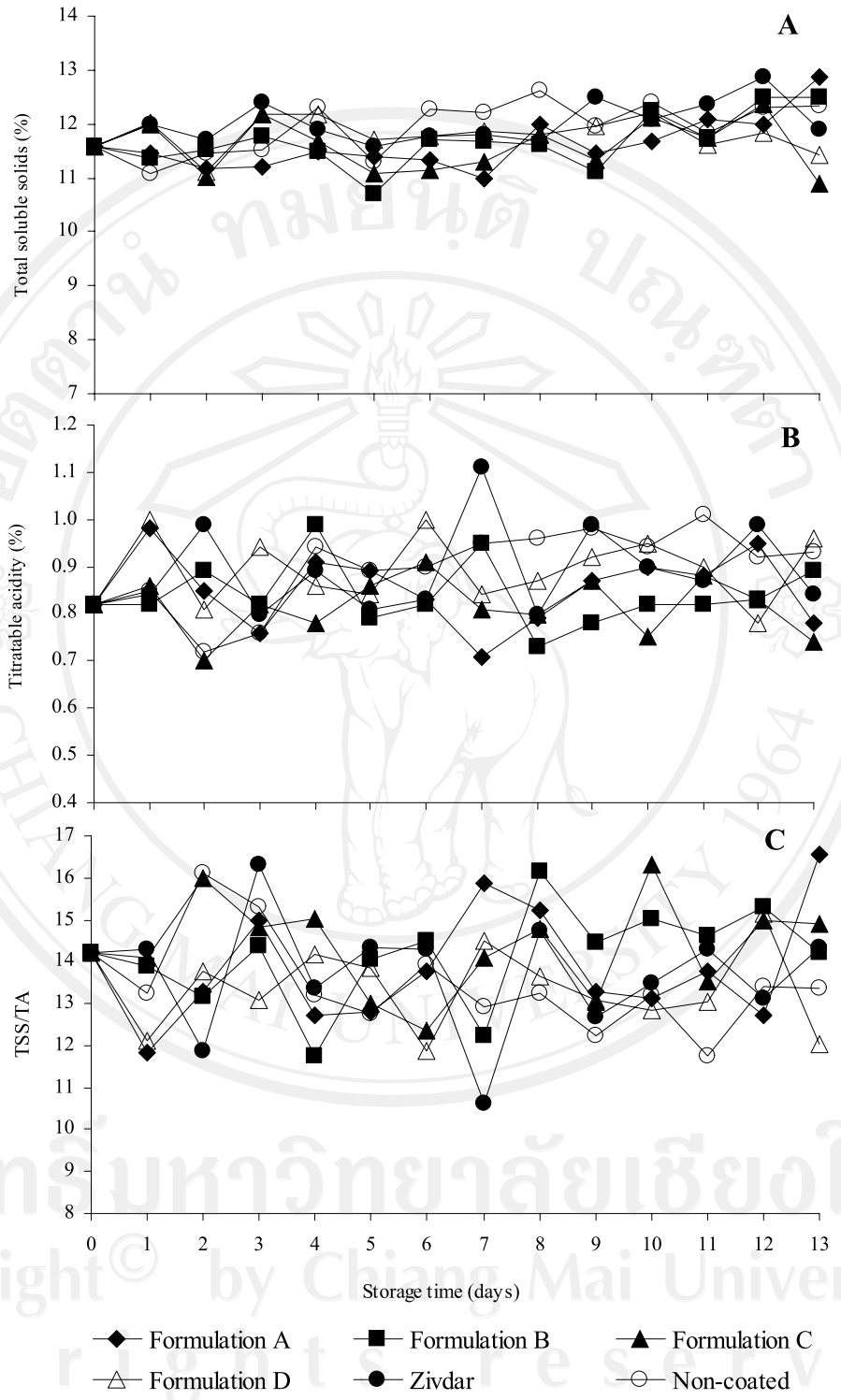

Figure 4.59 Effects of 4 developed coating materials and Zivdar on the (A) total soluble solids, (B) titratable acidity and (C) TSS/TA ratio of tangerine fruit stored at room temperature (27±3°C) and 56±11% relative humidity for 13 days

