Chapter 4

Results

Changes in quality and enzyme activity during ripening of 'Keaw Morakot' mango fruit at ambient condition

Firmness

The firmness of harvested mango fruit cv. Keaw Morakot at different maturities varied between 111.89-117.75 Newton, which had no significant difference. After 7 days of storage, the fruit at Maturity 1 had the lowest firmness (10.08 Newton), and differed with the fruit at Maturity 2 and 3 (Table 6). The firmness of the fruit had rapidly decreased after 2 days of storage. The firmness of the fruit at Maturity 2 tended to decrease less than the others (Figure 1, Appendix Table 1).

Color changes in pulp and peel

The L* value of the harvested mango pulp was 69.78-71.06 which had no significant difference. After storage for 7 days, the fruit at Maturity 3 had the lowest L* value which was 43.97, differed with the fruit at Maturity 2 which was 46.92 (Table 6). The L* value of the fruit decreased during storage. The pulp L* value at Maturity 3 tended to decrease more than the others (Figure 2, Appendix Table 2). However, the peel L* value at the beginning and 7 days of storage (55.32-56.15 and 55.63-56.04, respectively) did not significantly differ (Table 6). During storage, the peel L* value had a little change (Figure 3, Appendix Table 3).

The ºH value of the harvested mango pulp was 82.25-83.56 which had no significant difference. Stored at 7 days, the fruit at Maturity 2 showed the highest ºH value which was 62.24, and differed with the others (Table 6). The pulp ºH value decreased during storage. The pulp ºH value at Maturity 2 tended to decrease less than the others (Figure 4, Appendix Table 4). However, at the beginning and 7 days of storage, the peel ºH value (168.32-169.57 and 168.69-169.82, respectively) had no significant differences (Table 6). The peel ºH value had a little change during storage (Figure 5, Appendix Table 5).

The chroma value of the harvested mango pulp (46.58-47.33) had no significant differences. After storage for 7 days, the fruit at Maturity 2 showed the highest chroma value (35.02) which differed with the others (Table 6). The pulp chroma value decreased during storage, as the fruit at Maturity 2 tended to decrease less than the others (Figure 6, Appendix Table 6). However, at the beginning and 7 days of storage, the peel chroma value (31.98-32.35 and 31.31-31.52, respectively) had no significant differences (Table 6). The peel chroma value had a little change during storage (Figure 7, Appendix Table 7).

Table 6 Effects of maturity on firmness, L*, ºH and chroma values of pulp and peel of 'Keaw Morakot' mango fruit stored at ambient condition (26-31˚C, 60-70% RH) for 0 and 7 days

Treatments	Firmness	L*		ºH		Chroma	
	(Newton)	pulp	peel	pulp	peel	pulp	peel
0 days							
Maturity 1	116.65^{ns}	70.62^{ns}	55.32^{ns}	82.25^{ns}	168.32^{ns}	47.33^{ns}	32.33^{ns}
Maturity 2	117.75	71.06	55.52	83.56	169.02	46.58	32.35
Maturity 3	111.89	69.78	56.15	82.32	169.57	46.77	31.98
CV (%)	20.32	10.25	6.22	12.56	5.65	2.35	2.32
7 days							
Maturity 1	10.08^{b}	44.64^{b}	55.67^{ns}	56.54^{b}	168.69^{ns}	33.20^{b}	31.31^{ns}
Maturity 2	14.05^{a}	46.92^{a}	56.04	62.24^{a}	169.82	35.02^{a}	31.52
Maturity 3	13.10^{a}	43.97^{b}	55.63	57.78^{b}	169.75	32.85^{b}	31.24
CV (%)	9.25	16.54	8.36	2.44	7.63	8.45	0.64

***** Means within the same column followed by different letters differ significantly at $\rho<0.05$

ns = non-significant

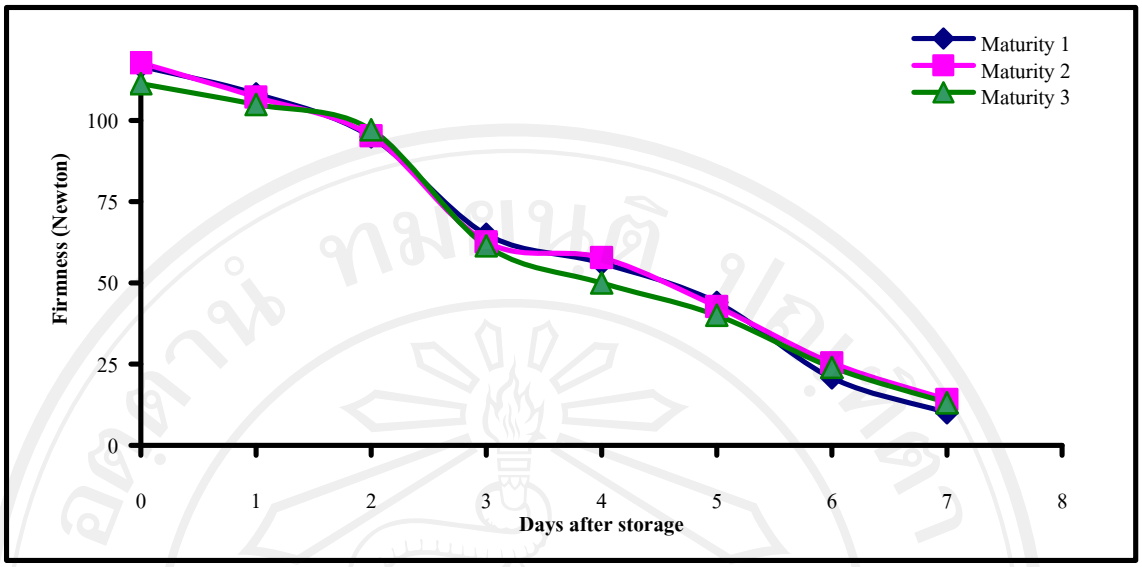


Figure 1 Changes in the firmness of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

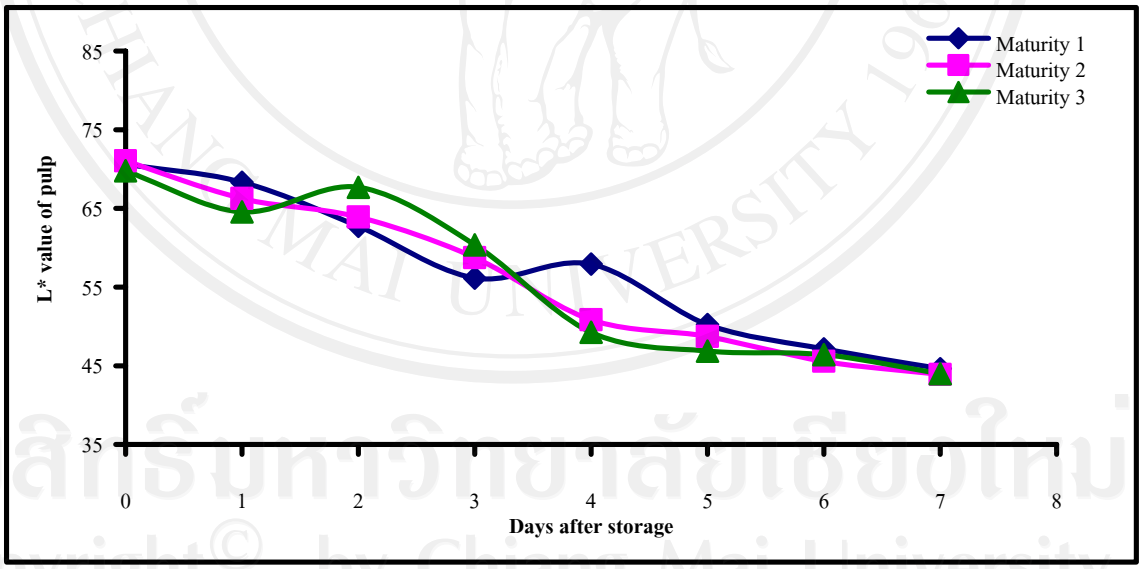


Figure 2 Changes in the L* value of 'Keaw Morakot' mango pulp during storage at ambient condition (26-31˚C, 60-70% RH)

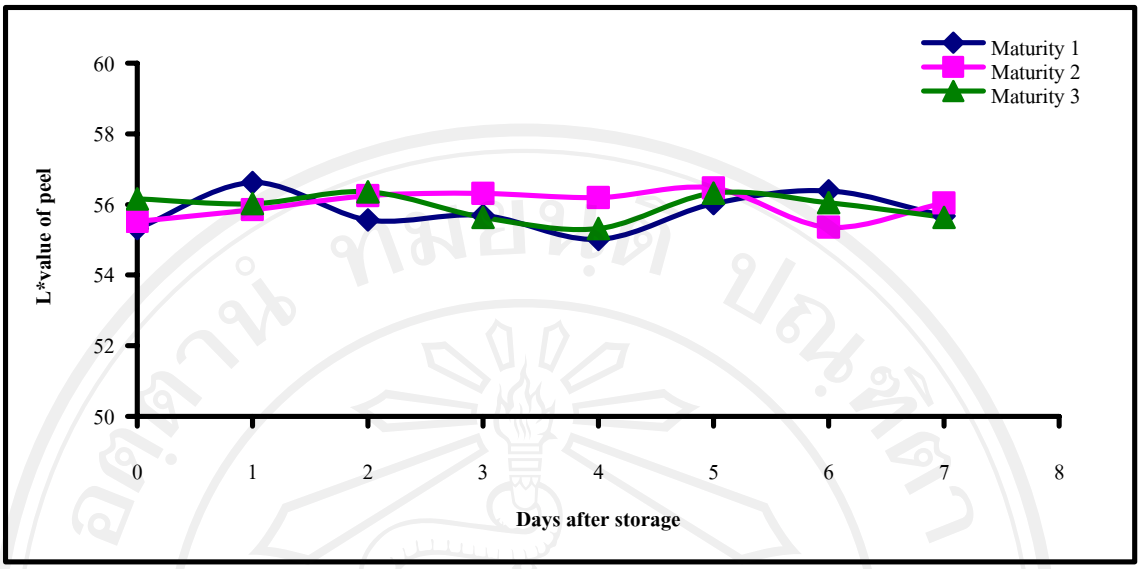


Figure 3 Changes in the L* value of 'Keaw Morakot' mango peel during storage at ambient condition (26-31˚C, 60-70% RH)

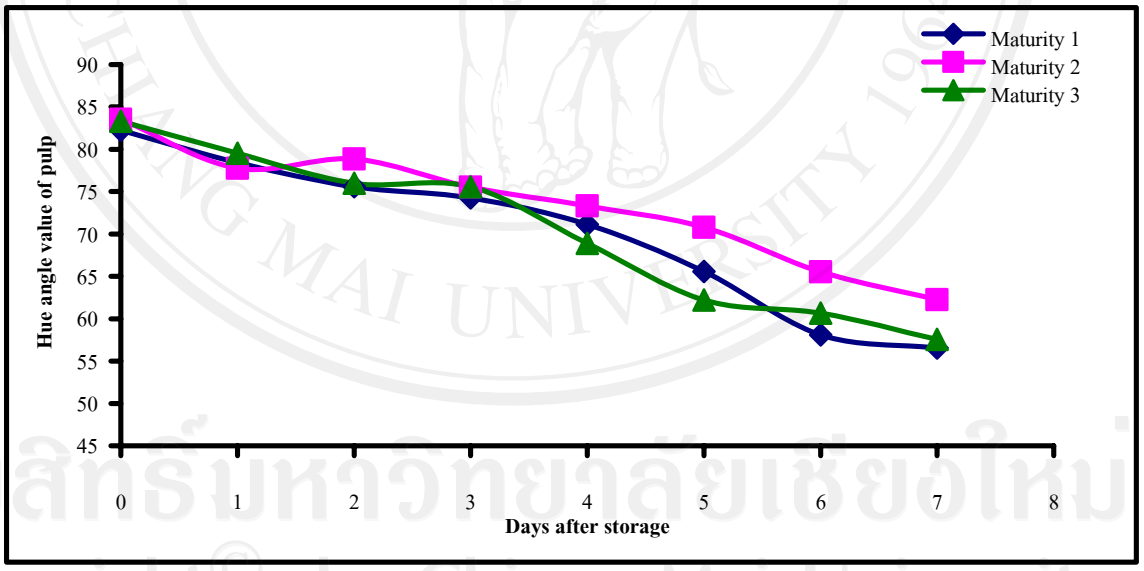


Figure 4 Changes in the ºH value of 'Keaw Morakot' mango pulp during storage at ambient condition (26-31˚C, 60-70% RH)

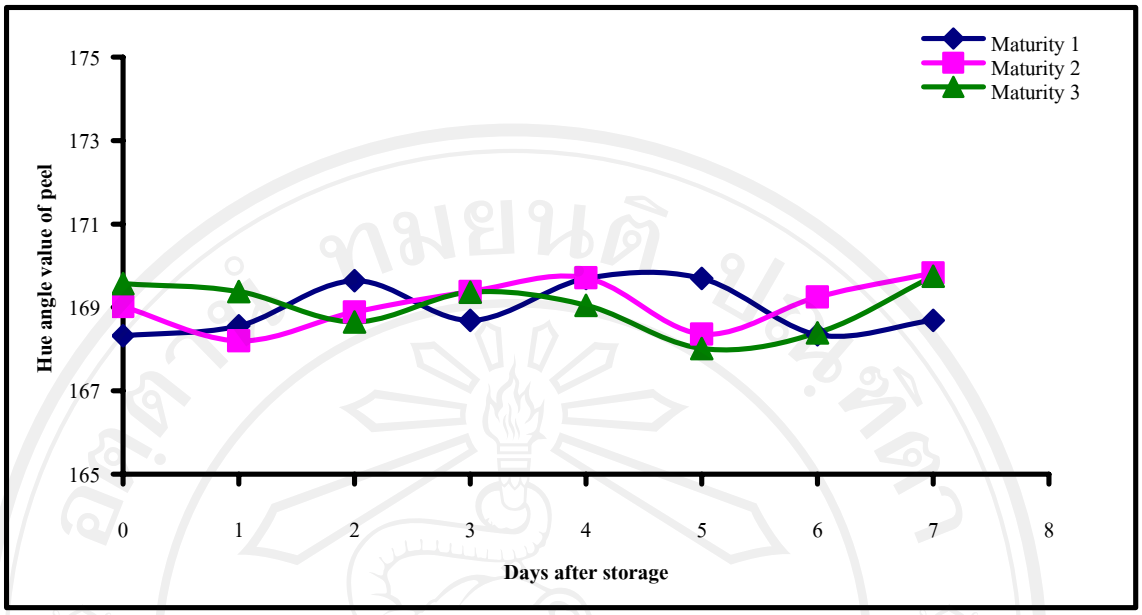


Figure 5 Changes in ºH value of 'Keaw Morakot' mango peel during storage at ambient condition (26-31˚C, 60-70% RH)

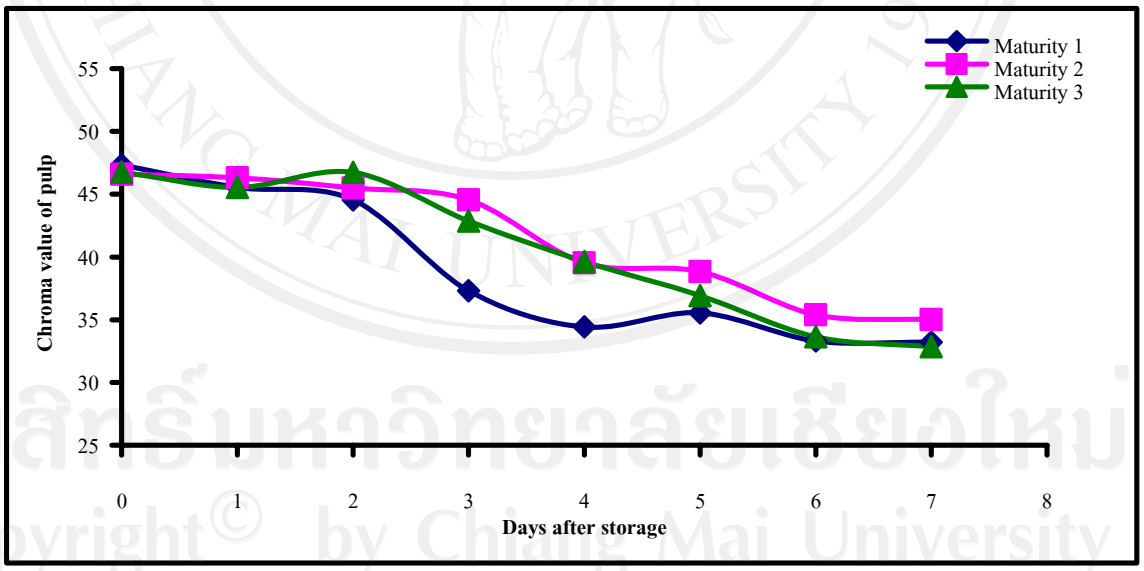


Figure 6 Changes in the chroma value of 'Keaw Morakot' mango pulp during storage at ambient condition (26-31˚C, 60-70% RH)

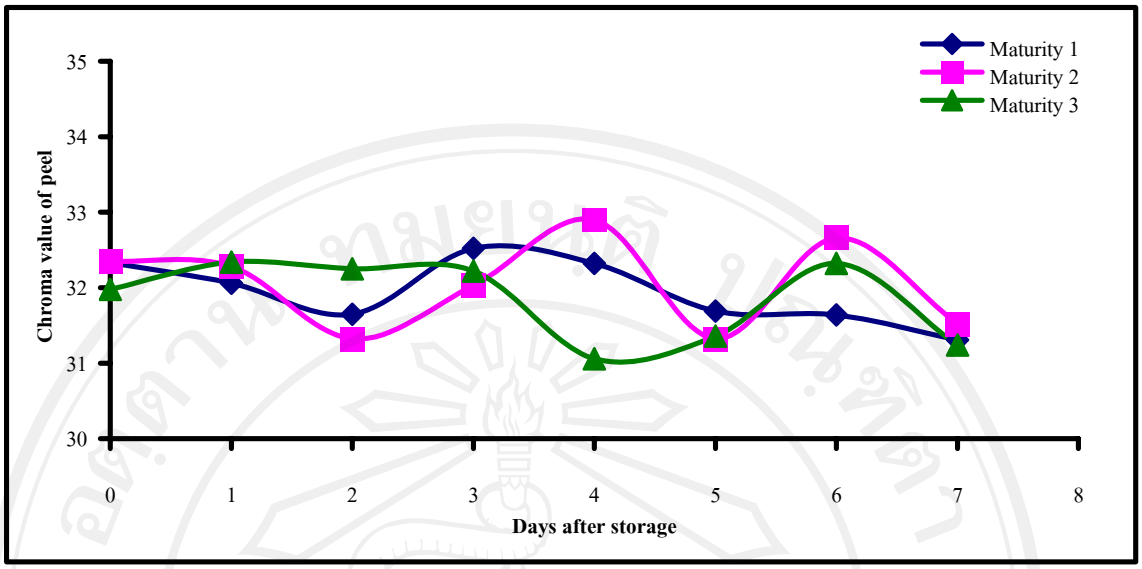


Figure 7 Changes in the chroma value of 'Keaw Morakot' mango peel during storage at ambient condition (26-31˚C, 60-70% RH)

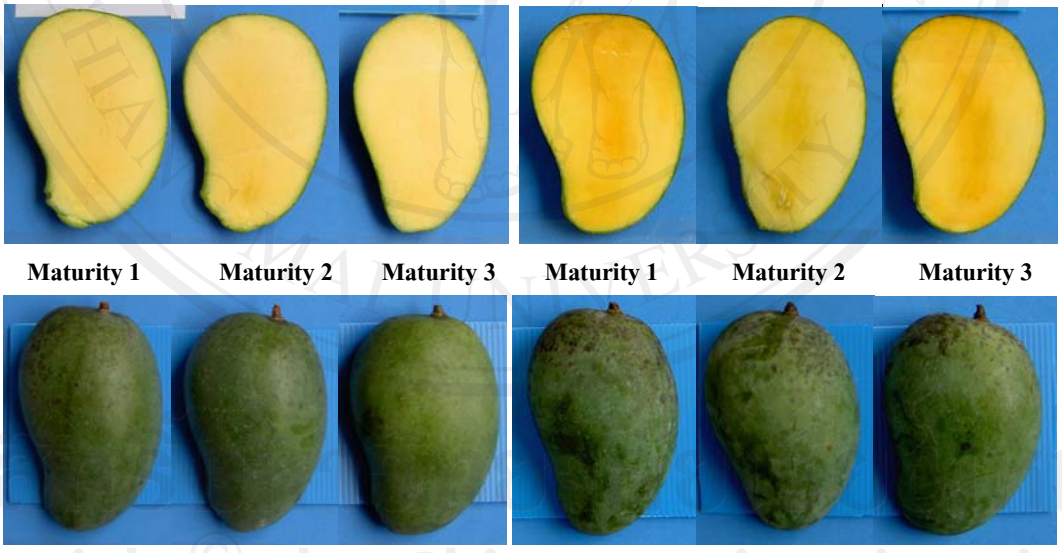


Figure 8 'Keaw Morakot' mango fruit at different maturity after storage for 0 and 7 days at ambient condition (26-31˚C, 60-70% RH)

Total soluble solids (TSS) content

The TSS content of the older mango fruit was higher than the younger one. At harvest, the TSS content of the fruit at Maturity 3 and 2 (8.10 and 8.00%, respectively) differed with Maturity 1 (7.56%). After storage for 7 days, the TSS of fruit at different maturities (19.53-20.26%) had no significant differences (Table 7). The TSS content of the fruit increased during storage, as the Maturity 3 tended to increase more than the Maturity 2 and 1 (Figure 9, Appendix Table 8).

Glucose content

The harvested fruit at Maturity 3 had the highest glucose content (0.50 g/100gFW), and differed with Maturity 1 and 2 (0.40 and 0.39 g/100gFW, respectively). After storage for 7 days, the fruit at Maturity 3 had the lowest content (0.63 g/100gFW) which differed with Maturity 1 and 2 (0.66 and 0.67 g/100gFW, respectively) (Table 7). The glucose content of the fruit increased during 0-5 days, but decreased a little thereafter (Figure 10, Appendix Table 9).

Fructose content

The fructose content of the harvested fruit at different maturities was not significantly different (1.96-2.15 g/100gFW). After storage for 7 days, the fruit at Maturity 3 had the lowest content (2.48 g/100gFW) which differed with Maturity 2 and 1 (2.88 and 2.81 g/100gFW, respectively) (Table 7). The fructose content of the fruit rapidly increased after 3 days of storage. However, the fruit at Maturity 3 tended to decrease after 4 days of storage (Figure 11, Appendix Table 10).

Sucrose content

The sucrose content of the harvested fruit at Maturity 3 (5.68 g/100gFW) differed with Maturity 1 (4.75 g/100gFW). However, after storage for 7 days, the fruit at Maturity 2 had the highest content (9.10 g/100gFW) and differed with Maturity 1 and 3 (8.79 and 8.69 g/100gFW, respectively) (Table 7). The sucrose content of the fruit rapidly increased during 0-5 days of storage, after that it had a little change (Figure 12, Appendix Table 11).