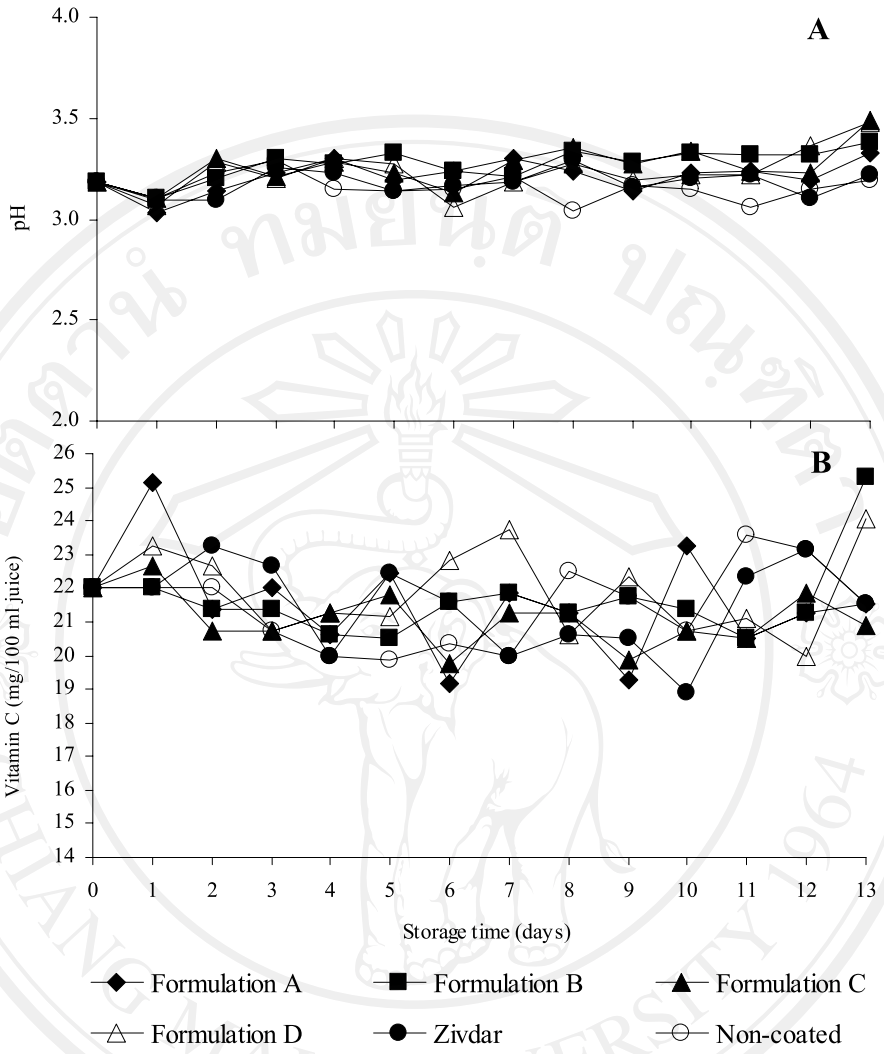

Figure 4.60 Effects of 4 developed coatings and Zivdar on the (A) pH and (B) vitamin C of tangerine fruit stored at room temperature (27±3°C) and 56±11% relative humidity for 13 days

4.5 Correlation between study variables

Correlation coefficients for internal O_2, internal CO_2 and ethanol content in juice are shown in Figure 4.61. The results showed that relationship between internal O_2 and ethanol content of tangerine fruit was linear with negative correlation (R = 0.774) and positive correlation was found between internal CO_2 and ethanol content (R = 0.821). Internal O_2 and CO_2 were both highly correlated and almost linearly related with ethanol content (Figure 4.61). These evidences indicated that low internal O_2 and high internal CO_2 induced the increasing of ethanol accumulation.