Table 7 Effects of maturity on TSS, glucose, fructose and sucrose contents of 'Keaw Morakot' mango fruit stored at ambient condition (26-31˚C, 60-70% RH) for 0 and 7 days

Treatments	TSS (%)	Glucose (g/100g FW)	Fructose (g/100g FW)	Sucrose (g/100g FW)
0 days				
Maturity 1	7.56[b]	0.40[b]	1.96[ns]	4.75[b]
Maturity 2	8.00[a]	0.39[b]	2.05	5.00[ab]
Maturity 3	8.10[a]	0.5[0a]	2.15	5.68[a]
CV (%)	15.02	5.64	10.61	11.25
7 days				
Maturity 1	19.53[ns]	0.66[a]	2.81[a]	8.79[b]
Maturity 2	19.93	0.67[a]	2.88[a]	9.10[a]
Maturity 3	20.26	0.63[b]	2.48[b]	8.69[b]
CV (%)	12.99	4.12	10.33	5.08

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

ns = non-significant

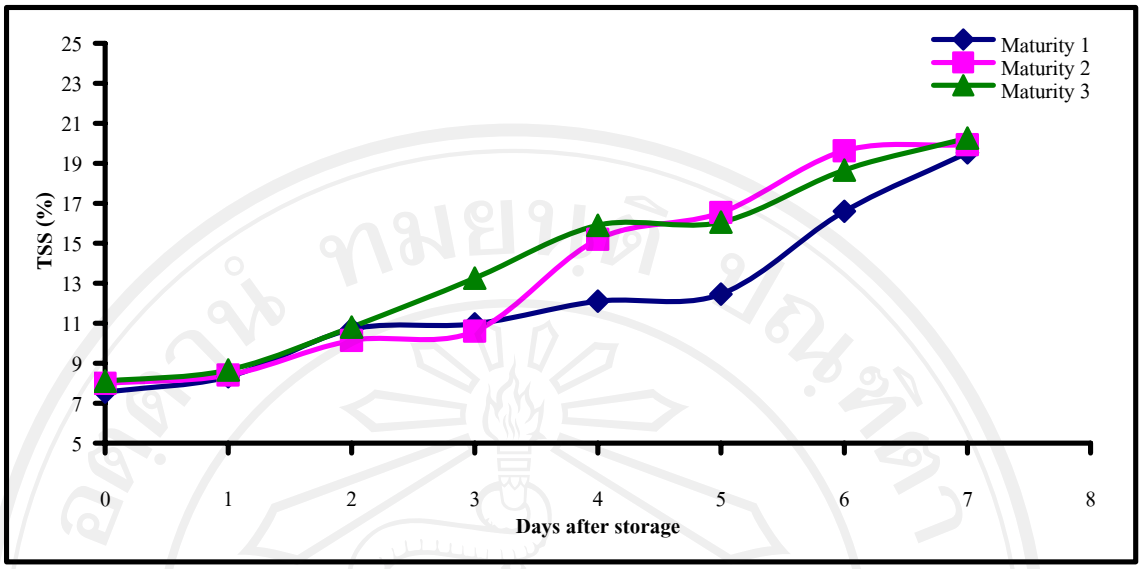


Figure 9 Changes in the TSS content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

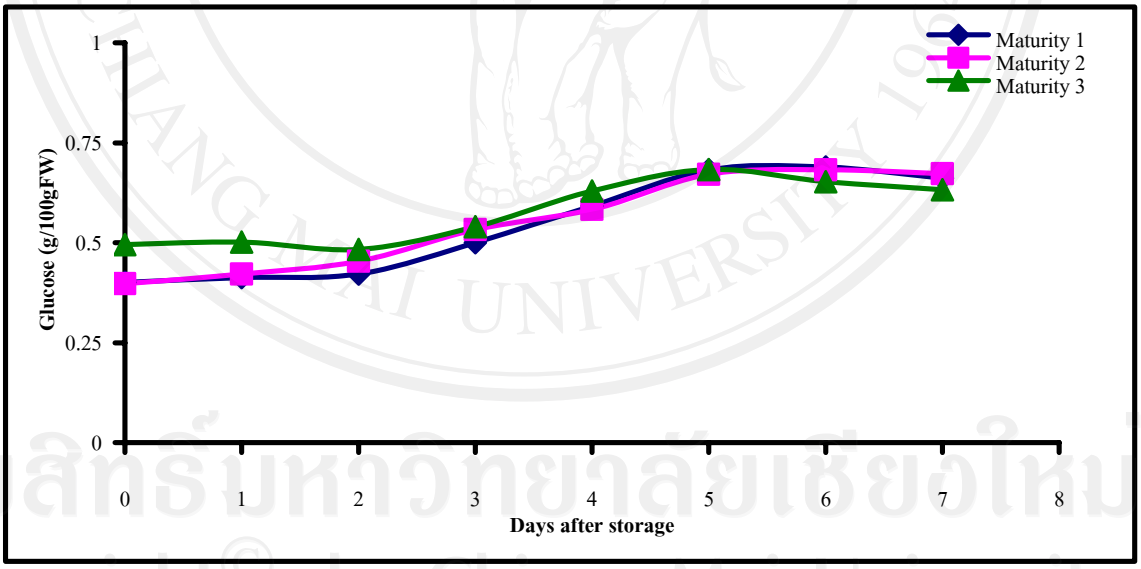


Figure 10 Changes in the glucose content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

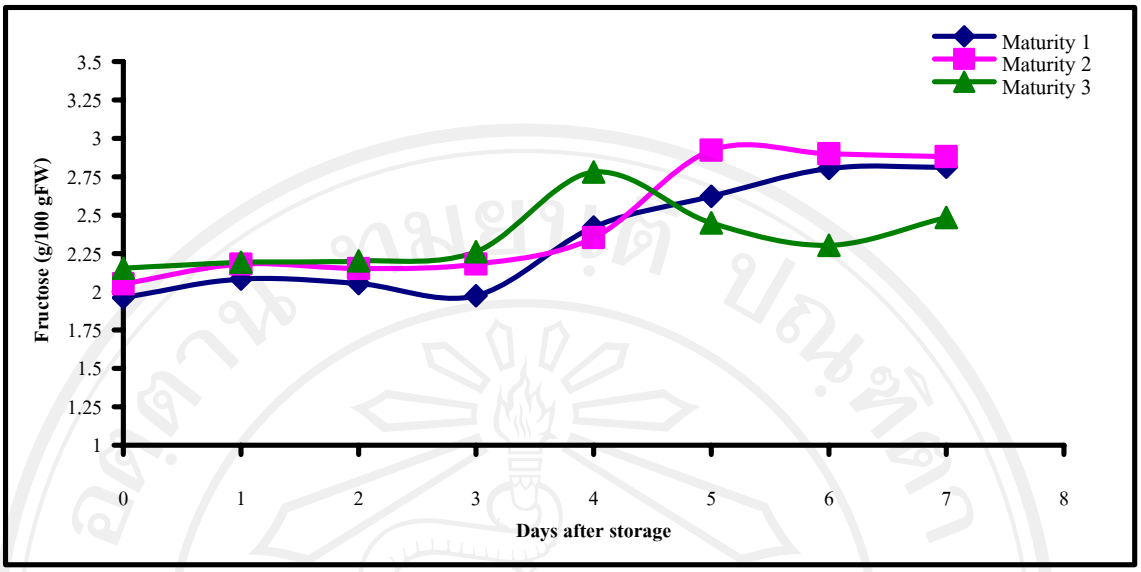


Figure 11 Changes in the fructose content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

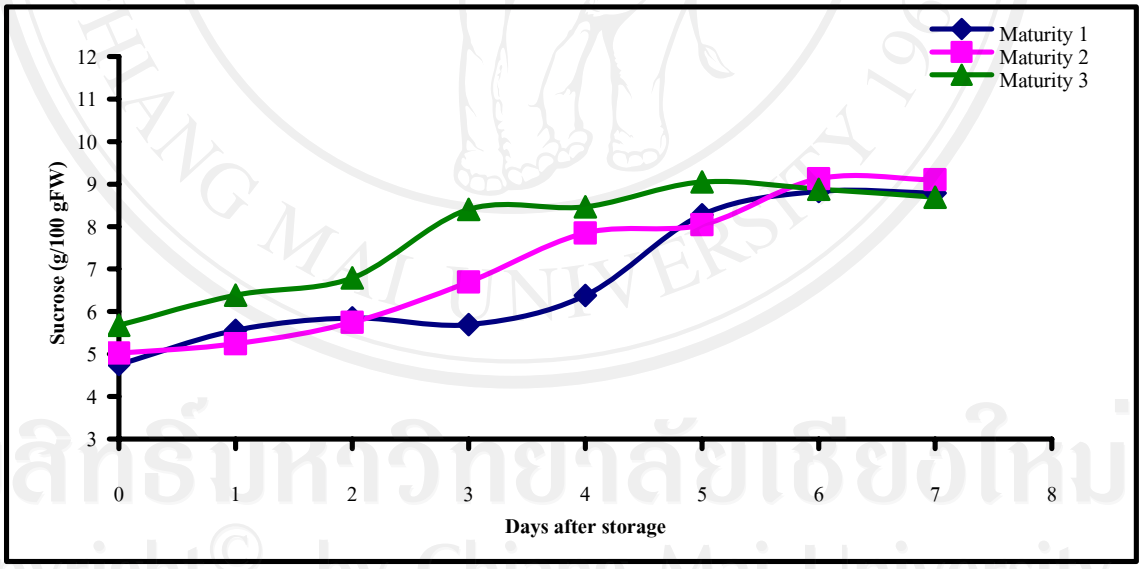


Figure 12 Changes in the sucrose content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

pH value

The harvested fruit at Maturity 3 showed the highest pH value (3.53) and differed with Maturity 1 and 2 (3.35 and 3.40, respectively). After storage for 7 days, the pH value (5.54-5.64) was not significantly different (Table 8). The pH value of the fruit increased during storage (Figure 13, Appendix Table 12).

Titratable acid (TA) content

The younger mature fruit tended to have higher TA content than the older fruit. The TA content of harvested fruit at Maturity 1 (1.02%) differed with Maturity 3 (0.90%). After storage for 7 days, the fruit at Maturity 1 still had the highest TA content (0.70%), significantly different with Maturity 2 and 3, (0.58 and 0.53%, respectively) (Table 8). The TA content of the fruit rapidly decreased after 5 days of storage, as the fruit at Maturity 1 decreased less than Maturity 2 and 3 (Figure 14, Appendix Table 13).

Citric acid content

The younger mature fruit tended to have higher citric acid content than the older fruit. The content of harvested fruit at Maturity 1 (0.38 g/100gFW) differed with Maturity 3 (0.36 g/100gFW). However, after storage for 7 days, the fruit at Maturity 2 had the highest content (0.29 g/100gFW) and differed with Maturity 1 and 3 (0.25 and 0.24 g/100gFW, respectively) (Table 8). The citric acid content of the fruit decreased during storage, as the fruit at Maturity 3 tended to rapidly decrease (Figure 15, Appendix Table 14).

Malic acid content

The malic acid content of the harvested fruit at Maturity 3 was the lowest (0.30 g/100gFW) and differed with Maturity 1 and 2 (0.33 and 0.32 g/100gFW, respectively). However, after storage for 7 days, the fruit at Maturity 2 had the highest content (0.26 g/100gFW) and differed with Maturity 1 and 3 (0.24 and 0.24 g/100gFW, respectively) (Table 8). The malic acid content of the fruit had a little decreasing during storage, as the fruit at Maturity 2 tended to slowly decrease (Figure 16, Appendix Table 14).

Vitamin C content

The older mature fruit tended to have higher vitamin C content than the younger one. The vitamin C content of harvested fruit at Maturity 3 and 2 (165.08 and 160.22 mg/100 ml, respectively) differed with Maturity 1 (145.24 mg/100 ml). Moreover, after storage for 7 days, the fruit at Maturity 2 and 3 still had the higher content (55.48 and 54.92 mg/100 ml, respectively) and differed with Maturity 1 (46.36 mg/100 ml) (Table 8). The vitamin C content of the fruit rapidly decreased at day 5 (Figure 17, Appendix Table 16).

Table 8 Effects of maturity on pH value, TA, citric acid, malic acid and vitamin C contents of 'Keaw Morakot' mango fruit stored at ambient condition (26-31˚C, 60-70% RH) for 0 and 7 days

Treatments	pH	TA (% as citric acid)	Citric acid (g/100g FW)	Malic acid (g/100g FW)	Vitamin C (mg/100 ml)
0 days					
Maturity 1	3.35^{b}	1.02^{a}	0.38^{a}	0.33^{a}	145.24^{b}
Maturity 2	3.40^{b}	0.96^{ab}	0.37^{ab}	0.32^{a}	160.22^{a}
Maturity 3	3.53^{a}	0.90^{b}	0.36^{b}	0.30^{b}	165.08^{a}
CV (%)	10.25	13.65	8.65	5.32	10.96
7 days					
Maturity 1	5.54^{ns}	0.70^{a}	0.25^{b}	0.24^{b}	46.36^{b}
Maturity 2	5.60	0.58^{b}	0.29^{a}	0.26^{a}	55.48^{a}
Maturity 3	5.64	0.53^{b}	0.24^{b}	0.24^{b}	54.92^{a}
CV (%)	18.99	11.30	10.85	14.01	13.14

* Means within the same column followed by different letters differ significantly at $\rho<0.05$
ns = non-significant

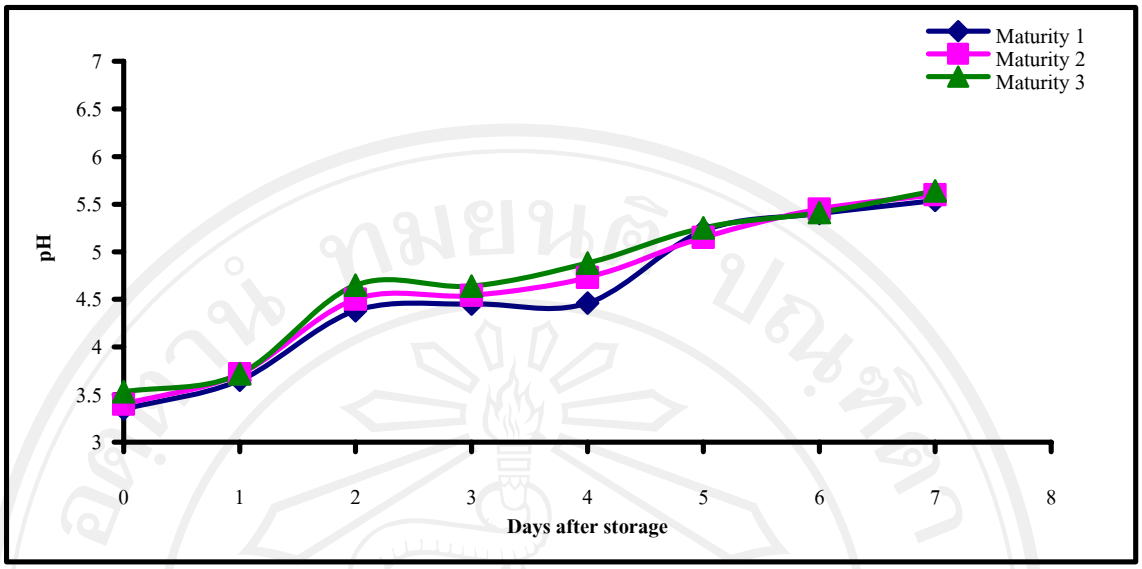


Figure 13 Changes in the pH value of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

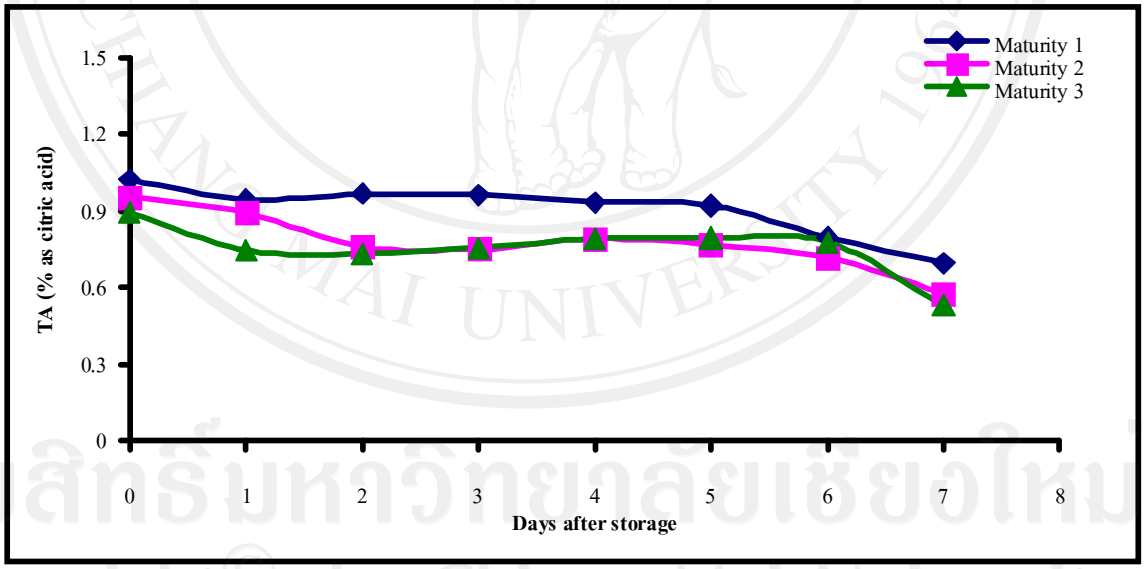


Figure 14 Changes in the TA content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

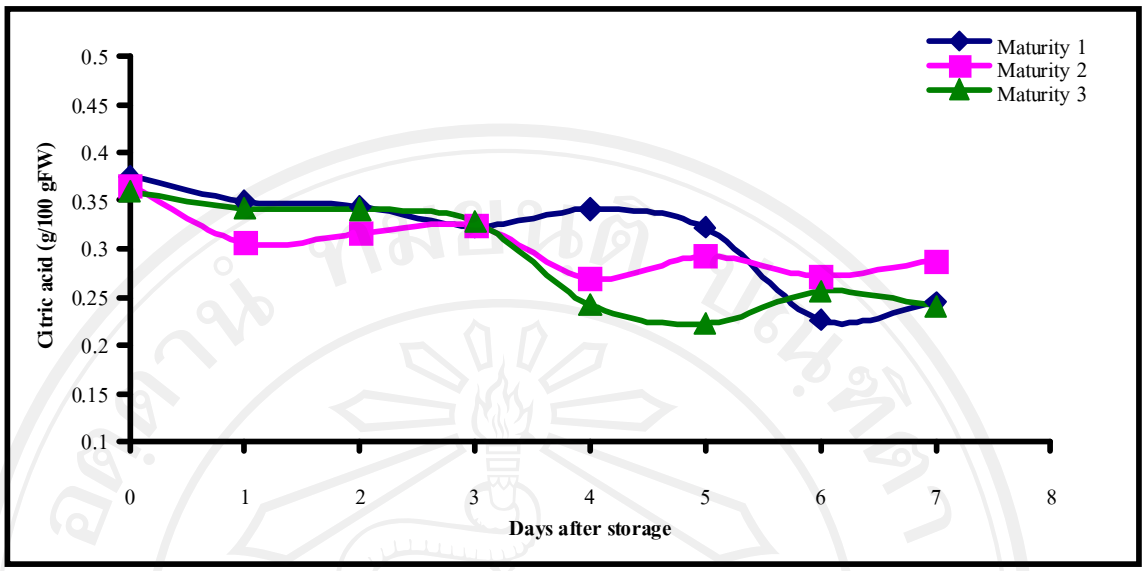


Figure 15 Changes in the citric acid content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

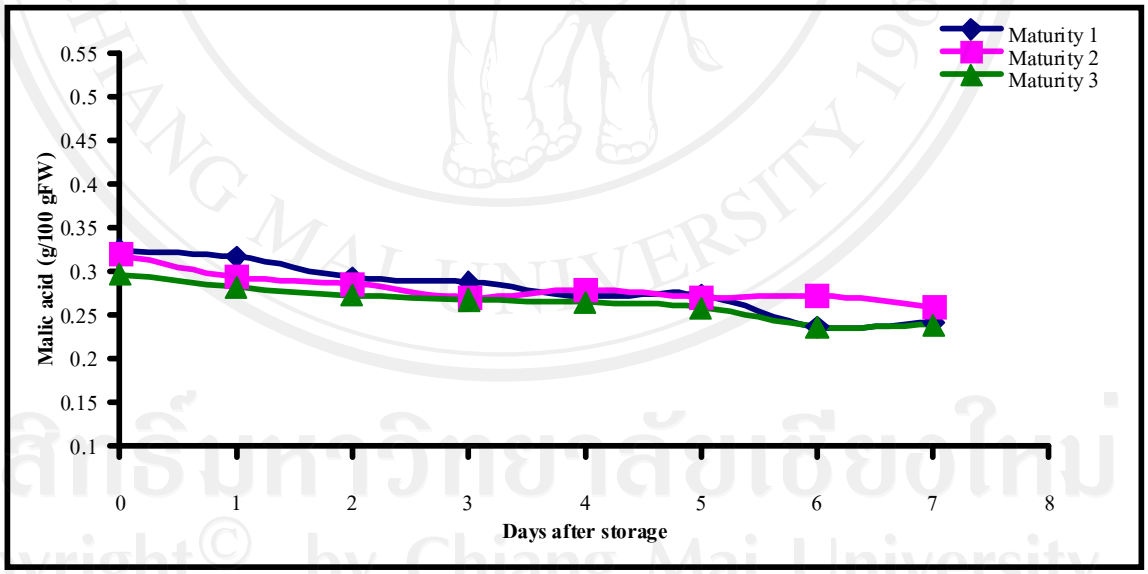


Figure 16 Changes in the malic acid content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

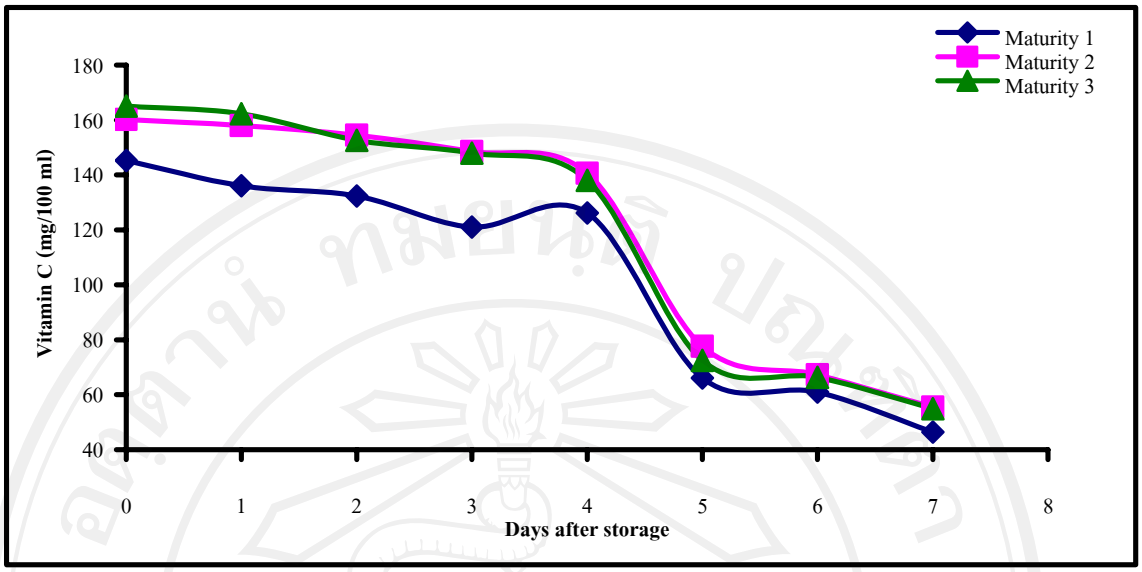


Figure 17 Changes in the vitamin C content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

Dry matter content

The dry matter content of the harvested fruit at different maturities was not significantly different (21.05-23.03%). However, at 7 days of storage, the fruit at Maturity 1 had the lowest content (24.74%) and differed with the fruit at Maturity 2 and 3 (27.54 and 28.28%, respectively) (Table 9). The dry matter content of the fruit tended to increase during storage and the fruit at Maturity 2 and 3 increased more than the fruit at Maturity 1 (Figure 18, Appendix Table 17).