A negative correlation was found for internal O_2 and internal CO_2 (R = 0.764). The correlation between internal O_2 and CO_2 was clearly linear (Figure 4.61).

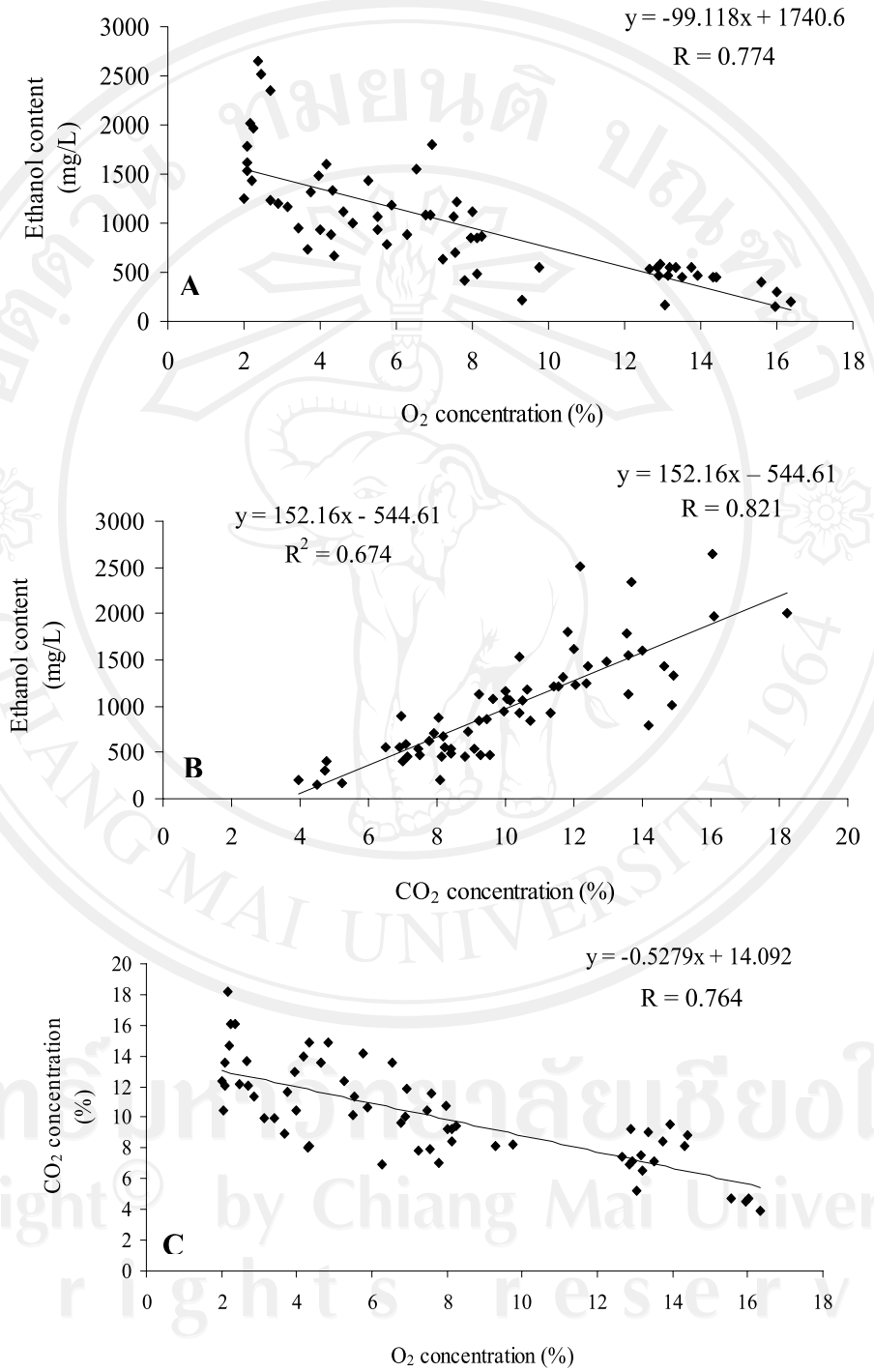

Figure 4.61 Correlation between internal O_2-ethanol content (A), internal CO_2-ethanol content (B) and internal O_2-internal CO_2 (C), combined results of experiment 4.2.1 and 4.4