Starch content

The starch content of the harvested fruit at Maturity 2 and 3 (8.34 and 8.80%, respectively) differed with Maturity 1 (7.60%). At 7 days of storage, the fruit at Maturity 2 and 3 (3.26 and 3.46%, respectively) also differed with Maturity 1 (2.89%) (Table 9). The starch content of the fruit decreased during storage, especially rapidly during 0-2 days of storage. The starch content of the older maturity fruit decreased less than the younger one (Figure 19, Appendix Table 18).

Chlorophylls content of peel

The total chlorophyll and chlorophyll a and b contents of the fruit peel were not significantly different at harvest (2.07-2.13, 1.33-1.40 and 0.70-0.78 mg/g FW, respectively) and storage for 7 days (0.79-0.91, 0.53-0.69 and 0.22-0.26 mg/g FW, respectively) (Table 9). The chlorophylls tended to rapidly decrease during 0-5 days of storage, after that there was a little change (Figure 20-22, Appendix Table 19-21).

β-carotene content of pulp

The β-carotene content of the harvested fruit pulp at Maturity 3 was highest (0.15 mg%) and significantly different with Maturity 1 and 2 (0.12 and 0.12 mg%, respectively). After storage for 7 days, the fruit at Maturity 1 had the lowest content (0.98 mg%), and differed with the fruit at Maturity 2 and 3 (1.10 and 1.05 mg%, respectively) (Table 9). The β-carotene of the fruit pulp increased during long-term storage. The fruit at Maturity 2 and 3 tended to have higher β-carotene content than Maturity 1 (Figure 23, Appendix Table 22).

Table 9 Effects of maturity on dry matter, starch, chlorophylls and β-carotene contents of 'Keaw Morakot' mango fruit stored at ambient condition (26-31˚C, 60-70% RH) for 0 and 7 days

Treatments	Dry matter (%)	Starch (%)	Chlorophylls (mg/g FW)			β-carotene (mg%)
			total	a	b	
0 days						
Maturity 1	21.05^{ns}	7.60^{b}	2.13^{ns}	1.35^{ns}	0.78^{ns}	0.12^{b}
Maturity 2	22.30	8.34^{a}	2.07	1.33	0.74	0.12^{b}
Maturity 3	23.03	8.80^{a}	2.10	1.40	0.70	0.15^{a}
CV (%)	20.12	8.69	5.61	8.69	2.02	12.65
7 days						
Maturity 1	24.74^{b}	2.89^{b}	0.79^{ns}	0.53^{ns}	0.26^{ns}	0.98^{b}
Maturity 2	27.54^{a}	3.26^{a}	0.85	0.63	0.22	1.10^{a}
Maturity 3	28.28^{a}	3.46^{a}	0.91	0.69	0.22	1.05^{a}
CV (%)	16.98	8.25	2.52	1.35	2.30	8.65

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

ns = non-significant

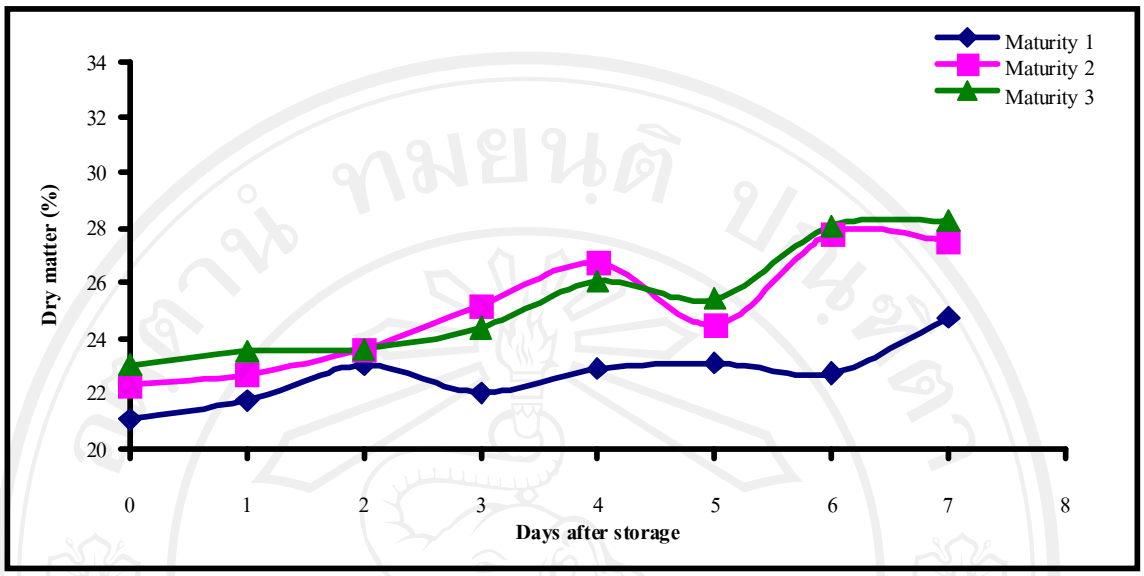


Figure 18 Changes in the dry matter content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

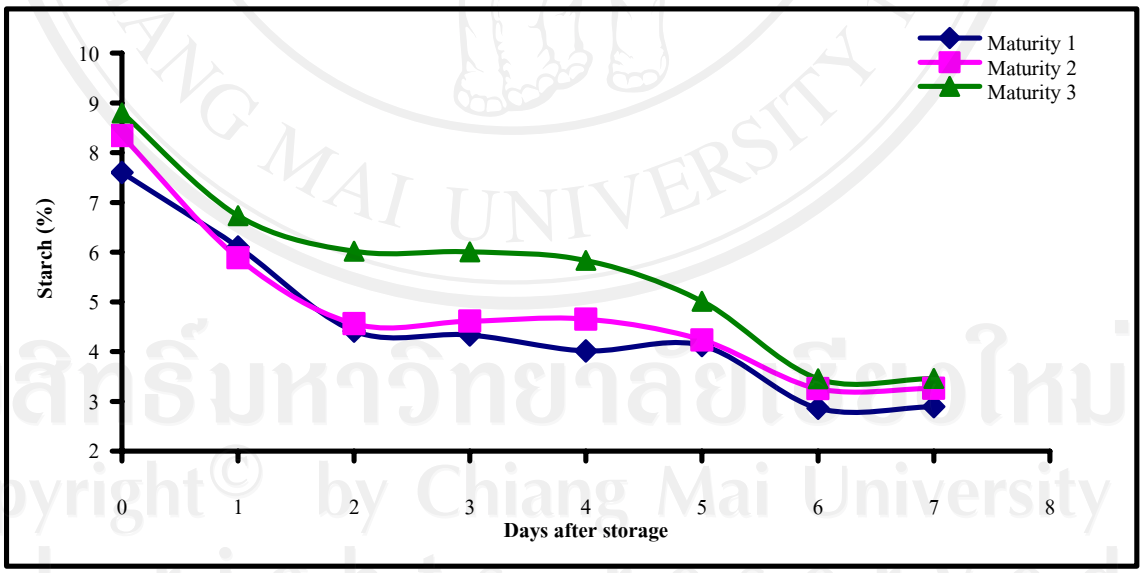


Figure 19 Changes in the starch content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

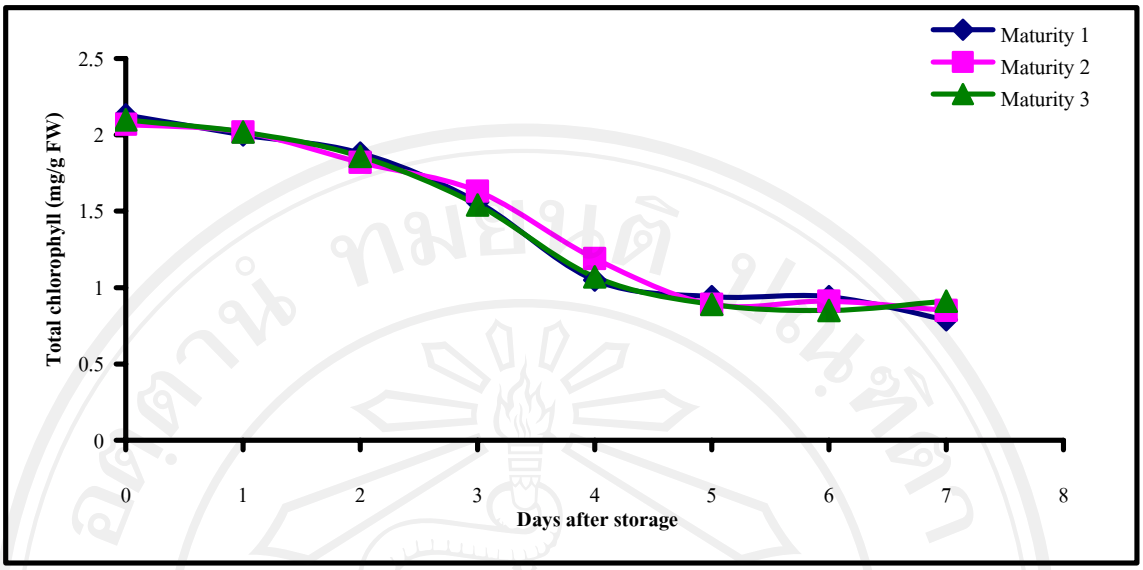


Figure 20 Changes in the total chlorophyll content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

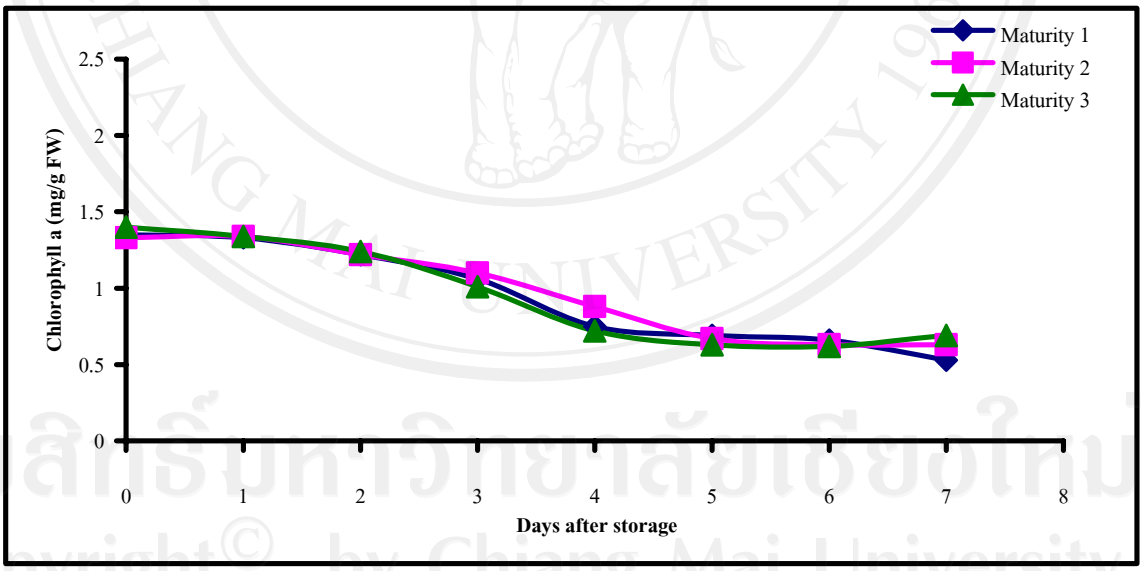


Figure 21 Changes in the chlorophyll a content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

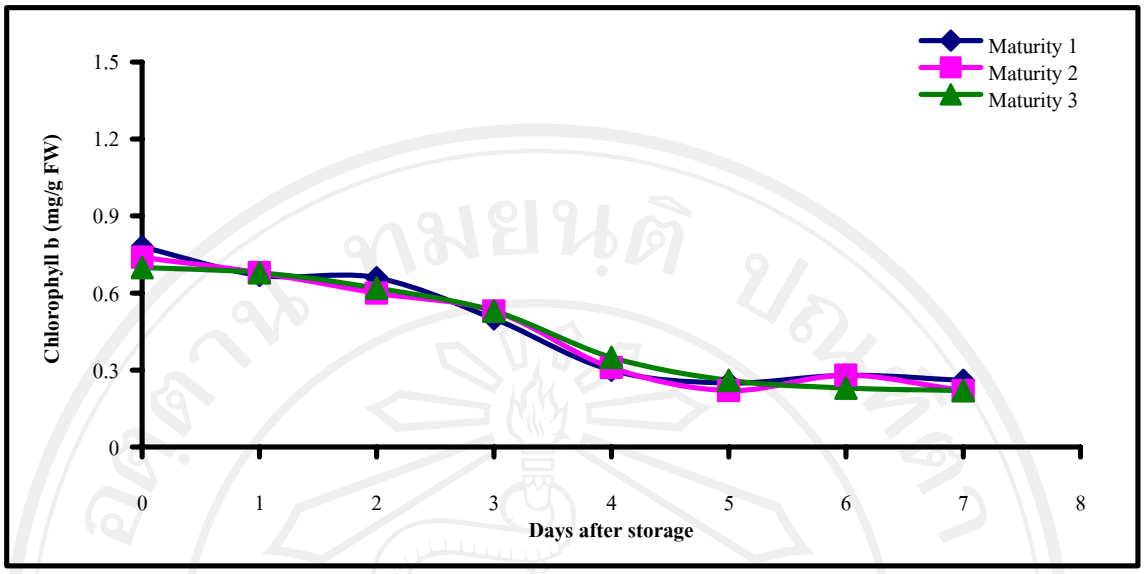


Figure 22 Changes in the chlorophyll b content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

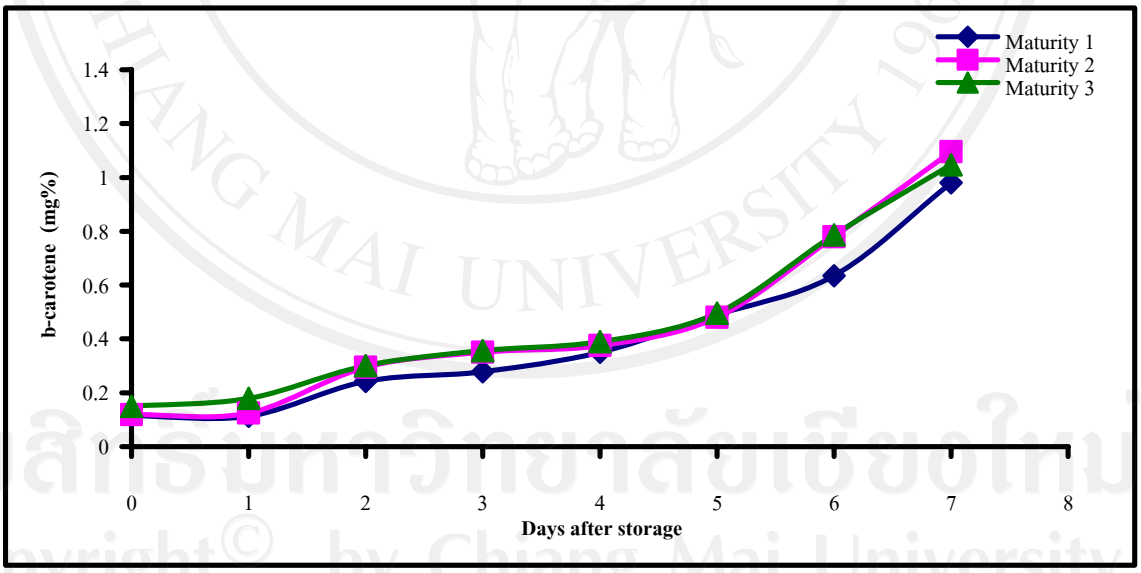


Figure 23 Changes in the β-carotene content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

Respiration rate

The older mango fruit tended to have higher respiration rate than the younger one. The respiration rate of the harvested mango fruit at Maturity 3 (90.43 mgCO_2/kg.hr^{-1}) differed with Maturity 1 (74.26 mg CO_2/kg.hr^{-1}). After storage for 7 days, the fruit at Maturity 3 had the highest respiration rate (285.10 mg CO_2/kg.hr^{-1}) and differed with Maturity 1 and 2 (266.60 and 260.40 mg CO_2/kg.hr^{-1}, respectively) (Table 10). The respiration rate of the fruit increased to peak at the day 5 of storage. During storage, the respiration rate of the fruit at Maturity 3 was higher than Maturity 1 and 2 (Figure 24, Appendix Table 23).

Ethylene production

The harvested mango fruit at Maturity 3 had the highest ethylene production (0.78 µl C_2H_4/kg.hr^{-1}) which was significantly different with the fruit at Maturity 1 and 2 (0.56 and 0.54 µl C_2H_4/kg.hr^{-1}, respectively). At 7 days of storage, the ethylene production of the fruit at Maturity 3 and 2 (2.17 and 2.13 µl C_2H_4/kg.hr^{-1}, respectively) differed with Maturity 1 (2.01 µl C_2H_4/kg.hr^{-1}) (Table 10). The ethylene production of the fruit at Maturity 1 increased to peak at the day 4, while the fruit at Maturity 2 and 3, at the day 5. During storage, the ethylene production of the older maturity fruit tended to be higher than the younger one (Figure 25, Appendix Table 24).

Table 10 Effects of maturity on respiration rate and ethylene production of 'Keaw Morakot' mango fruit stored at ambient condition (26-31˚C, 60-70% RH) for 0 and 7 days

Treatments	Respiration rate ($mg\ CO_2/kg.hr^{-1}$)	Ethylene production ($\mu l\ C_2H_4/kg.hr^{-1}$)
0 days		
Maturity 1	74.26^{b}	0.56^{b}
Maturity 2	84.66^{ab}	0.54^{b}
Maturity 3	90.43^{a}	0.78^{a}
CV (%)	10.70	5.06
7 days		
Maturity 1	266.60^{b}	2.01^{b}
Maturity 2	260.40^{b}	2.13^{a}
Maturity 3	285.10^{a}	2.17^{a}
CV (%)	12.40	7.25

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

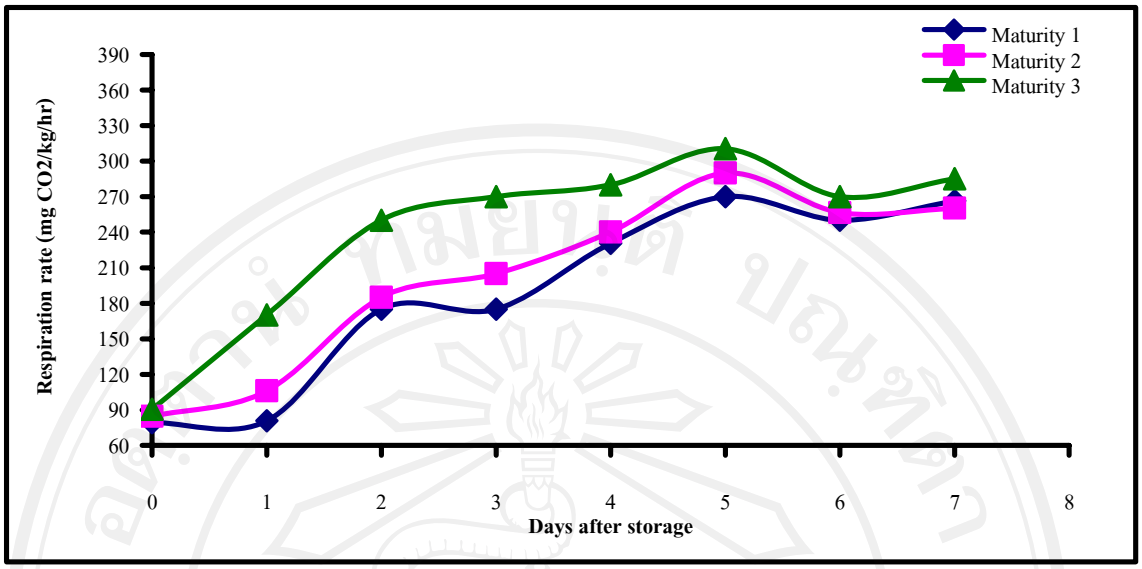


Figure 24 Changes in the respiration rate of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

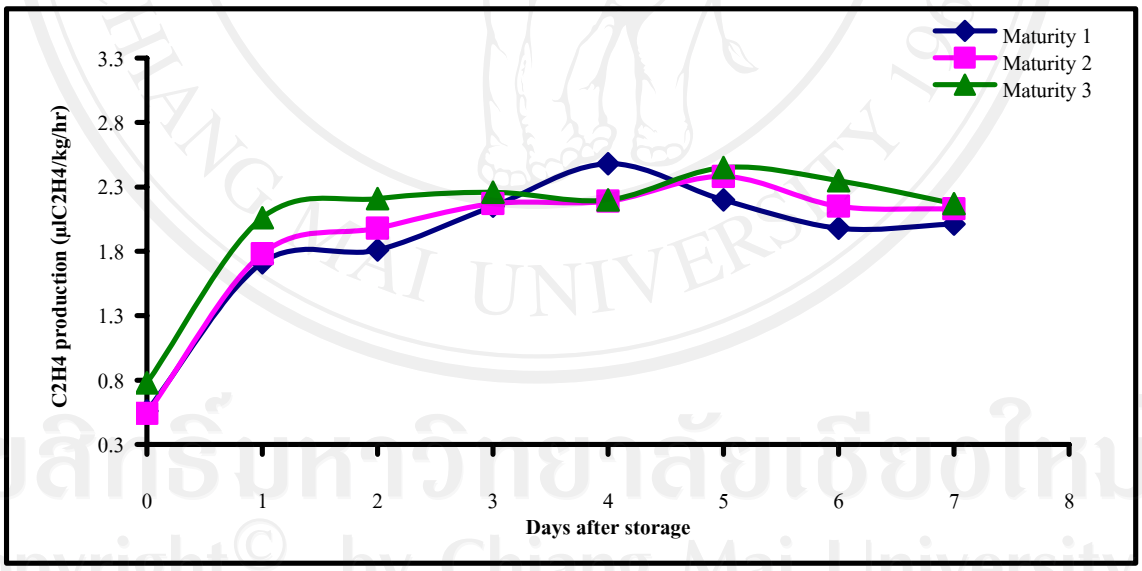


Figure 25 Changes in the ethylene production of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

WSP content

The WSP content of the harvested mango fruit with different maturities was 2.42-2.53 g D-galacturonic acid/100g AIS, and had no significant difference. However, after storage for 7 days, the WSP of the fruit at Maturity 2 was the lowest (7.52 g D-galacturonic acid/100g AIS), significantly different with the fruit at Maturity 1 and 3 (8.23 and 8.02 g D-galacturonic acid/100g AIS, respectively) (Table 11). The WSP of the fruit increased during storage, and the fruit at Maturity 2 tended to increase less than Maturity 1 and 3 (Figure 26, Appendix Table 25).

PG activity

The PG activity of the harvested mango fruit at Maturity 2 was the lowest (222.30 nmole D-galacturonic acid/mg protein/min) and differed with the fruit at Maturity 1 and 3 (235.65 and 240.36 nmole D-galacturonic acid/mg protein/min, respectively). However, after storage for 7 days, the PG activity of the fruit with different maturities had no significant differences which were 316.32-320.65 nmole D-galacturonic acid/mg protein/min (Table 11). The PG activity of the fruit rapidly increased during 5 days of storage, after that there was a little change (Figure 27, Appendix Table 26).

PME activity

At harvest and 7 days of storage, the PME activity of the fruit at different maturities had no significant difference. They were 198.06-206.12 and 115.42-121.05 µmole acetic acid/mg protein/min, repectively (Table 11). The PME activity of the fruit slowly increased during 3 days of storage, except the fruit at Maturity 3, and then it rapidly decreased (Figure 28, Appendix Table 27).

Sensory evaluation

After storage for 7 days, the fruit at Maturity 2 had the highest score of texture (4.52 scores), and differed with the fruit at Maturity 1 and 3 (3.74 and 3.83 scores, respectively). Similarly, the feeling of the fruit at Maturity 2 had highest score (4.26 scores) and differed with the fruit at Maturity 1 and 3 (3.80 and 3.84 scores, repectively) while the taste of the fruit at Maturity 2 had highest score (4.58 scores) and differed with the fruit at Maturity 1 (4.05 scores). Although a consistency (3.66-3.92 scores) had no significant difference, the fruit at Maturity 2 tended to have high scores of this (Table 12).

Table 11 Effects of maturity on WSP content, PG and PME activities of 'Keaw Morakot' mango fruit stored at ambient condition (26-31˚C, 60-70% RH) for 0 and 7 days

Treatments	WSP content (g D-galacturonic acid/100g AIS)	PG activity (nmole D-galacturonic acid/mg protein/min)	PME activity (µmole acetic acid/mg protein/min)
0 days			
Maturity 1	2.53^{ns}	235.65^{a}	204.00^{ns}
Maturity 2	2.42	222.30^{b}	206.12
Maturity 3	2.53	240.36^{a}	198.06
CV (%)	10.67	18.27	22.63
7 days			
Maturity 1	8.23^{a}	319.02^{ns}	115.42^{ns}
Maturity 2	7.52^{b}	316.32	121.05
Maturity 3	8.02^{a}	320.65	119.18
CV (%)	10.02	11.09	5.63

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

ns = non-significant

Table 12 Effects of maturity on texture, consistency, feeling and taste of 'Keaw Morakot' mango fruit stored at ambient condition (26-31˚C, 60-70% RH) for 7 days

Treatments	Texture (scores)	Consistency (scores)	Feeling (scores)	Taste (scores)
Maturity 1	3.74^{b}	3.66^{ns}	3.80^{b}	4.05^{b}
Maturity 2	4.52^{a}	3.92	4.26^{a}	4.58^{a}
Maturity 3	3.83^{b}	3.80	3.84^{b}	4.50^{a}
CV (%)	2.54	6.07	1.89	0.67

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

ns = non-significant

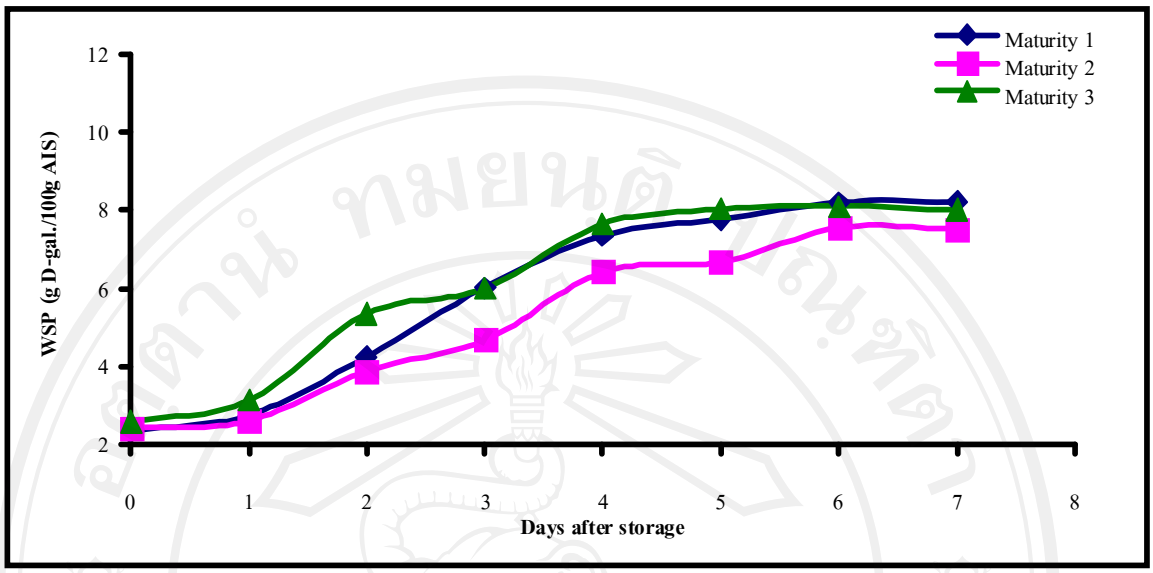


Figure 26 Changes in the WSP content of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

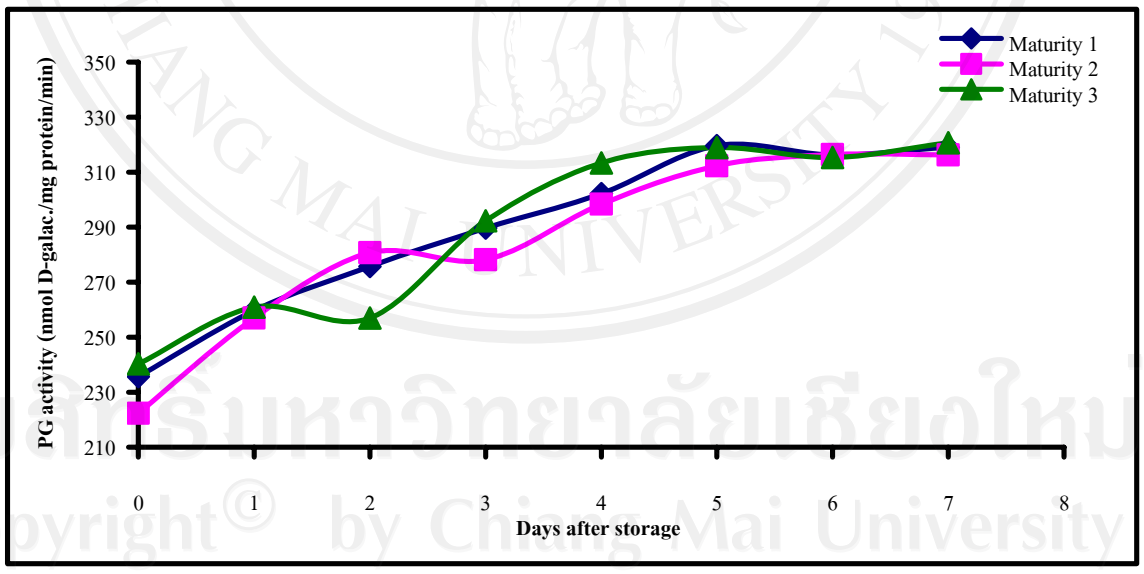


Figure 27 Changes in the PG activity of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

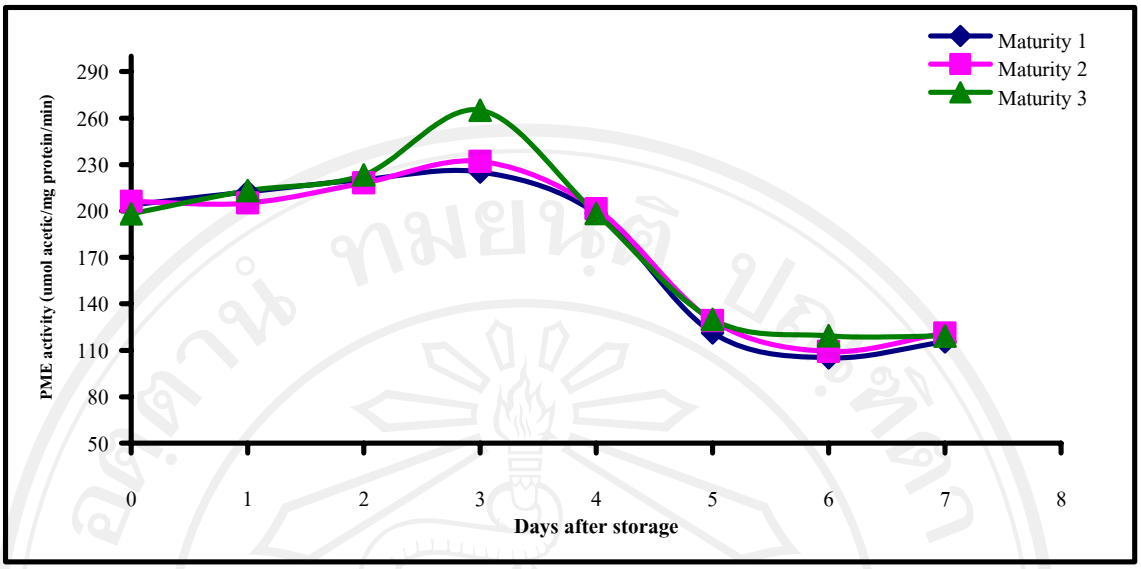


Figure 28 Changes in the PME activity of 'Keaw Morakot' mango fruit during storage at ambient condition (26-31˚C, 60-70% RH)

Changes in quality and enzyme activity during ripening of 'Keaw Morakot' mango fruit at low temperature

Firmness

After storage at 13˚C for 12 days, the firmness of the fruit at Maturity 2 (97.80 Newton) tended to have higher than Maturity 1 and 2, but, only differed with Maturity 1 (86.12 Newton) (Table 13). At the beginning of storage at 25˚C for ripening, the firmness of the fruit at Maturity 2 was 88.37 Newton and differed with the fruit at Matutity 1 which was 78.45 Newton. After storage for 7 days, the firmness of the fruit at Maturity 2 (15.65 Newton) also differed with at Maturity 1 (10.08 Newton) (Table 14). The firmness of the fruit at different maturities slowly decreased during storage at low temperature, but their rapidly during 3-5 days of storage for ripening. The fruit at Maturity 2 tended to decrease less than the others (Figure 29-30, Appendix Table 28-29).

Color changes in pulp and peel

After storage at 13˚C for 12 days, the L* value of fruit pulp at Maturity 2 and 3 were 70.85 and 69.82, respectively, and differed with Maturity 1 which was 67.81. The fruit at Maturity 2 showed the highest chroma value (41.45) and differed with the fruit at Maturity 1 and 3 (39.25 and 39.29, respectively). But the ºH value of pulp was not significantly different (Table 13). The L*, ºH and chroma values of pulp decreased a little during storage, as the fruit at Maturity 2 tended to decrease less than the others (Figure 31, 35 and 39, Appendix Table 30, 34 and 38). At the beginning and 7 days of storage at 25˚C, the L* value of fruit pulp was not significantly different. But the ºH value fruit pulp at Maturity 2 (74.97 and 55.90, respectively) differed with Maturity 3 (73.56 and 53.35, respectively). At the beginning, Maturity 2 had the highest chroma value (39.81) and differed with Maturity 1 and 3 (37.22 and 37.25, respectively) but at 7 days, there was not significantly different (Table 14). The L* and ºH values of the pulp decreased rapidly during 2-4 days and Maturity 2 tended to decrease less than the others. For the chroma value, there was a little decrease (Figure 32, 36 and 40, Appendix Table 32, 36 and 40). The L*, ºH and chroma values of fruit peel which stored either at 13˚C or 25˚C were not significantly different (Table 13-14). The L* value of peel tended to have a little decrease during storage at 13˚C, but increase during storage at 25˚C. But the ºH and chroma values had a little change (Figure 33-34, 37-38 and 41-42, Appendix Table 32-33, 36-37 and 40-41).

Table 13 Effects of maturity on firmness, L*, ºH and chroma values of pulp and peel of 'Keaw Morakot' mango fruit stored at 13˚C, 85-90% RH for 12 days

Treatments	Firmness	L*		ºH		Chroma	
	(Newton)	pulp	peel	pulp	peel	pulp	peel
Maturity 1	86.12^{b}	67.81^{b}	55.63^{ns}	75.02^{ns}	168.95^{ns}	39.25^{b}	32.33^{ns}
Maturity 2	97.80^{a}	70.85^{a}	55.70	75.37	168.01	41.45^{a}	32.95
Maturity 3	90.35^{ab}	69.82^{a}	55.32	75.12	168.07	39.29^{b}	32.75
CV (%)	9.98	1.45	3.69	8.78	3.75	4.03	5.02

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

ns = non-significant

Table 14 Effects of maturity on firmness, L*, ºH and chroma values of pulp and peel of 'Keaw Morakot' mango fruit stored at 25 ˚C, 70-75% RH for 0 and 7 days, after storage at 13˚C, 85-90% RH for 21 days

Treatments	Firmness	L*		ºH		Chroma	
	(Newton)	pulp	peel	pulp	peel	pulp	peel
0 days							
Maturity 1	78.45^{b}	64.64^{ns}	54.67^{ns}	74.65^{a}	168.55^{ns}	37.22^{b}	32.31^{ns}
Maturity 2	88.37^{a}	64.98	53.04	74.97^{a}	168.03	39.81^{a}	32.52
Maturity 3	81.35^{ab}	64.90	52.63	73.56^{b}	168.21	37.25^{b}	32.24
CV (%)	12.99	12.35	12.54	10.13	2.44	2.73	1.56
7 days							
Maturity 1	10.08^{b}	42.34^{ns}	56.69^{ns}	53.78^{b}	169.87^{ns}	33.75^{ns}	30.91^{ns}
Maturity 2	15.65^{a}	42.72	56.24	55.90^{a}	169.85	33.85	30.52
Maturity 3	10.10^{b}	42.94	56.83	53.35^{b}	169.05	33.33	30.74
CV (%)	12.99	11.89	1.65	3.44	2.44	6.56	0.56

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

ns = non-significant

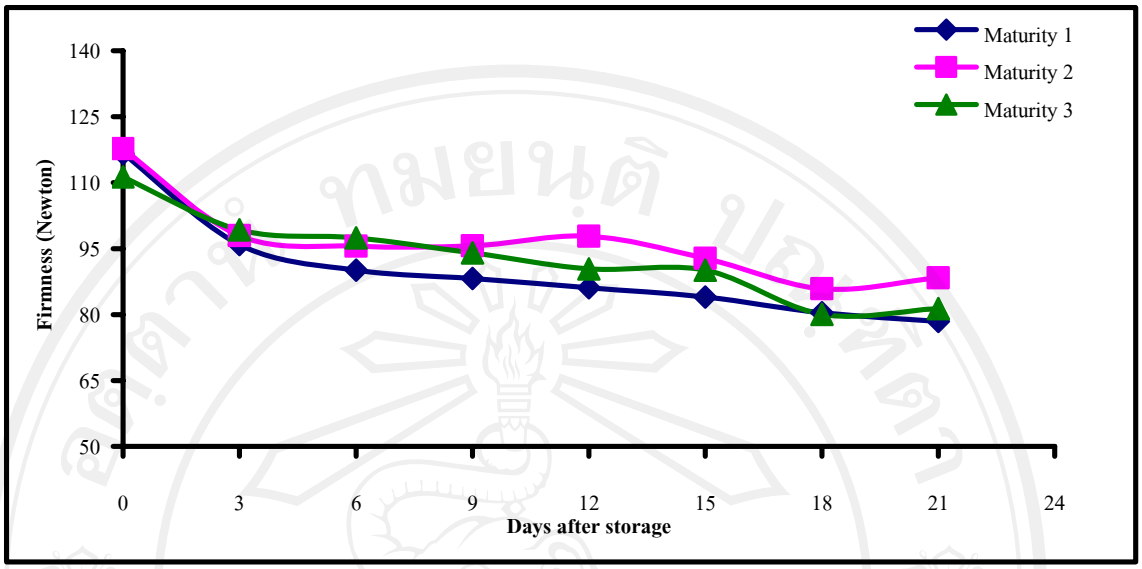


Figure 29 Changes in the firmness of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

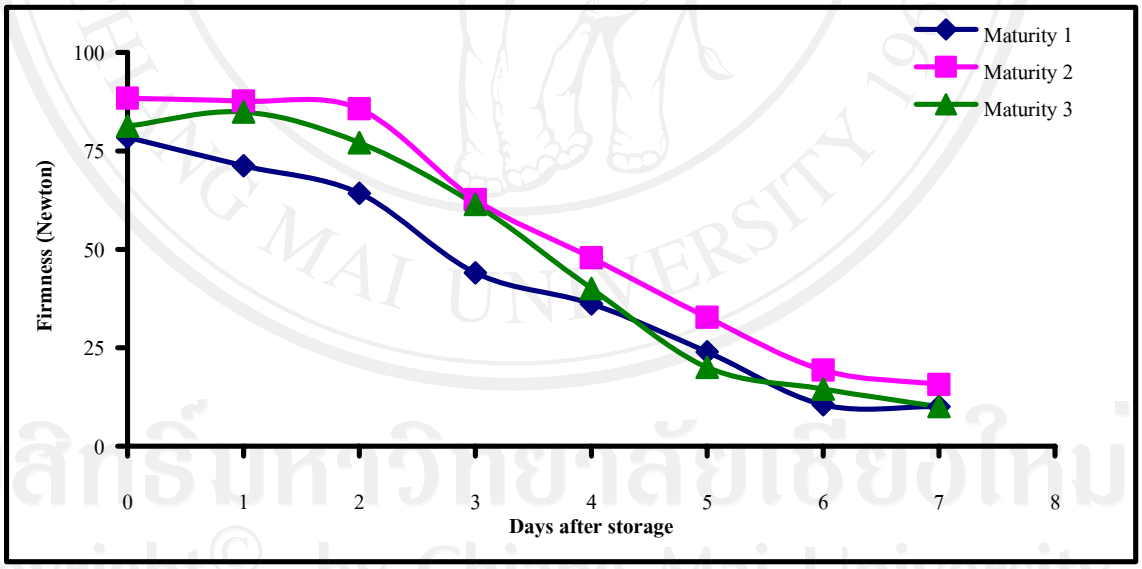


Figure 30 Changes in the firmness of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

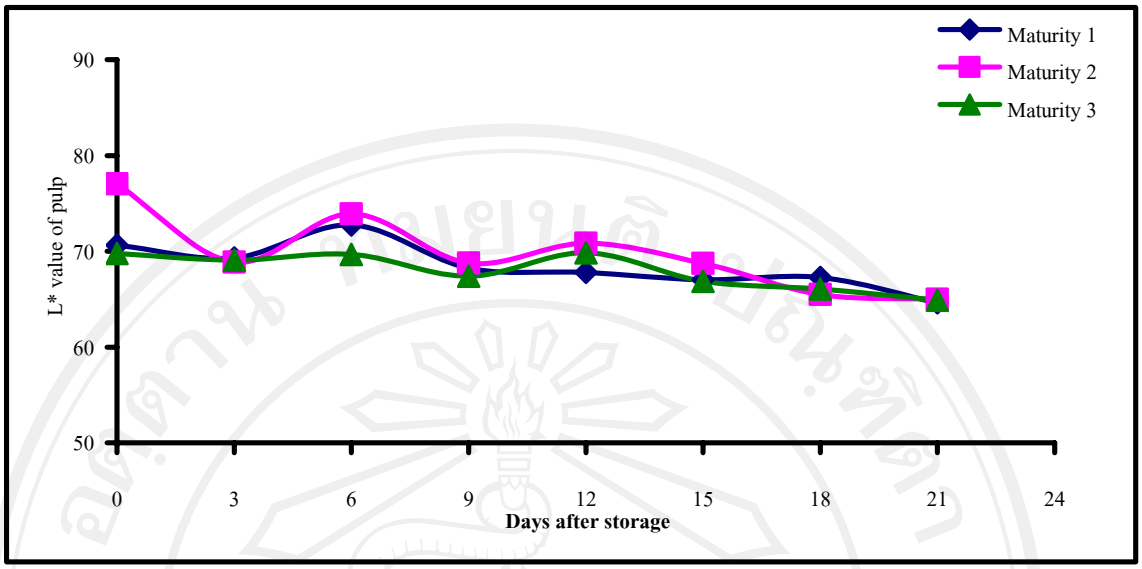


Figure 31 Changes in the L* value of 'Keaw Morakot' mango pulp stored at 13°C, 85-90% RH

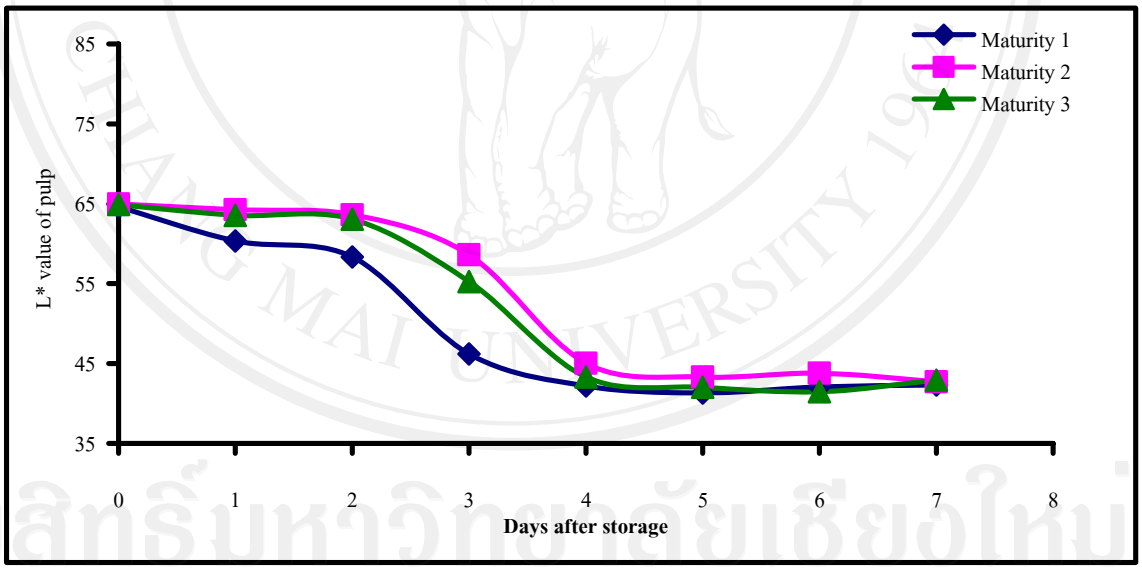


Figure 32 Changes in the L* value of 'Keaw Morakot' mango pulp stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