4.6 Scanning electron microscope (SEM) observation and permeability of coatings

4.6.1 Scanning electron microscope (SEM) observation

4.6.1.1 SEM observation on the fruit surface coated with commercial coatings

The SEM images of non-coated fruit showed that the surface of tangerine fruit coated with a non-uniform layer of natural wax (Figure 4.62 J-1 and J-2). Stomata are observed on the surface (Figure 4.62 K-1). After coated with commercial coatings, the peel and it non-coated surface gain a uniform cover. Fruit surfaces coated with Sealkote and Wax (unknown) indicated somewhat hardened and cracked coating (Figure 4.62 B-1, B-2, I-1 and I-2). Coated with Citrashine, Fomesa, Rosy Plus, Citrosol AK, Zivdar and Perfect Shine showed more uniform cover. Figure 4.62 K-2 showed the clogging of the outer stomatal (vestibular) pore by the applied commercial wax layer.

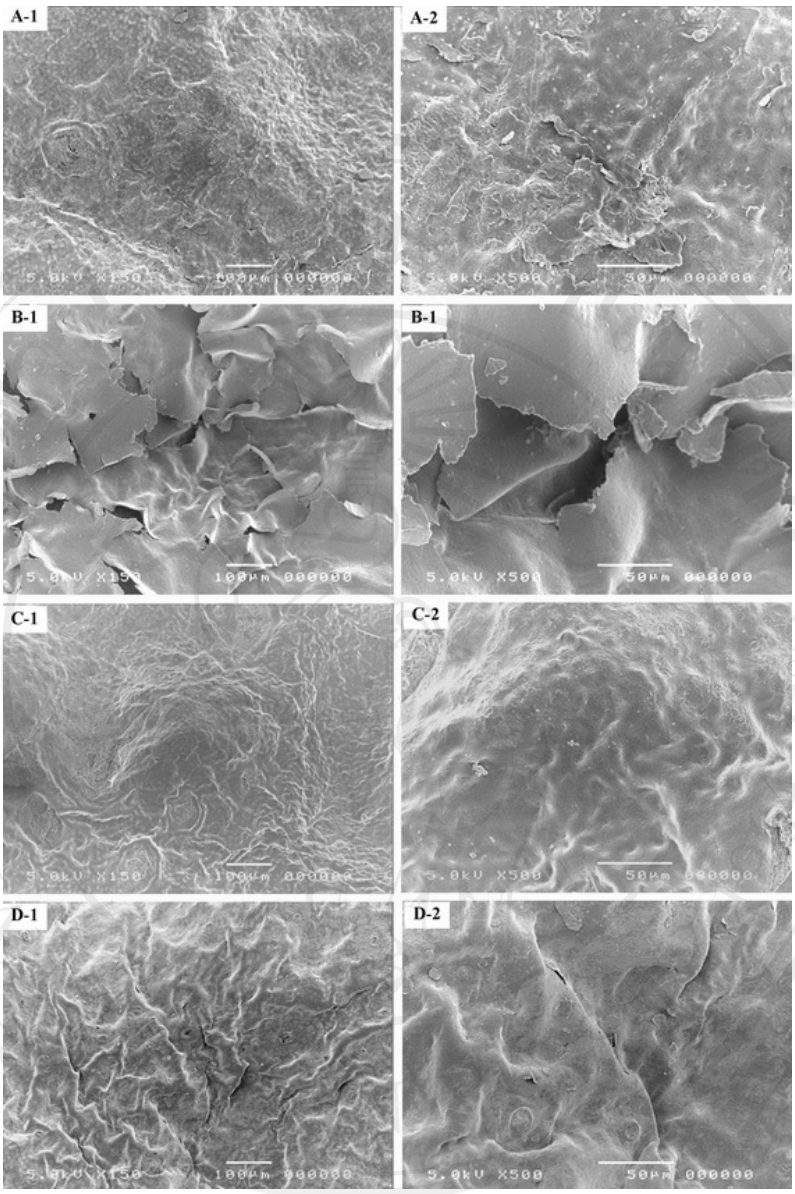

Figure 4.62 SEM images of the tangerine fruit surface (A-1, A-2) coated with Citrashine (×150, ×500), (B-1, B-2) coated with Sealkote (×150, ×500), (C-1, C-2) coated with Fomesa (×150, ×500) and (D-1, D-2) coated with Rosy Plus (×150, ×500)

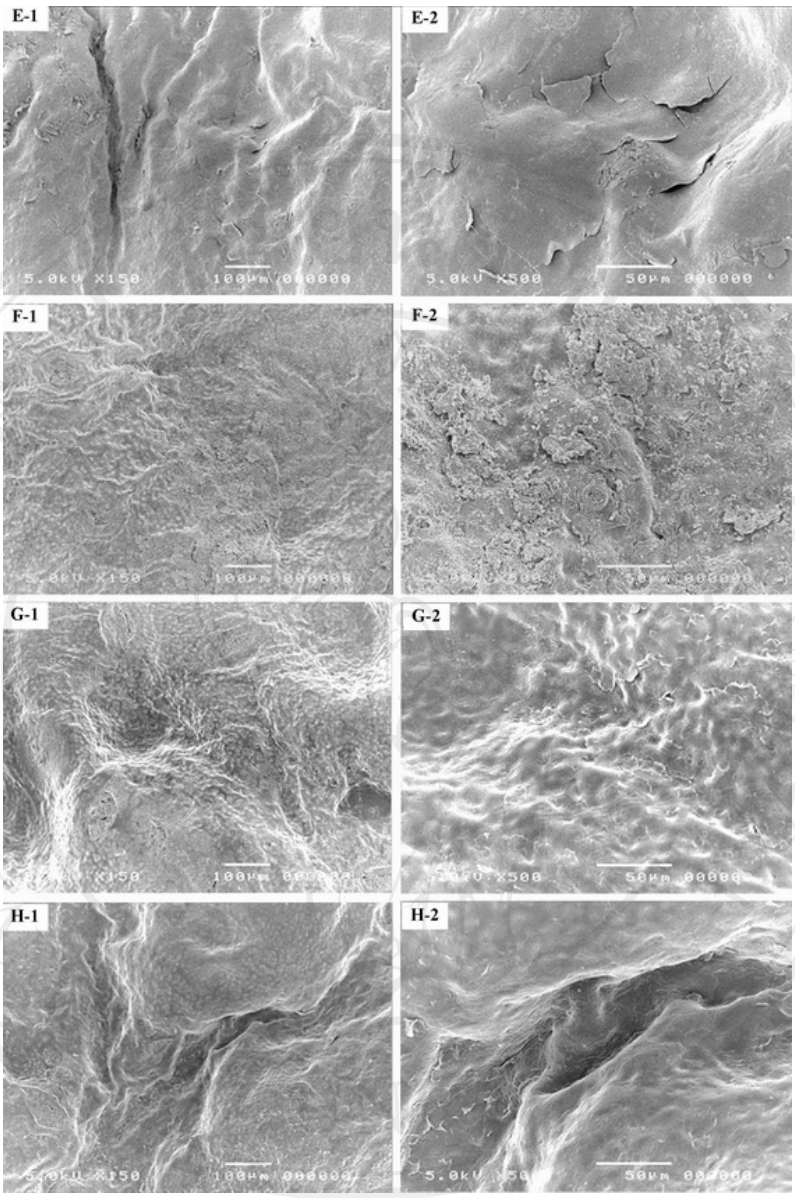

Figure 4.62 (continued) SEM images of the tangerine fruit surface (E-1, E-2) coated with Citrosol AK (×150, ×500), (F-1, F-2) coated with Supershine-C (×150, ×500), (G-1, G-2) coated with Zivdar (×150, ×500) and (H-1, H-2) coated with Perfect Shine (×150, ×500)

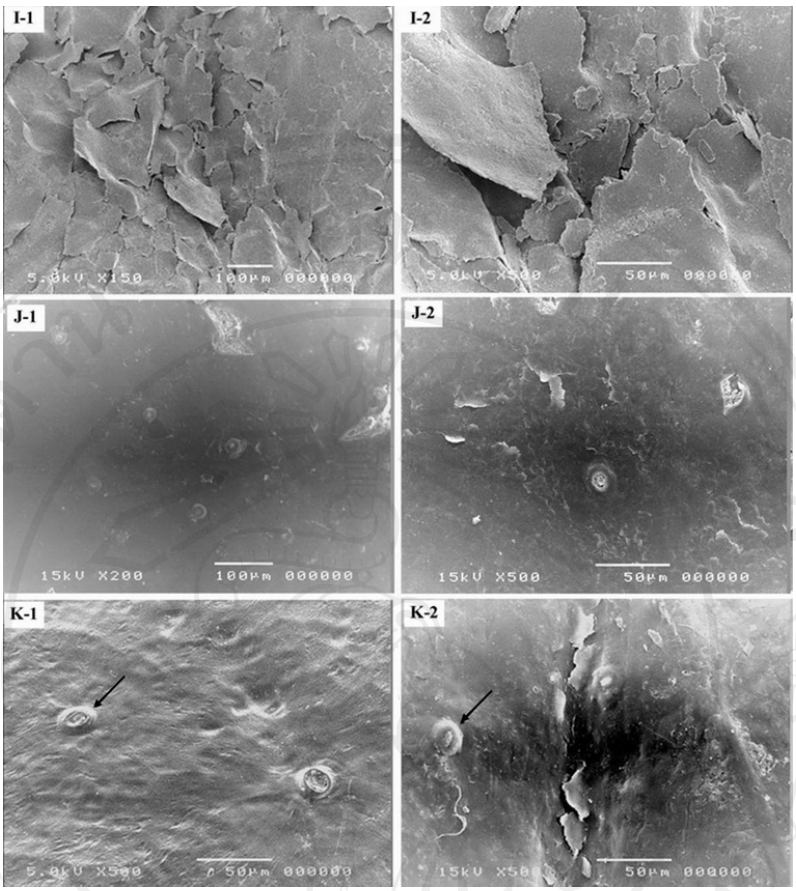

Figure 4.62 (continued) SEM images of the tangerine fruit surface (I-1, I-2) coated with Wax (unknown) (×150, ×500), (J-1, J-2) surface of non-coated (×200, ×500), (K-1) stomatal of tangerine fruit (×500) and (K-2) stomatal pore clogged by the applied coating (×500)

4.6.1.2 SEM observation of surface coated with developed coating materials and Zivdar

The epicuticular wax of 'Sai Nam Phueng' tangerine peel had a crystalline structure with high density of small platelets scattered on the surface and embedded in an amorphous wax layer and a number of round, presumably caused by mechanical damage during fruit handling (Figure 4.64A). Stomata were observed on the surface as shown in Figure 4.64B. Similar observations were made in fruit coated with formulation B and formulation C coatings, but lifted platelets were less pronounced than in non-coated fruit (Figure 4.64 B-1, B-2, C-1 and C-2). After coating with formulation A, formulation D and Zivdar, most platelets on the surface were flattened and the skin surface appeared relatively homogeneous (Figure 4.64 A-1, A-2, D-1, D-2, E-1 and E-2).