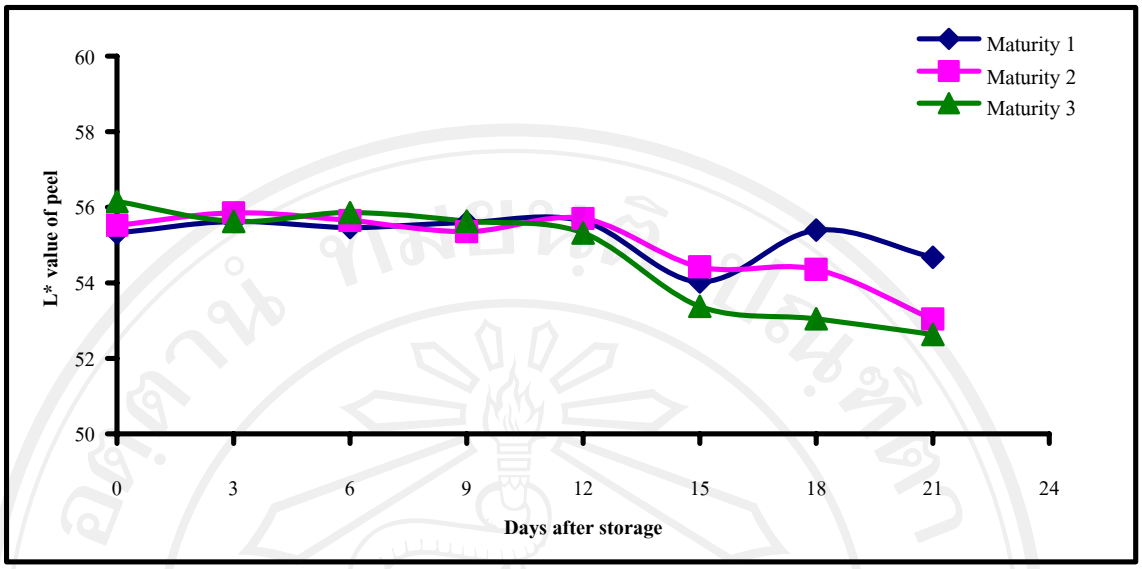


Figure 33 Changes in the L* value of 'Keaw Morakot' mango peel stored at 13°C, 85-90% RH

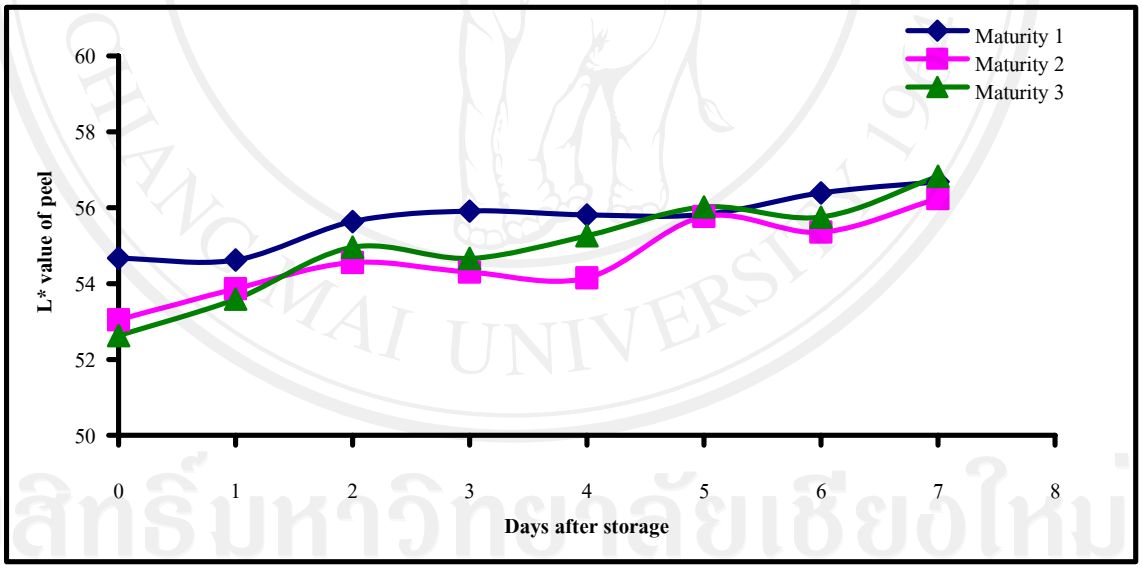


Figure 34 Changes in the L* value of 'Keaw Morakot' mango peel stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

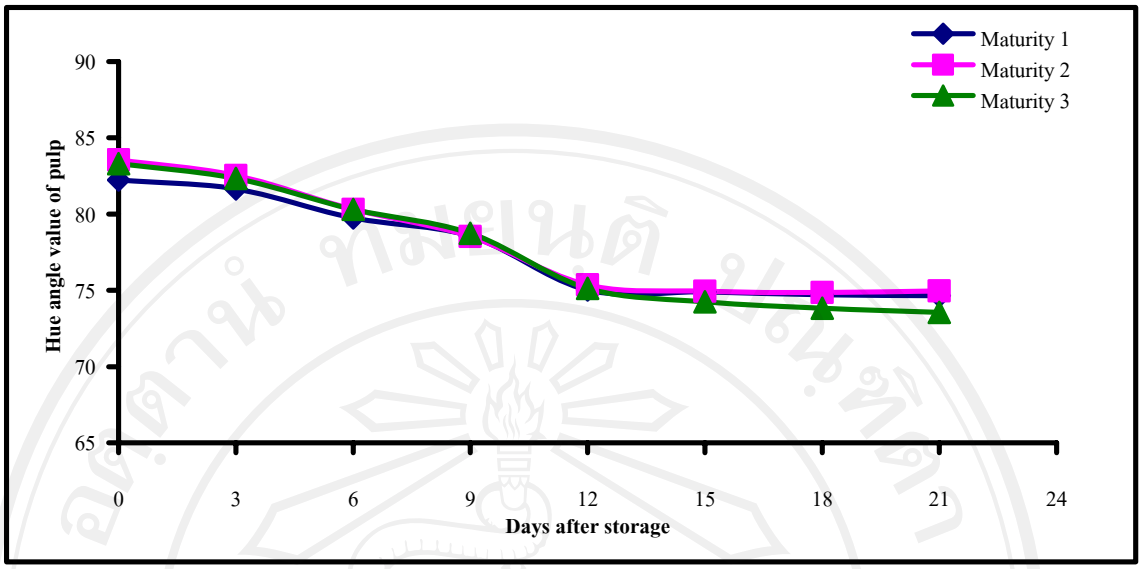


Figure 35 Changes in the ºH value of 'Keaw Morakot' mango pulp stored at 13°C, 85-90% RH

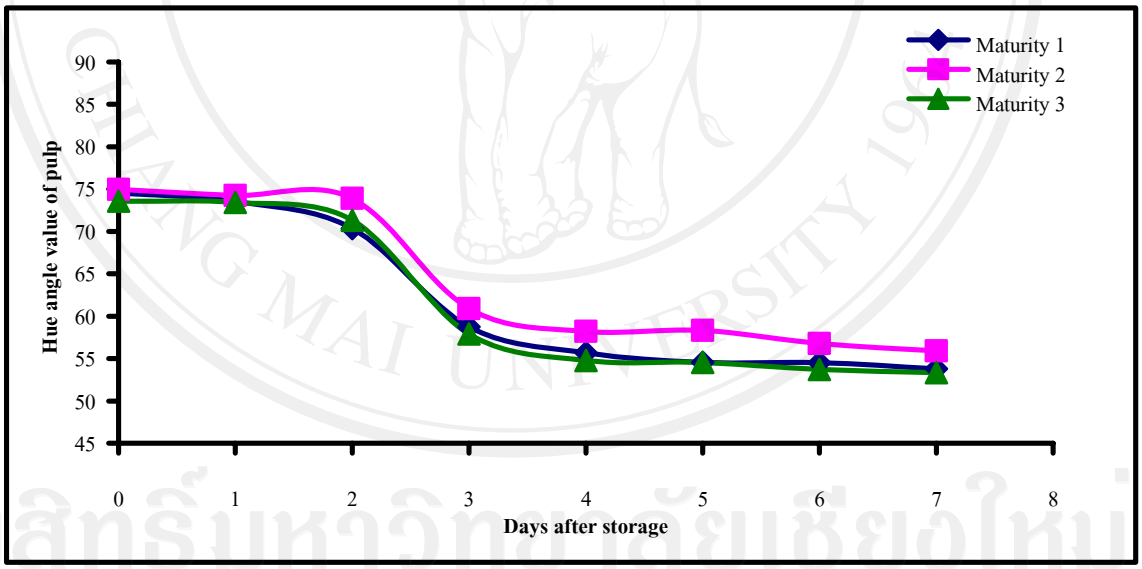


Figure 36 Changes in the ºH value of 'Keaw Morakot' mango pulp stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

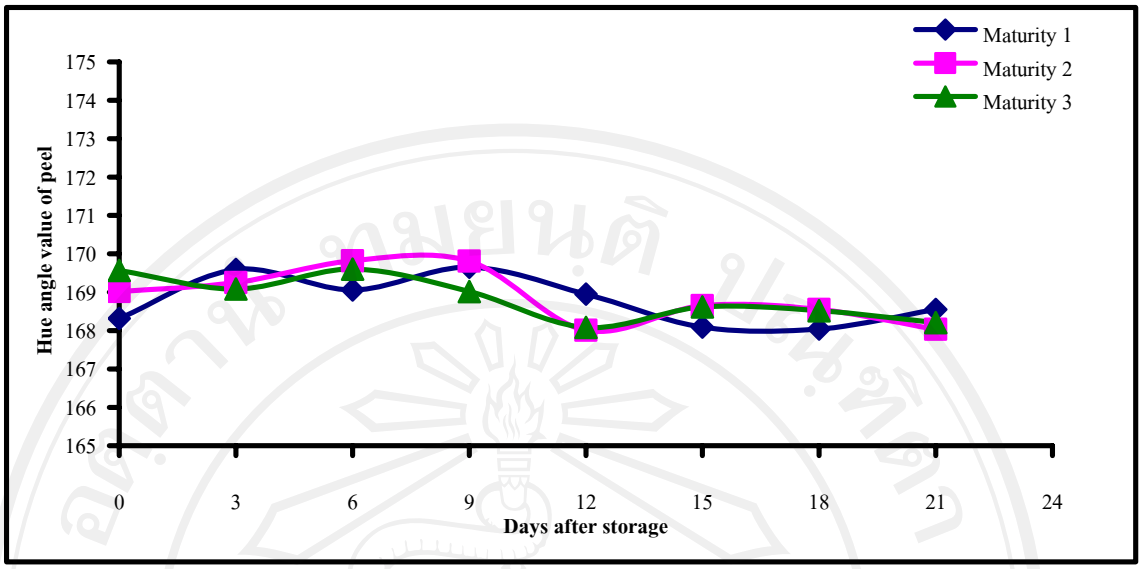


Figure 37 Changes in the ºH value of 'Keaw Morakot' mango peel stored at 13°C, 85-90% RH

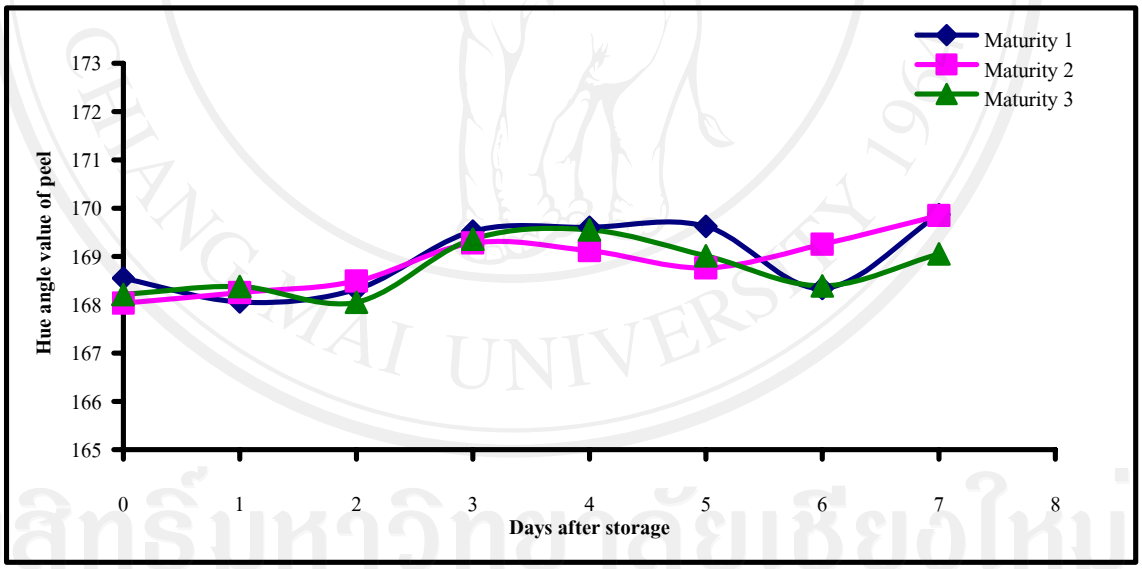


Figure 38 Changes in the ºH value of 'Keaw Morakot' mango peel stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

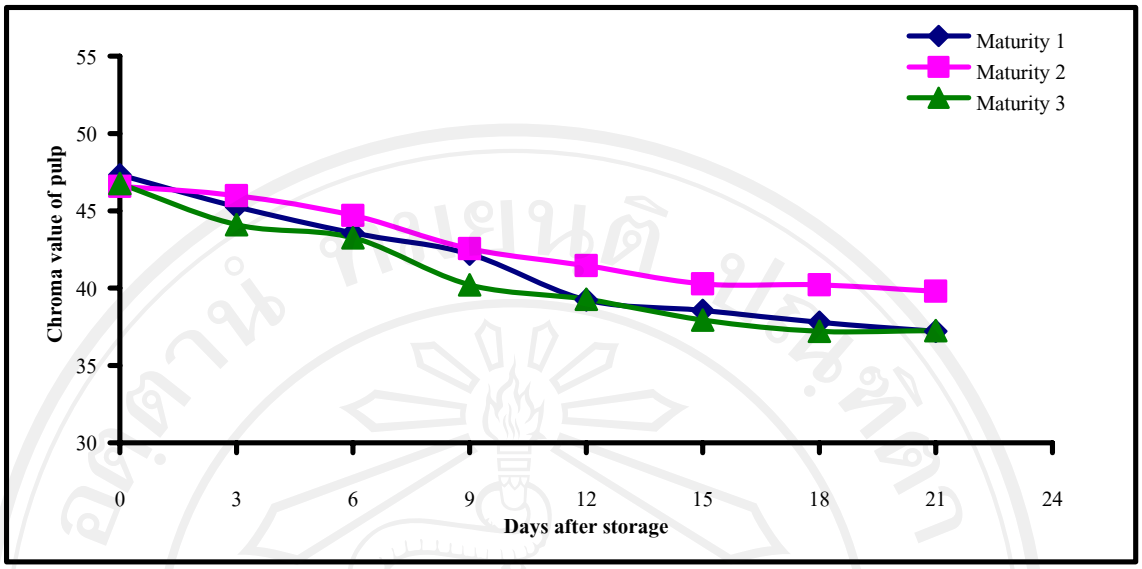


Figure 39 Changes in the chroma value of 'Keaw Morakot' mango pulp stored at 13°C, 85-90% RH

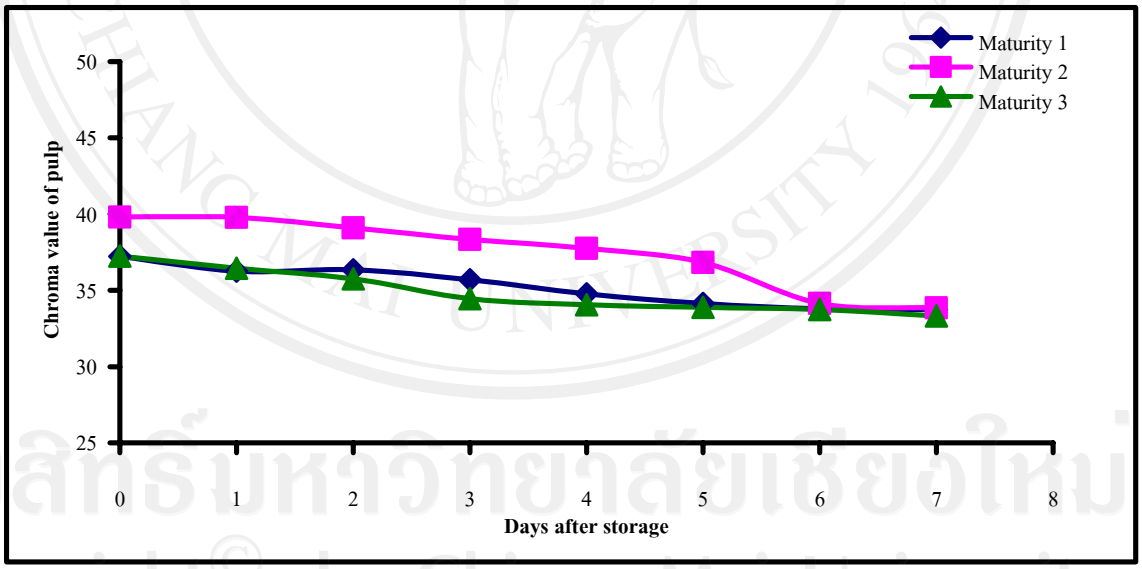


Figure 40 Changes in the chroma value of 'Keaw Morakot' mango pulp stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

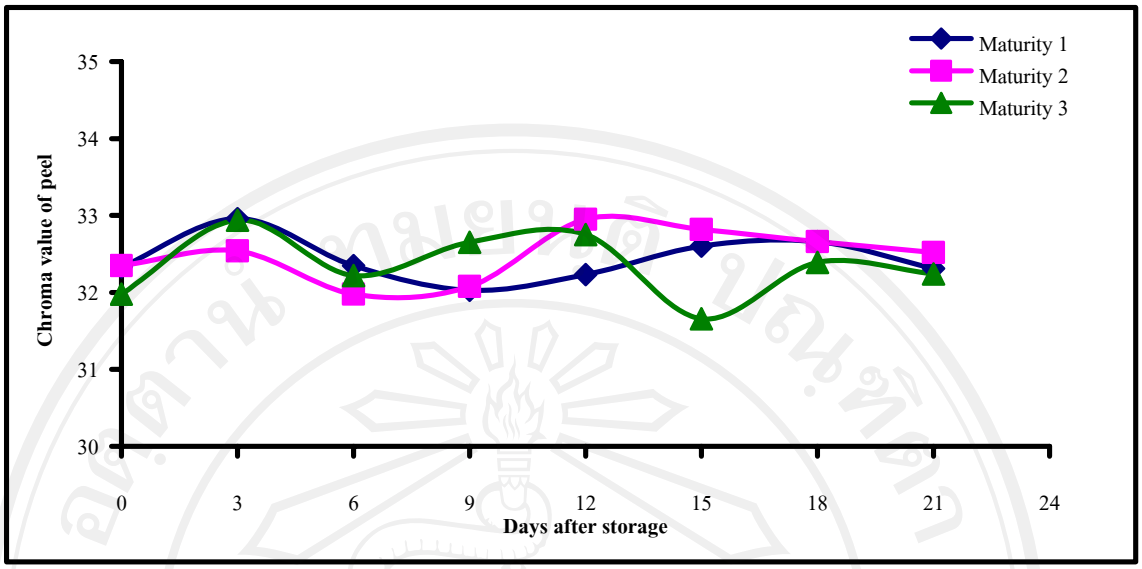


Figure 41 Changes in the chroma value of 'Keaw Morakot' mango peel stored at 13°C, 85-90%RH

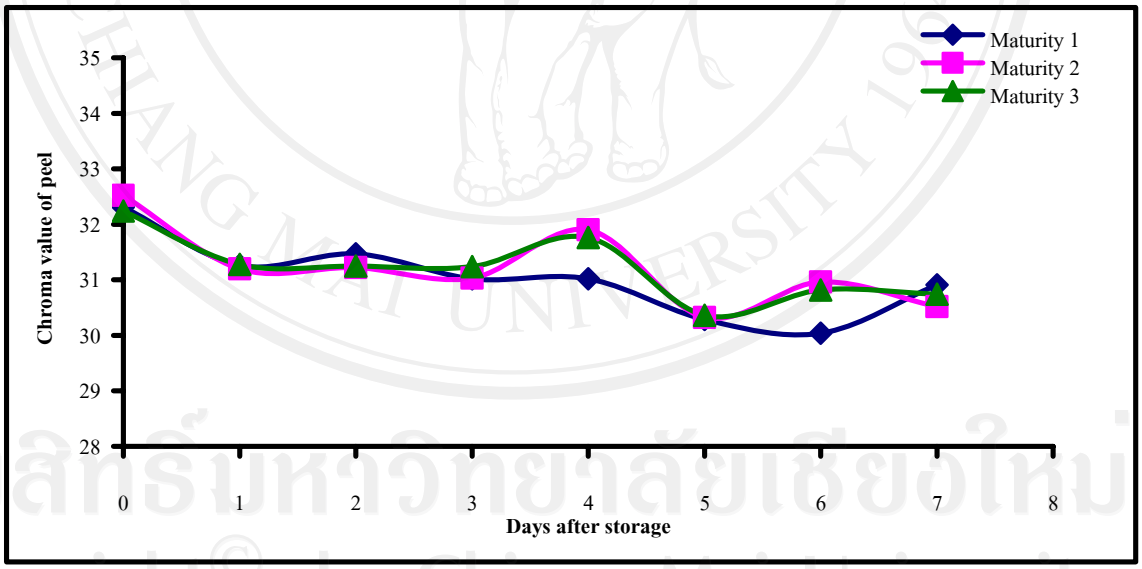


Figure 42 Changes in the chroma value of 'Keaw Morakot' mango peel stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