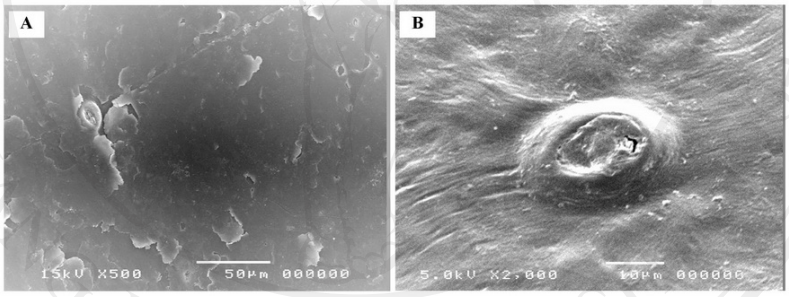

Figure 4.63 SEM images of the (A) stomata and wax platelets on the surface of non-coated fruit (×500) and (B) a stoma on the surface of non-coated fruit (×2,000)

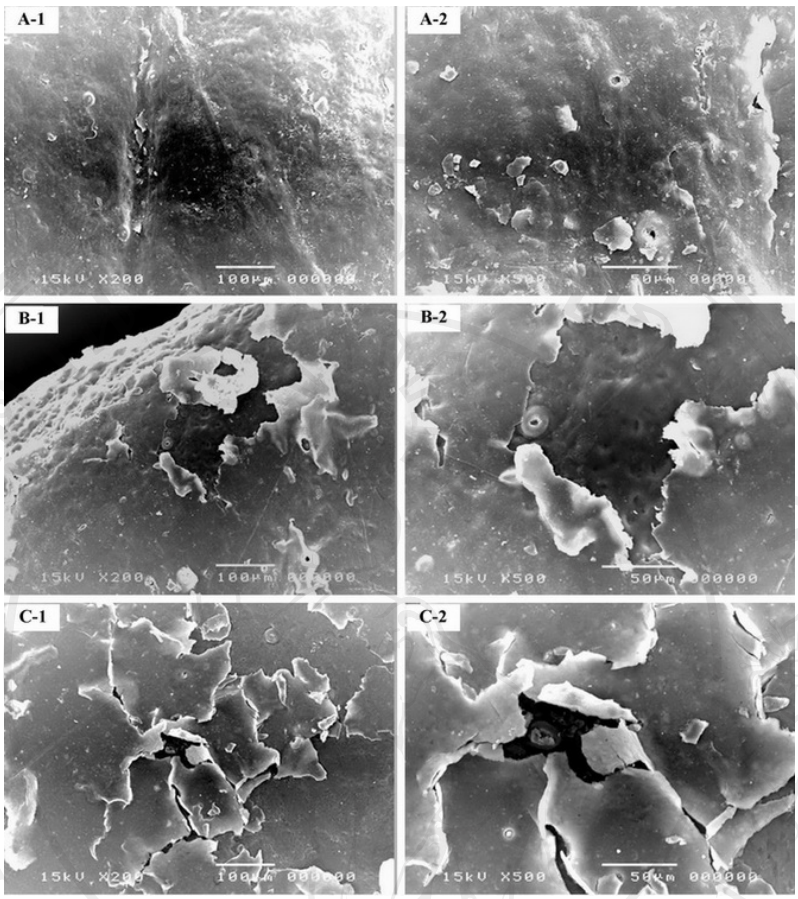

Figure 4.64 SEM images of the tangerine fruit surface (A-1, A-2) coated with formulation A (×200, ×500), (B-1, B-2) coated with formulation B (×200, ×500) and (C-1, C-2) coated with formulation C (×200, ×500)

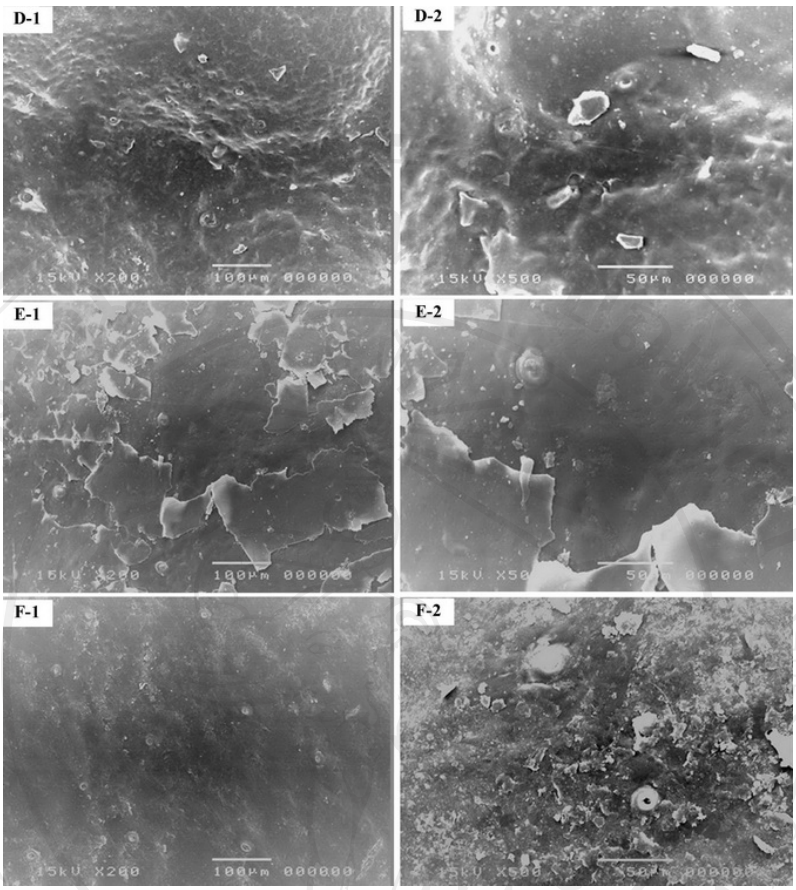

Figure 4.64 (continued) SEM images of the tangerine fruit surface (D-1, D-2) coated with formulation D (×200, ×500), (E-1, E-2) coated with Zivdar (×200, ×500) and (F-1, F-2) non-coated fruit (×200, ×500)

4.6.2 Permeability of coatings

4.6.2.1 Oxygen permeability

The O_2 permeability of 17.5% polyethylene micro-emulsion + 0.5% shellac microemulsion was 4,421 cm^3/m^2-day and 4,217 cm^3/m^2-day for Zivdar. Film coated with two coatings had permeance values lower than those of non-coated film. The results demonstrated that 17.5% polyethylene micro-emulsion + 0.5% shellac microemulsion and Zivdar coatings reduced the O_2 permeance about 12 and 16%, respectively, when compared with cast polypropylene film (control) (Table 4.35).

4.6.2.2 Water vapor permeability

Under the condition of measurement, there was less variation in permeability to water vapor of 17.5% polyethylene microemulsion + 0.5% shellac microemulsion (2,069 g/m^2-d) and Zivdar (2,045 g/m^2-d). The water vapor permeance of coated and uncoated films showed slightly differences. Commercial coating (Zivdar) and 17.5% polyethylene microemulsion + 0.5% shellac microemulsion reduced the water vapor permeance about 8 and 6%, respectively (Table 4.36).

Table 4.35 Comparison of oxygen permeabilities between developed coating and commercial coating on the cast polypropylene film (CCP film)

Coating materials	Test conditions	Oxygen permeability (cm^3/m^2-day)
17.5% PE + 0.5% SL	23°C; 0% relative humidity	4,421
Zivdar	23°C; 0% relative humidity	4,217
Non-coated (20 μm CCP film)	23°C; 0% relative humidity	5,012

PE = polyethylene microemulsion SL = shellac microemulsion

Table 4.36 Comparison of water vapor permeabilities between developed coating and commercial coating on the kraft paper

Coating materials	Test conditions	Water vapor permeability (g/m^2-day)
17.5% PE + 0.5% SL	38°C; 98% relative humidity	2,069
Zivdar	38°C; 98% relative humidity	2,045
Non-coated (kraft paper)	38°C; 98% relative humidity	2,212

PE = polyethylene microemulsion SL = shellac microemulsion