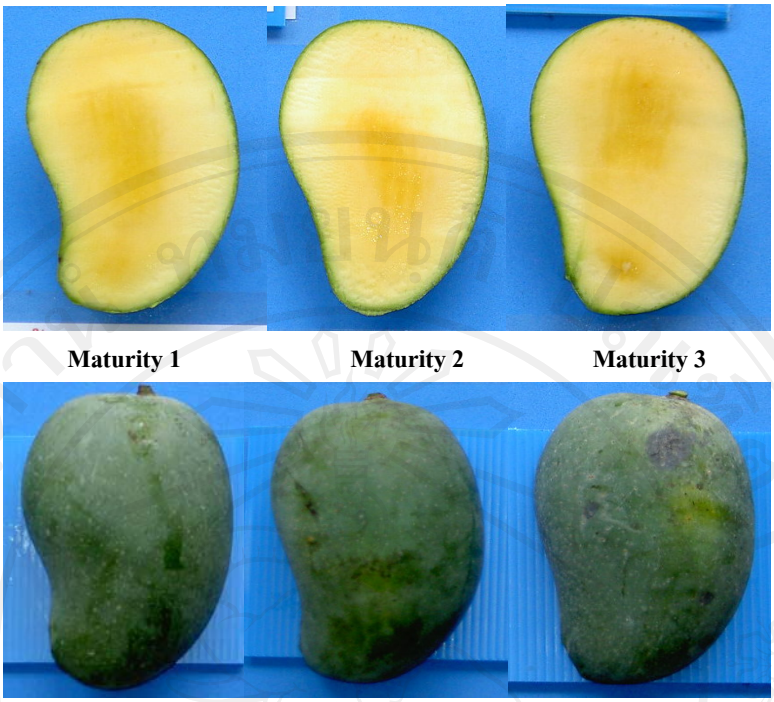


Figure 43 'Keaw Morakot' mango fruit after storage at 13°C, 85-90% RH for 12 days

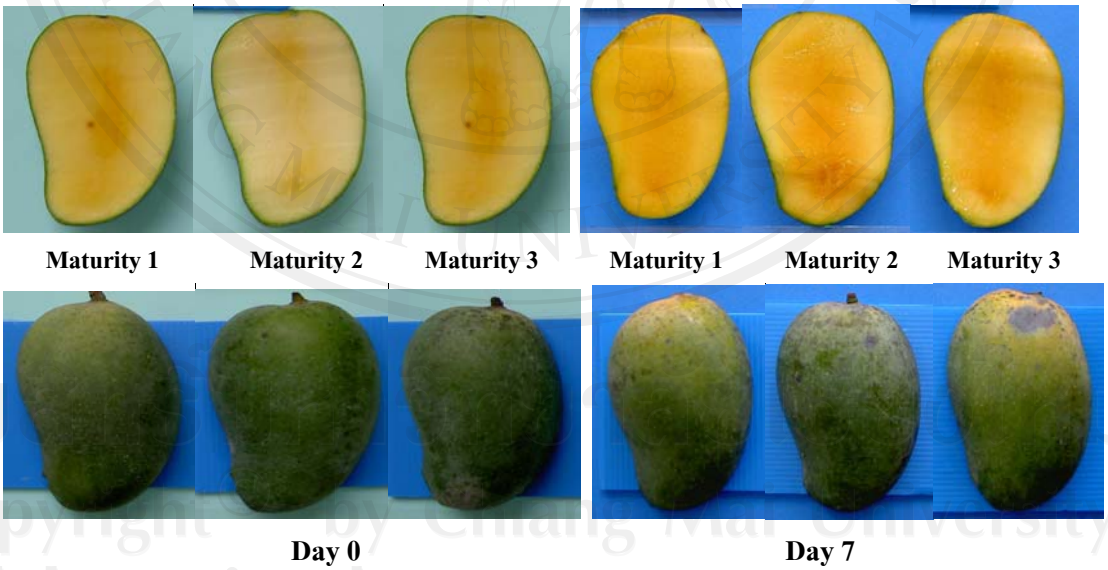


Figure 44 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH for 0 and 7 days after storage at 13°C, 85-90% RH for 21 days

TSS content

Storage at 13˚C for 12 days, the TSS of the fruit (11.20-11.90%) was not significantly different (Table 15). The TSS of the fruit slowly increased during storage (Figure 45, Appendix Table 42). Similarly, the TSS of the fruit at the beginning and 7 days of storage at 25˚C for ripening (11.82-12.69% and 19.05-19.98%, respectively) did not differ (Table16). The TSS of the fruit rapidly increased during 2-6 days of storage for ripening and the fruit at Maturity 2 tended to increase less than the others (Figure 46, Appendix Table 43).

Glucose content

The glucose content of the fruit did not differ when storage at 13˚C for 12 days and at 0 and 7 days of storage at 25˚C (Table 15-16). The glucose content increased during 0-6 days of storage at 13˚C, after that there was a little change (Figure 47, Appendix Table 44). During storage for ripening, the glucose content increased after 2 days (Figure 48, Appendix Table 45).

Fructose content

The fruit at Maturity 3 had the highest fructose content (2.25 g/100gFW) and differed with Maturity 1 and 2 (2.17 and 2.18 g/100gFW, respectively) when storage at 13˚C for 12 days (Table 15). The fructose tended to increase after 9 days of storage (Figure 49, Appendix Table 46). But at the beginning of storage at 25˚C, the fructose did not differ. However, after storage for 7 days, fruit at Maturity 2 had the highest fructose content (2.95 g/100gFW) and differed with Maturity 1 and 3 (2.53 and 32.57 g/100gFW, respectively) (Table 16). The fructose of the fruit at Maturity 2 and 3 rapidly increased and had higher content comparing to Maturity 1 (Figure 50, Appendix Table 47).

Sucrose content

After storage at 13˚C for 12 days, the sucrose content of the fruit at Maturity 3 was highest (7.02 g/100gFW) and differed with Maturity 1 and 2 (6.66 g/100gFW) (Table 15). During storage, the sucrose of the fruit increased (Figure 51, Appendix Table 48). However, at the beginning of storage at 25˚C, the sucrose content did not differ. But at 7 days, Maturity 2 had the highest sucrose content (9.32 g/100gFW) and differed with Maturity 1 and 3 (8.95 and 9.05 g/100gFW, respectively) (Table 16). During storage for ripening, the sucrose increased. The fruit at Maturity 2 and 3 tended to rapidly increase and had higher content than Maturity 1 (Figure 52, Appendix Table 49).

Table 15 Effects of maturity on TSS, glucose, fructose and sucrose contents of 'Keaw Morakot' mango fruit stored at 13˚C, 85-90% RH for 12 days

Treatments	TSS (%)	Glucose (g/100g FW)	Fructose (g/100g FW)	Sucrose (g/100g FW)
Maturity 1	11.36^{ns}	0.52^{ns}	2.17^{b}	6.66^{b}
Maturity 2	11.20	0.51	2.18^{b}	6.66^{b}
Maturity 3	11.90	0.53	2.25^{a}	7.02^{a}
CV (%)	10.90	14.78	7.30	6.68

* Means within the same column followed by different letters differ significantly at $\rho<0.05$
ns = non-significant

Table 16 Effects of maturity on TSS, glucose, fructose and sucrose contents of 'Keaw Morakot' mango fruit stored at 25˚C, 70-75% RH for 0 and 7 days, after storage at 13˚C, 85-90% RH for 21 days

Treatments	TSS (%)	Glucose (g/100g FW)	Fructose (g/100g FW)	Sucrose (g/100g FW)
0 days				
Maturity 1	12.55^{ns}	0.52^{ns}	2.35^{ns}	6.95^{ns}
Maturity 2	12.69	0.52	2.35	7.23
Maturity 3	11.82	0.53	2.37	7.26
CV (%)	10.56	12.67	12.35	10.20
7 days				
Maturity 1	19.05^{ns}	0.65^{ns}	2.53^{b}	8.95^{b}
Maturity 2	19.98	0.68	2.95^{a}	9.32^{a}
Maturity 3	19.05	0.65	2.57^{b}	9.05^{b}
CV (%)	10.90	6.60	13.03	6.89

* Means within the same column followed by different letters differ significantly at $\rho<0.05$
ns = non-significant

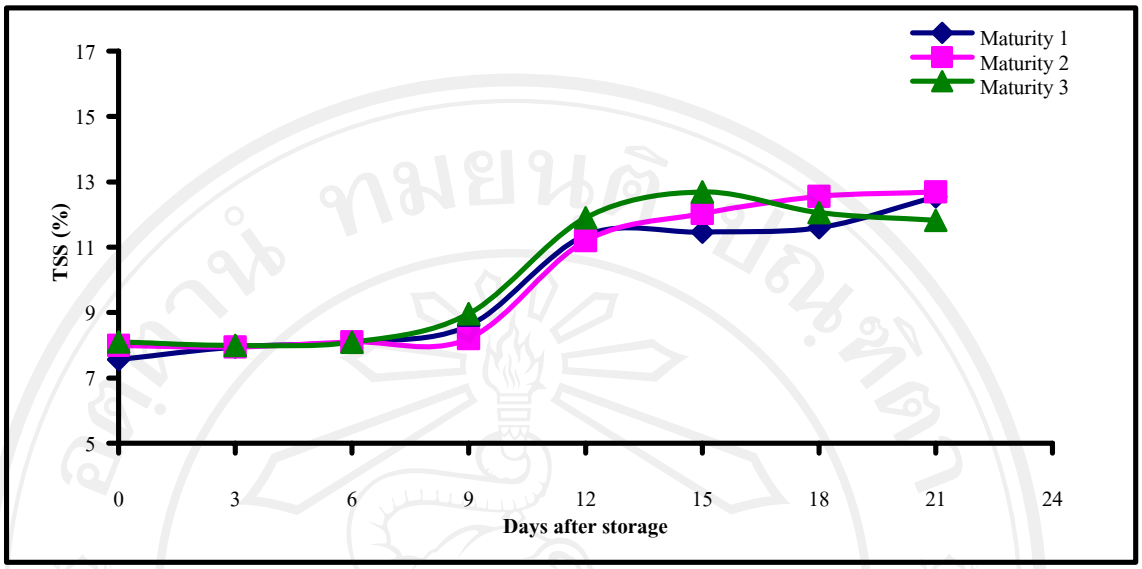


Figure 45 Changes in the TSS content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

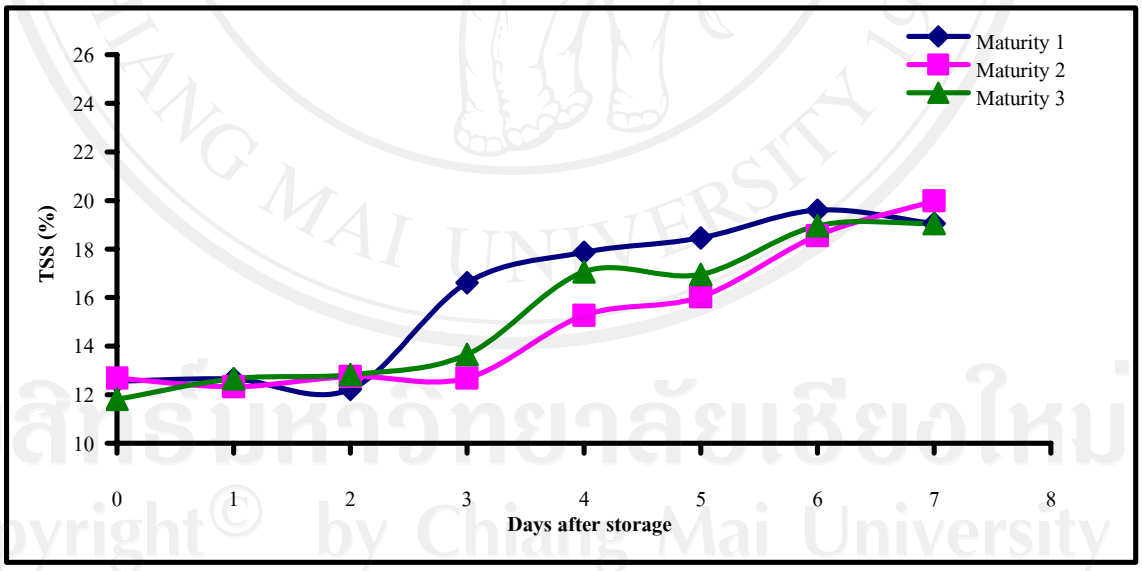


Figure 46 Changes in the TSS content of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

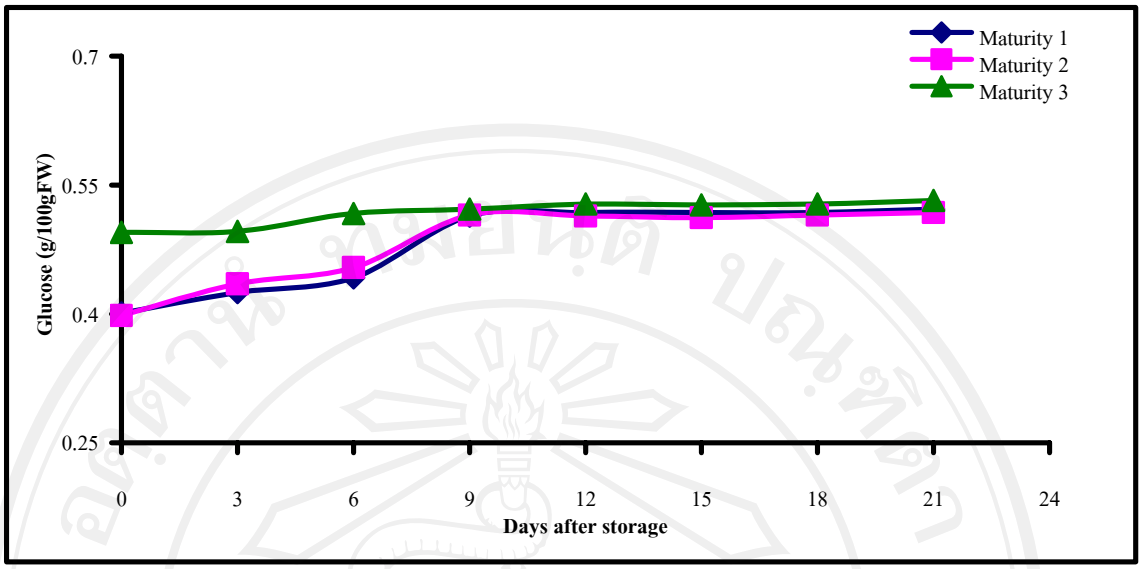


Figure 47 Changes in the glucose content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

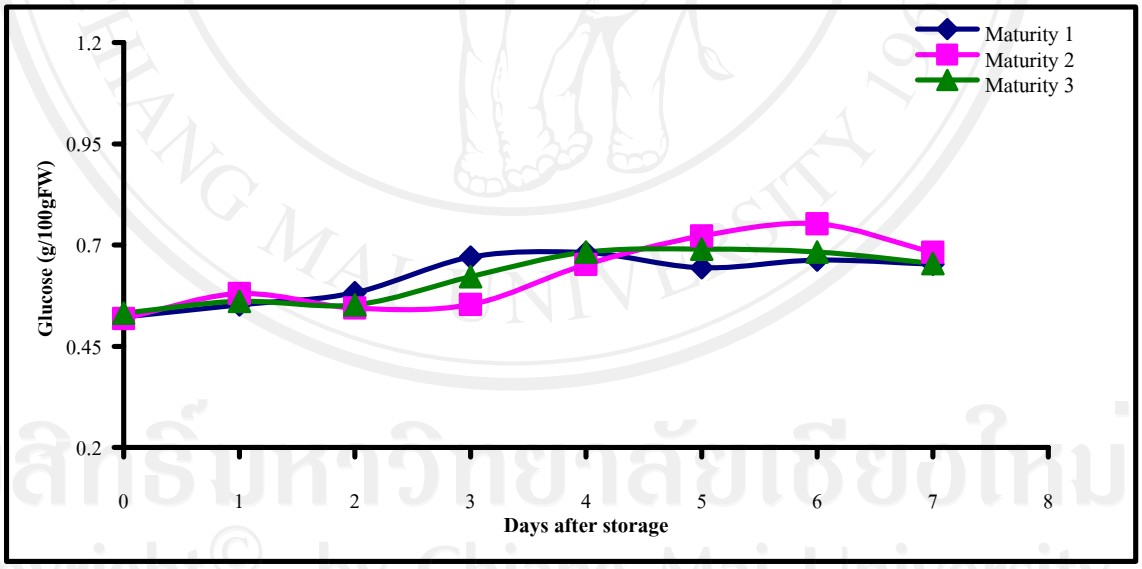


Figure 48 Changes in the glucose content of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

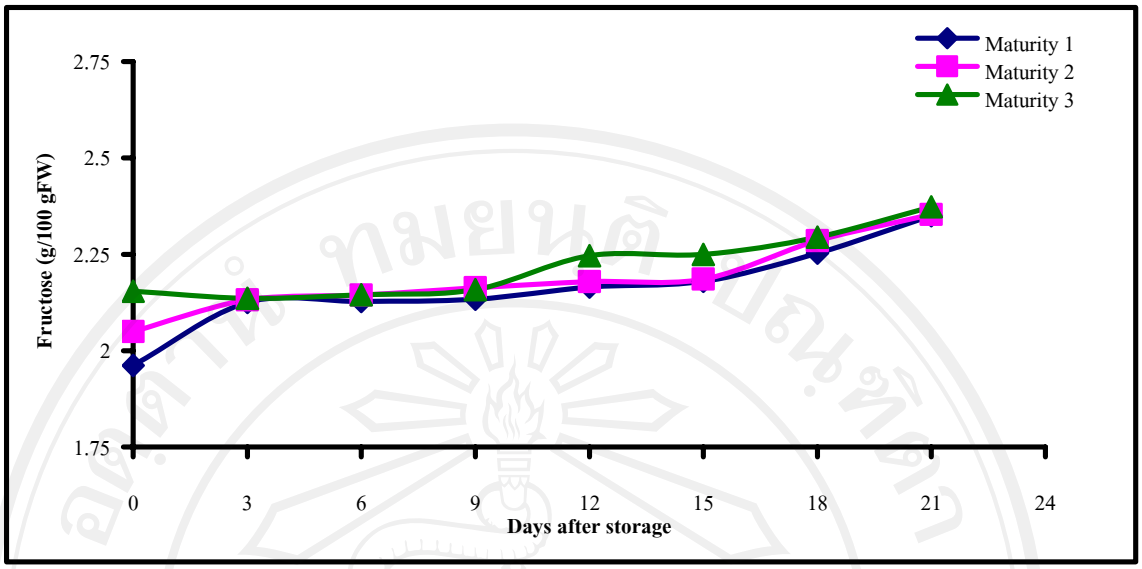


Figure 49 Changes in the fructose content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

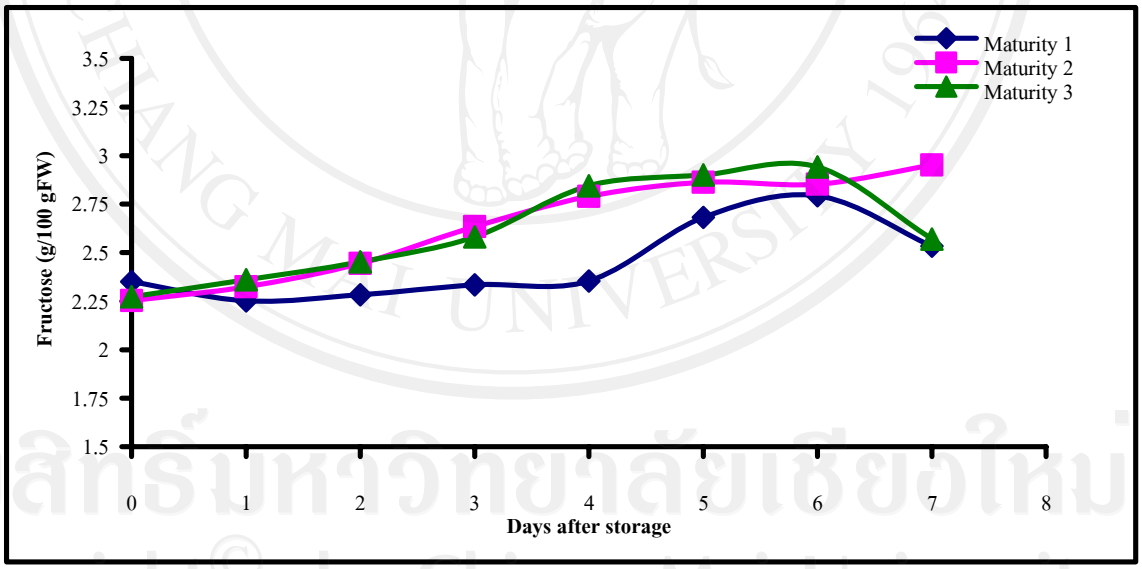


Figure 50 Changes in the fructose content of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

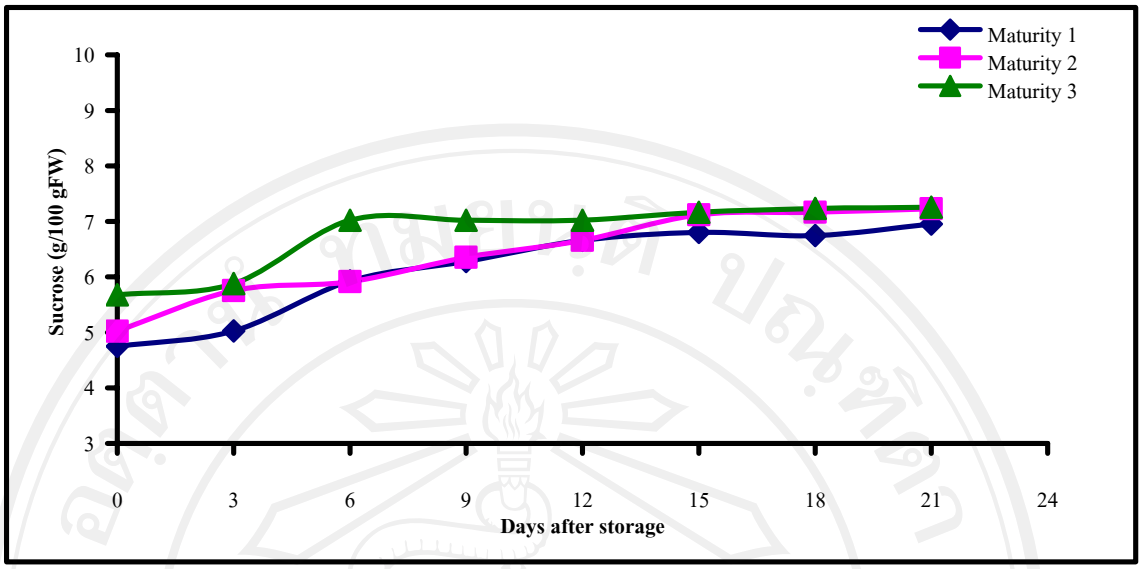


Figure 51 Changes in the sucrose content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

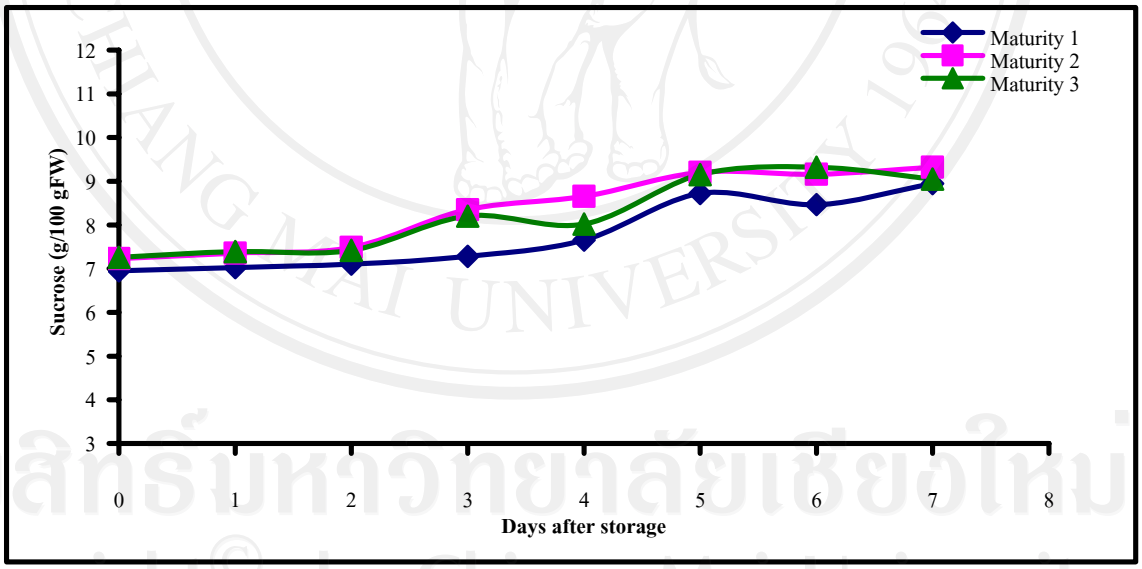


Figure 52 Changes in the sucrose content of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

pH value

The fruit at Maturity 3 had the highest pH value (4.55) and differed with Maturity 1 and 2 (4.37 and 4.34, respectively) when storage at 13˚C for 12 days (Table 17). During long-term storage, the pH value of the fruit increased and the fruit at Maturity 3 tended to increase more than the others (Figure 53, Appendix Table 50). Similarly, at the beginning of storage at 25 ˚C for fruit ripening, the fruit at Maturity 3 had the highest value (5.36) and differed with Maturity 1 and 2 (5.16 and 5.14, respectively). However, after storage for 7 days, the pH of the fruit did not differ (Table 18). The pH value of the fruit tended to slowly increase and the fruit at Maturity 2 had lower pH value than the others (Figure 54, Appendix Table 51).

TA content

Storage at 13˚C for 12 days, the TA content of the mango fruit at Maturity 3 was the lowest (0.75%), significantly different with Maturity 1 and 2 (0.77 and 0.76%, respectively) (Table 17). Similarly, at the beginning and 7 days of storage at 25˚C, the fruit at Maturity 3 had the lowest TA content (0.68 and 0.51%, respectively), significantly different with Maturity 1 and 2 (0.72 and 0.52%, respectively) (Table 18). Stoatge at 13˚C, the TA content of the fruit decreased a little during 0-6 days, rapid decrease during 6-12 days and a little decrease again during 12-21 days (Figure 55, Appendix Table 52). Storage at 25˚C, the TA content of the fruit at Maturity 1, 2 and 3 decreased rapidly during 2-4, 4-5 and 2-5 days, respectively (Figure 56, Appendix Table 53).

Citric acid content

The citric acid content of the fruit at Maturity 3 was lowest (0.32 g/100gFW), significantly different with Maturity 1 and 2 (0.34 g/100gFW) when storage at 13˚C for 12 days (Table 17). The citric acid content of the fruit decreased and tended to rapidly decrease during 6-12 days of storage. The fruit at Maturity 3 had citric acid content less than the others (Figure 57, Appendix Table 54). At the beginning of storage at 25˚C, the fruit at Maturity 3 showed the lowest citric acid content (0.30 g/100gFW), and differed with Maturity 1 and 2 (0.32 and 0.32 g/100gFW, respectively). However, after storage for 7 days, the fruit at Maturity 2 had highest content, and differed with Maturity 1 and 3 (Table 18). The citric acid content decreased and the fruit at Maturity 3 had lower content during storage (Figure 58, Appendix Table 55).

Malic acid content

After storage at 13˚C for 12 days, the malic acid content of the fruit at Maturity 3 was lowest (0.28 g/100gFW) and differed with Matuiry 1 and 2 (0.30 g/100gFW) (Table 17). During storage, the malic acid content of the fruit tended to decrease a little and the fruit at Maturity 3 had lower content (Figure 59, Appendix Table 56). At the beginning of storage at 25˚C, the fruit at Maturity 3 showed the lowest malic acid content (0.27 g/100gFW), and differed with Maturity 1 and 2 (0.30 and 0.30 g/100gFW, respectively). However, after storage for 7 days, the fruit at Maturity 2 had highest malic acid content, and differed with Maturity 1 and 3 (Table 18). During storage at 25˚C, the malic acid content of the fruit decreased and the fruit at Maturity 2 tended to slowly decrease than the others (Figure 60, Appendix Table 57).

Vitamin C content

The fruit at Maturity 1 showed the lowest vitamin C content (121.12 mg/100g) and differed with Maturity 2 and 3 (140.68 and 144.22 mg/100 ml, respectively) when storage at 13˚C for 12 days (Table 17). During long-term storage, the vitamin C content of the fruit decreased and the fruit at Maturity 2 tended to slowly decrease during late storage (Figure 61, Appendix Table 58). Thus, storage at 25˚C for 0 and 7 days, it was observed that the fruit at Maturity 2 had the highest vitamin C content (122.98 and 52.98 mg/100 ml, respectively), significantly different with Maturity 1 (106.33 and 46.33 mg/100 ml, respectively) and Maturity 3 (100.25 and 47.25 mg/100 ml, respectively) (Table 18). During storage for ripening, the vitamin C content of the fruit decreased but the fruit at Matuirity 2 slowly decreased than the others (Figure 62, Appendix Table 59).

Table 17 Effects of maturity on pH value, TA, citric acid, malic acid and vitamin C contents of 'Keaw Morakot' mango fruit stored at 13˚C, 85-90% RH for 12 days

Treatments	pH	TA (% as citric acid)	Citric acid (g/100g FW)	Malic acid (g/100g FW)	Vitamin C (mg/100 ml)
Maturity 1	4.37[b]	0.77[a]	0.34[a]	0.30[a]	121.12[b]
Maturity 2	4.34[b]	0.76[a]	0.34[a]	0.30[a]	140.68[a]
Maturity 3	4.55[a]	0.75[b]	0.32[b]	0.28[b]	144.22[a]
CV (%)	4.98	13.08	3.33	6.03	13.08

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

Table 18 Effects of maturity on pH value, TA, citric acid, malic acid and vitamin C contents of 'Keaw Morakot' mango fruit placed in 25˚C, 70-75% RH for 0 and 7 days, after storage at 13˚C, 85-90% RH for 21 days

Treatments	pH	TA (% as citric acid)	Citric acid (g/100g FW)	Malic acid (g/100g FW)	Vitamin C (mg/100 ml)
0 days					
Maturity 1	5.16[b]	0.72[a]	0.32[a]	0.30[a]	106.33[b]
Maturity 2	5.14[b]	0.72[a]	0.32[a]	0.30[a]	122.98[a]
Maturity 3	5.36[a]	0.68[b]	0.30[b]	0.27[b]	100.25[b]
CV (%)	2.90	14.45	2.89	4.76	20.05
7 days					
Maturity 1	5.56[ns]	0.52[a]	0.22[b]	0.20[b]	46.33[b]
Maturity 2	5.52	0.52[a]	0.26[a]	0.22[a]	52.98[a]
Maturity 3	5.60	0.51[b]	0.22[b]	0.20[b]	47.25[b]
CV (%)	9.34	8.22	8.56	12.58	8.03

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

ns = non-significant

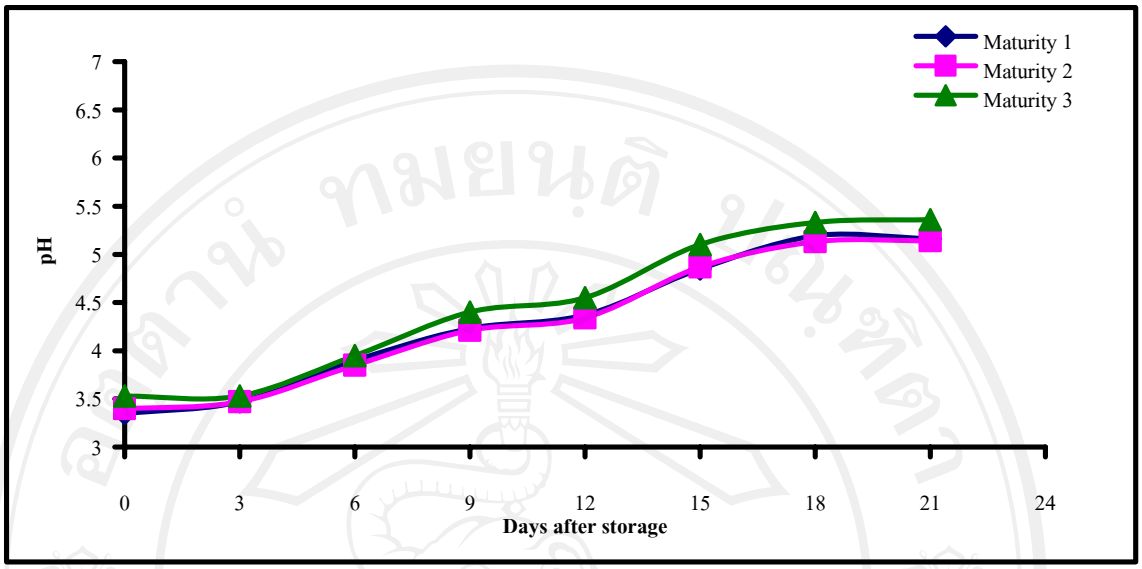


Figure 53 Changes in the pH value of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

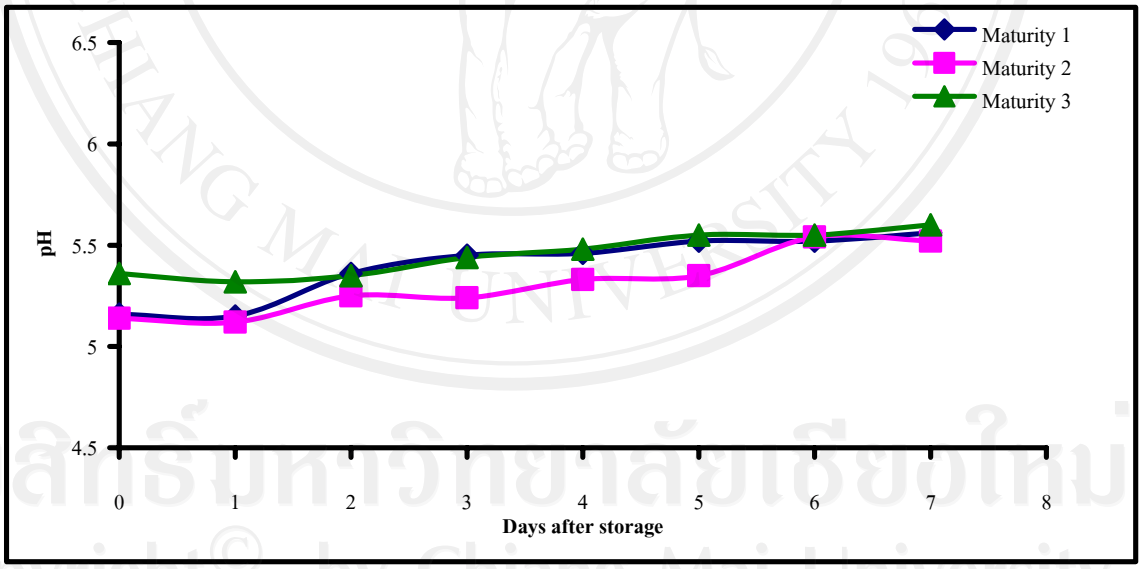


Figure 54 Changes in the pH value of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

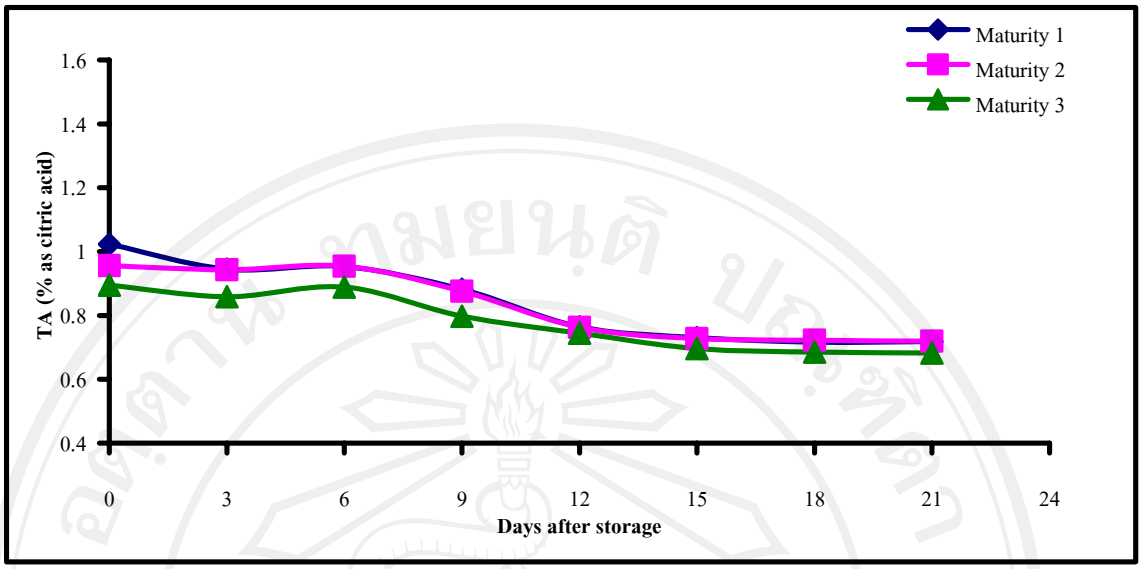


Figure 55 Changes in the TA content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

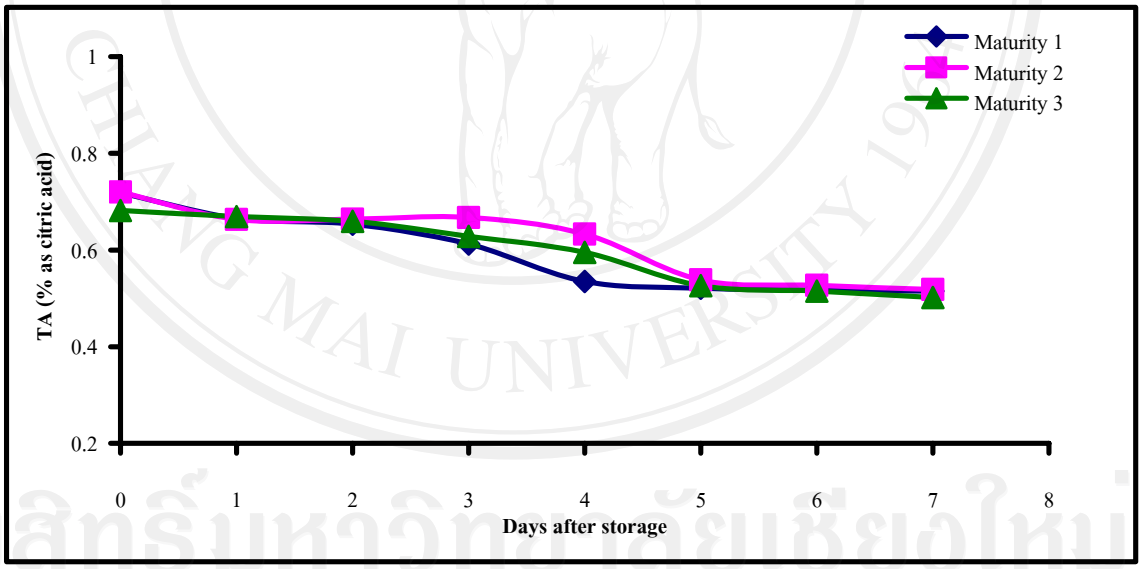


Figure 56 Changes in the TA content of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH,
after storage at 13°C, 85-90% RH for 21 days

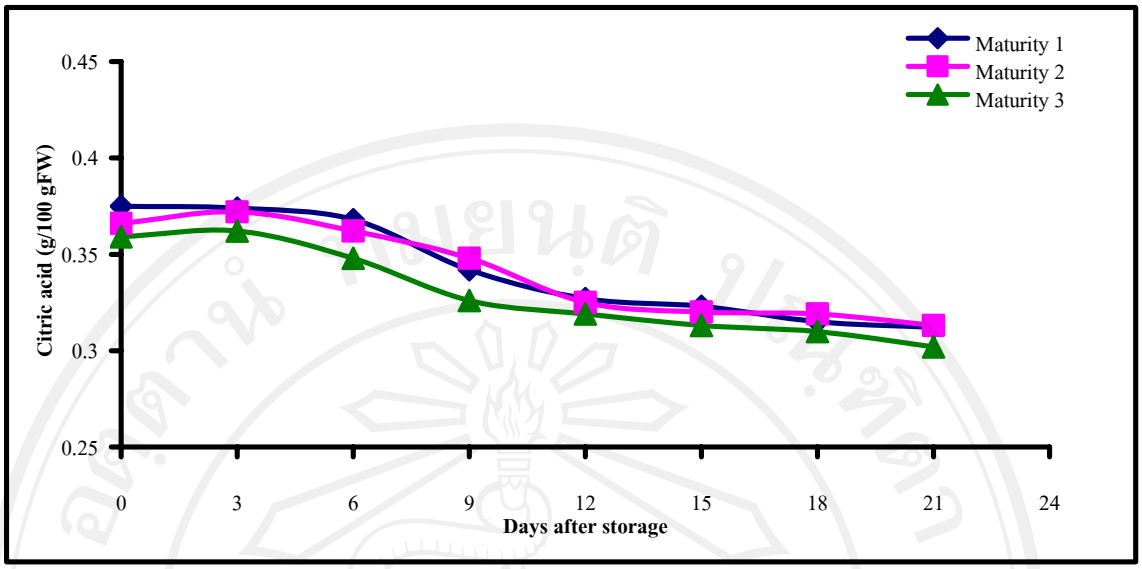


Figure 57 Changes in the citric acid content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

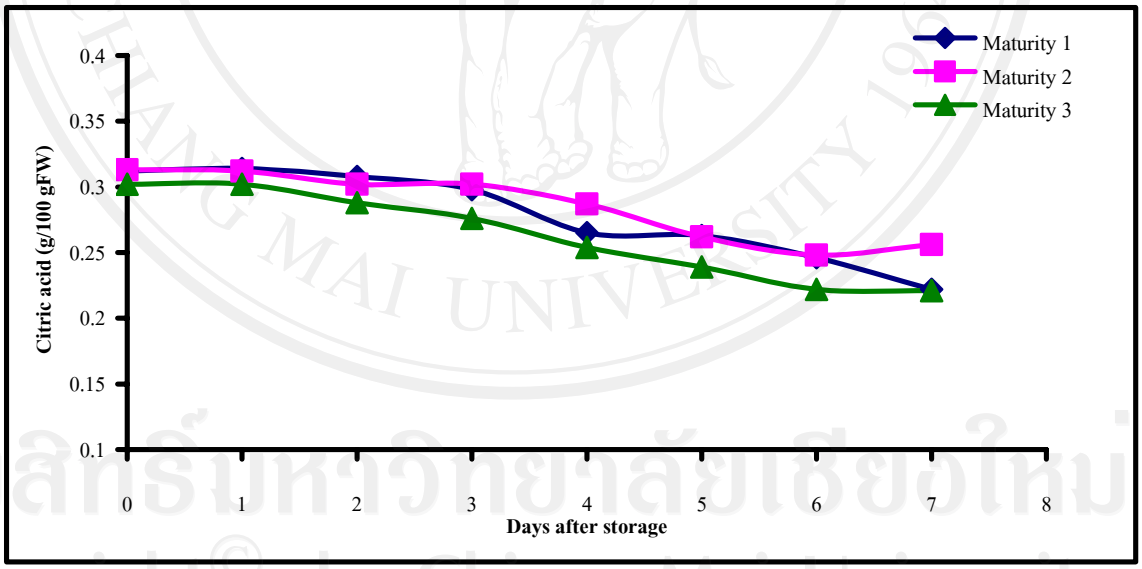


Figure 58 Changes in the citric acid content of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

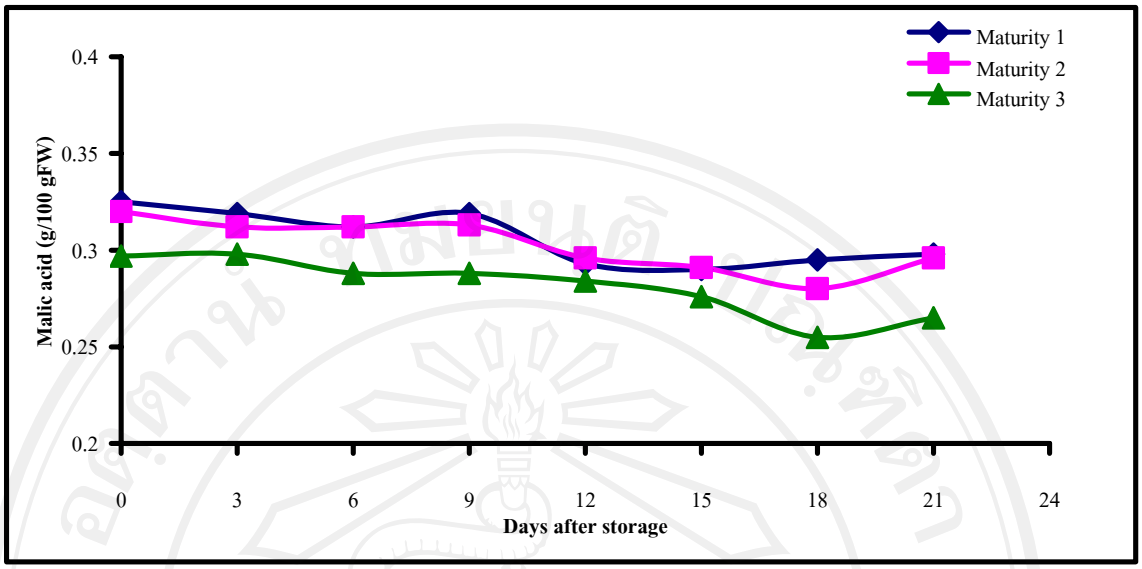


Figure 59 Changes in the malic acid content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

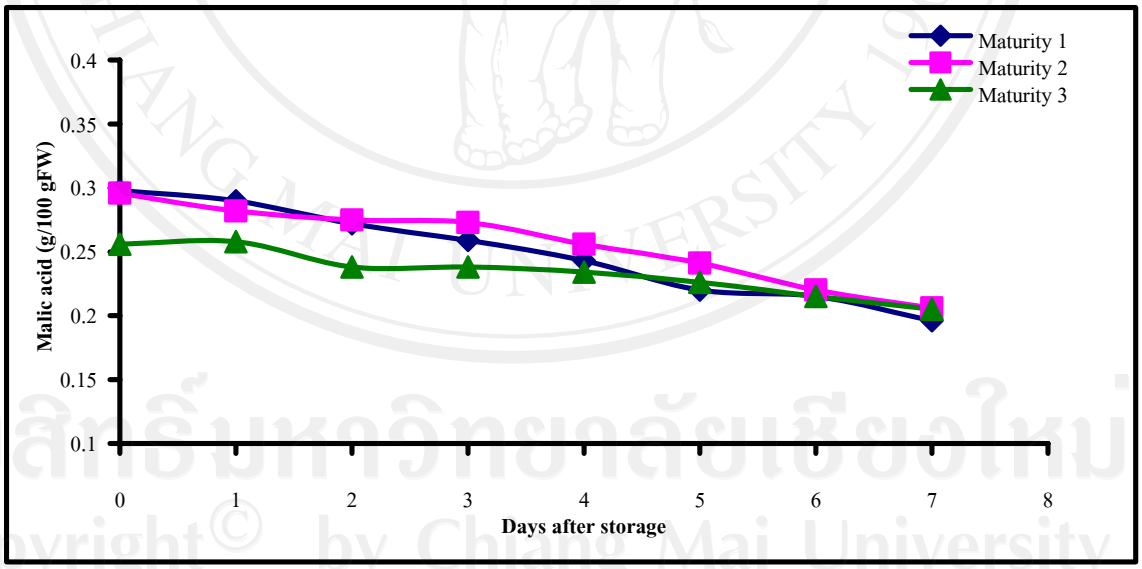


Figure 60 Changes in the malic acid content of 'Keaw Morakot' mango fruit at 25°C, 70-75% RH,

after storage at 13°C, 85-90% RH for 21 days

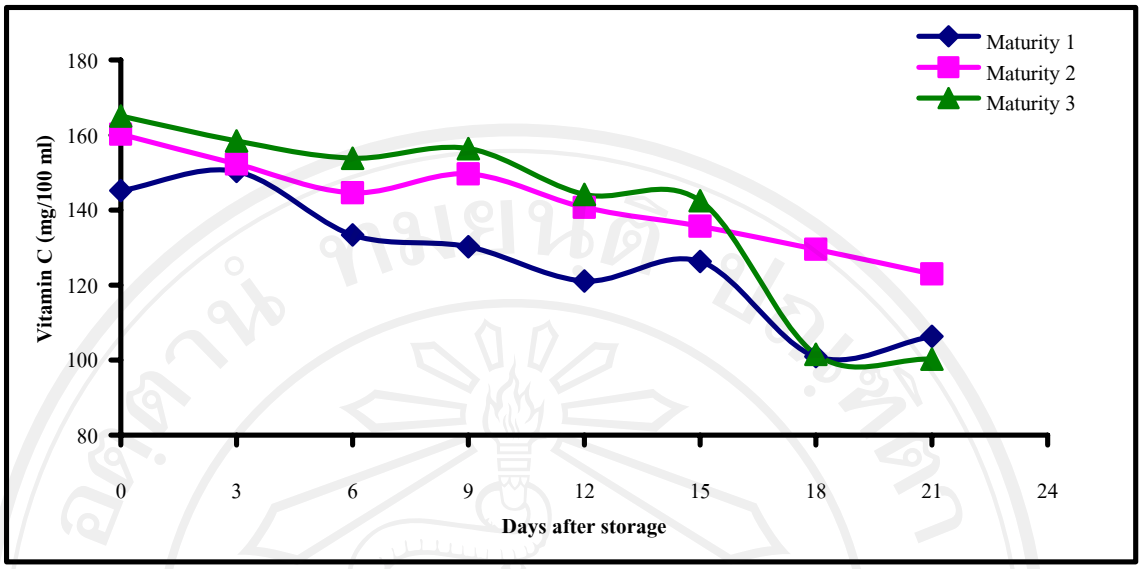


Figure 61 Changes in the vitamin C content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

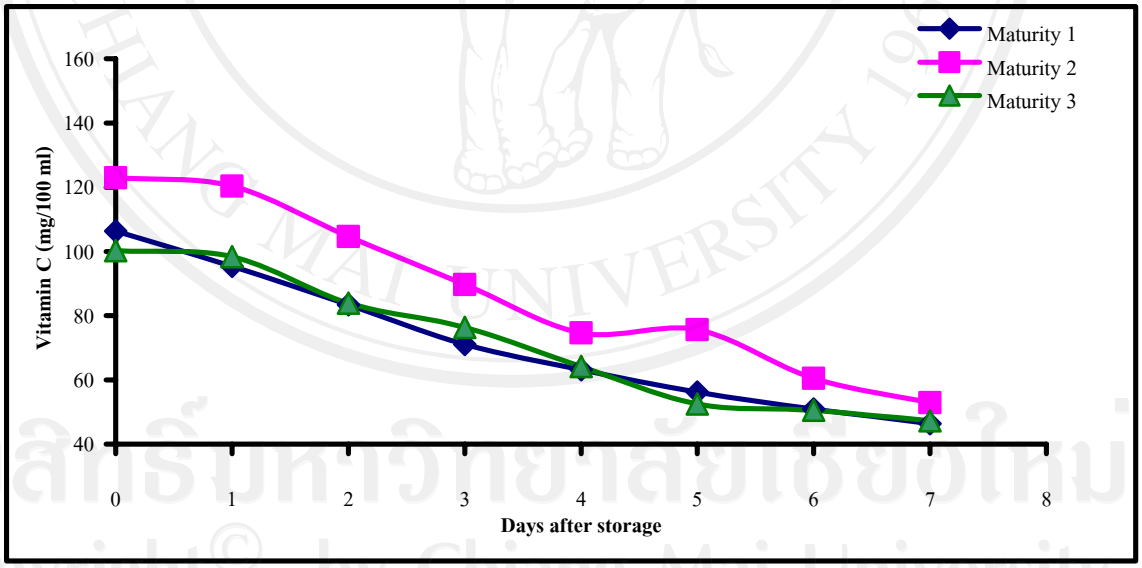


Figure 62 Changes in the vitamin C content of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

Dry matter content

The dry matter content of the fruit at Maturity 1 was lowest (22.99%), significantly different with Maturity 2 and 3 (24.82 and 24.01%, respectively) when storage at 13˚C for 12 days (Table 19). The dry matter content of the fruit tended to increase during 0-6 days of storage (Figure 63, Appendix Table 60). Similarly, during storage at 25˚C for 0 and 7 days, the fruit at Maturity 1 tended to have lower dry matter content than Maturity 2 and 3 (Table 20). The dry matter content of the fruit tended to increase during storage. This observation suggested that the fruit at Maturity 2 and 3 had more dry matter content than Maturity 1 (Figure 64, Appendix Table 61).

Starch content

After storage at 13˚C for 12 days, the starch content of the fruit at Maturity 2 was the highest (5.66%) and differed with Maturity 1 and 3 (5.30 and 5.33%, respectively) (Table 19). The starch content of the fruit decreased during storage (Figure 65, Appendix Table 62). The fruit at Maturity 2 also had the higher starch during storage at 25˚C for 0 and 7 days (5.00 and 2.69%, respectively), significantly different with Maturity 1 (4.45 and 2.45%, respectively) (Table 20). This observation indicated that the fruit at Maturity 1 had lower dry matter than Maturity 2 and 3 (Figure 66, Appendix Table 63).

Chlorophylls content of peel

The total chlorophyll and chlorophyll a and b contents of the fruit at different maturities were not significantly different, either by storage at 13˚C for 12 days or at 25˚C for 0 and 7 days (Table 19-20). The total chlorophyll and chlorophyll a decreased during 0-15 days at 13˚C while at 25˚C, they tended to decrease a little (Figure 67-70, Appendix Table 64-67). The chlorophyll b content decreased during 6-15 days at 13˚C but at 25˚C, it tended to be consistent (Figure 71-72, Appendix Table 68-69).

β-carotene content of pulp

The β-carotene content of the fruit at Maturity 3 was highest and differed with Maturity 1 and 2 when storage at 13˚C for 12 days (Table 19). At the beginning of storage at 25˚C, the β-carotene contents were not significantly different. After storage for 7 days, the β-carotene content at Maturity 2 and 3 (1.10 and 1.09 mg%, respectively) differed with Maturity 1 (0.90 mg%)

(Table 20). The β-carotene content of the fruit increased during storage (Figure 73-74, Appendix Table 70-71).

Table 19 Effects of maturity on dry matter, starch, chlorophylls and β-carotene contents of 'Keaw Morakot' mango fruit stored at 13˚C, 85-90% RH for 12 days

Treatments	Dry matter (%)	Starch (%)	Chlorophylls (mg/g FW)			β-carotene (mg%)
			total	a	b	
Maturity 1	22.99[b]	5.30[b]	1.35[ns]	0.85[ns]	0.50[ns]	0.42[b]
Maturity 2	24.82[a]	5.66[a]	1.39	0.88	0.51	0.42[b]
Maturity 3	24.01[a]	5.33[b]	1.47	0.92	0.55	0.47[a]
CV (%)	12.35	6.55	3.38	4.34	2.32	13.20

* Means within the same column followed by different letters differ significantly at $\rho<0.05$
ns = non-significant

Table 20 Effects of maturity on dry matter, starch, chlorophylls and β-carotene contents of 'Keaw Morakot' mango fruit stored at 25˚C, 70-75% RH for 0 and 7 days, after storage at 13˚C, 85-90% RH for 21 days

Treatments	Dry matter (%)	Starch (%)	Chlorophylls (mg/g FW)			β-carotene (mg%)
			total	a	b	
0 days						
Maturity 1	22.03[b]	4.45[b]	0.99[ns]	0.73[ns]	0.26[ns]	0.49[ns]
Maturity 2	23.28[ab]	4.99[a]	1.11	0.83	0.28	0.49
Maturity 3	24.05[a]	4.57[ab]	1.15	0.89	0.26	0.49
CV (%)	10.15	6.85	4.31	2.30	1.30	12.35
7 days						
Maturity 1	24.70[b]	2.45[b]	0.79[ns]	0.53[ns]	0.23[ns]	0.90[b]
Maturity 2	27.55[a]	2.69[a]	0.80	0.58	0.22	1.10[a]
Maturity 3	27.45[a]	2.57[a]	0.77	0.05	0.22	1.09[a]
CV (%)	20.15	16.85	3.05	1.25	2.09	12.67

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

ns = non-significant

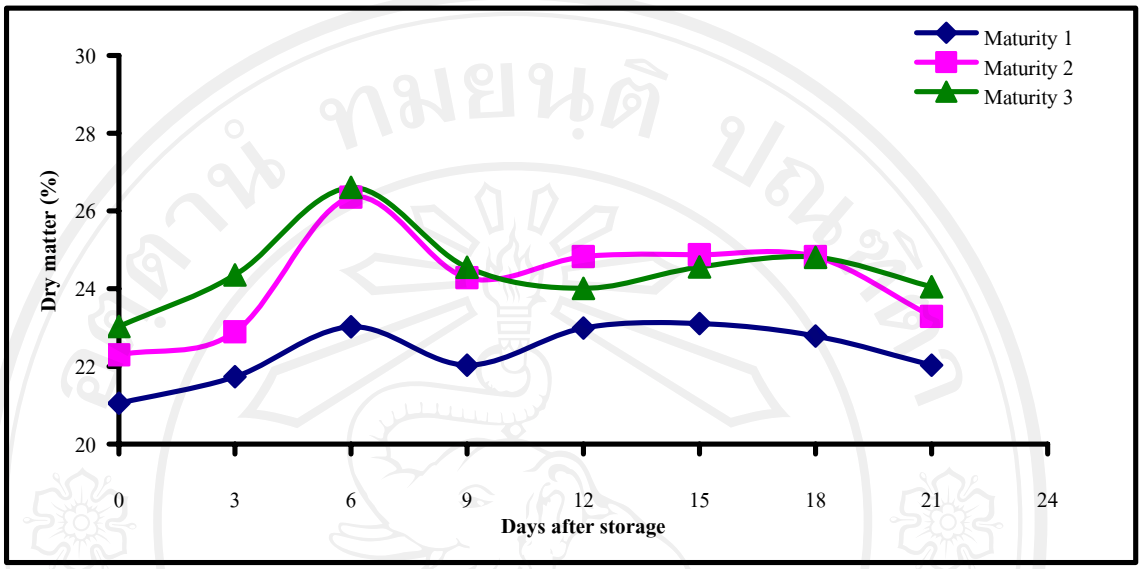


Figure 63 Changes in the dry matter content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

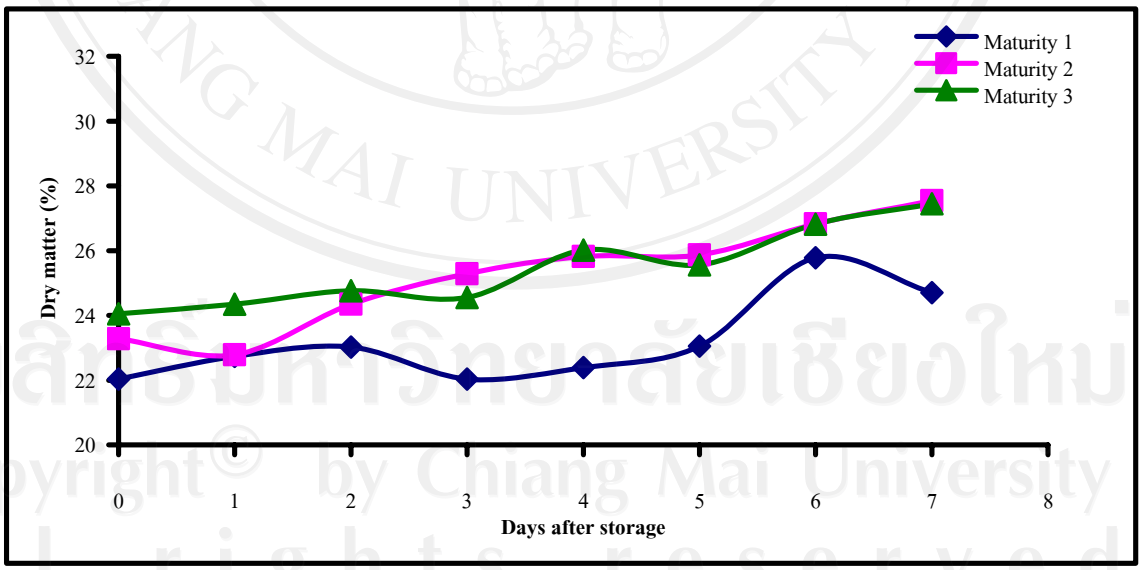


Figure 64 Changes in the dry matter content of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

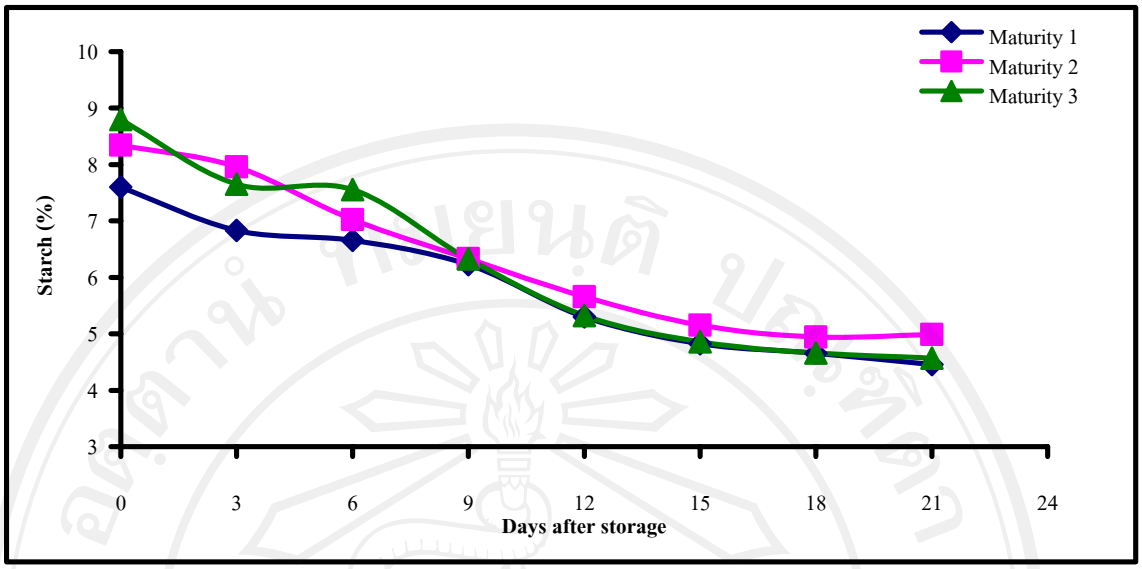


Figure 65 Changes in the starch content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

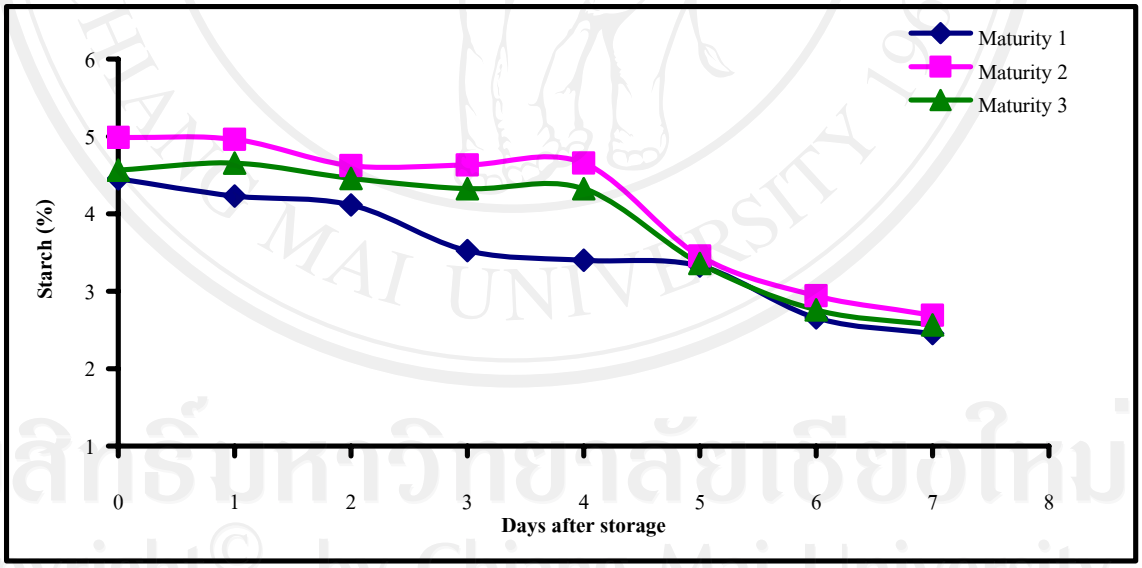


Figure 66 Changes in the starch content of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

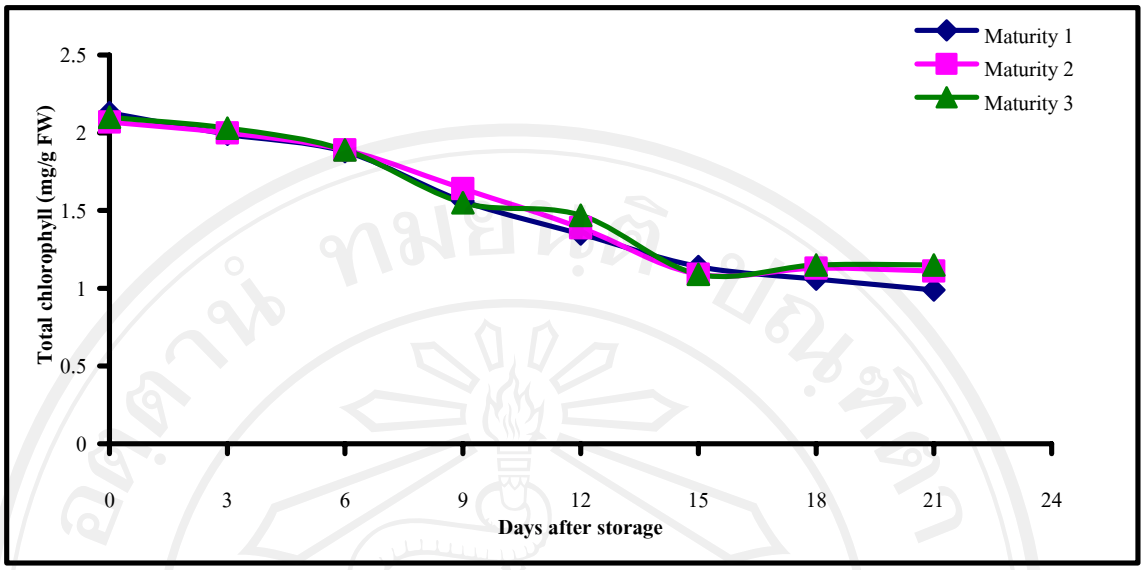


Figure 67 Changes in the total chlorophyll content of 'Keaw Morakot' mango fruit stored at 13°C,
85-90% RH

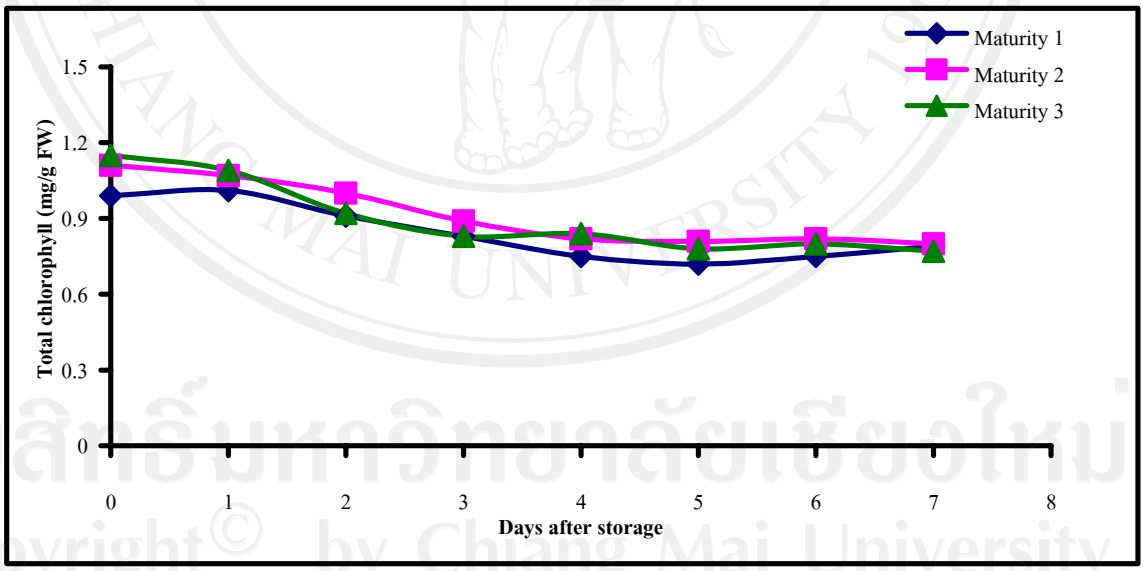


Figure 68 Changes in the total chlorophyll content of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90%RH for 21 days

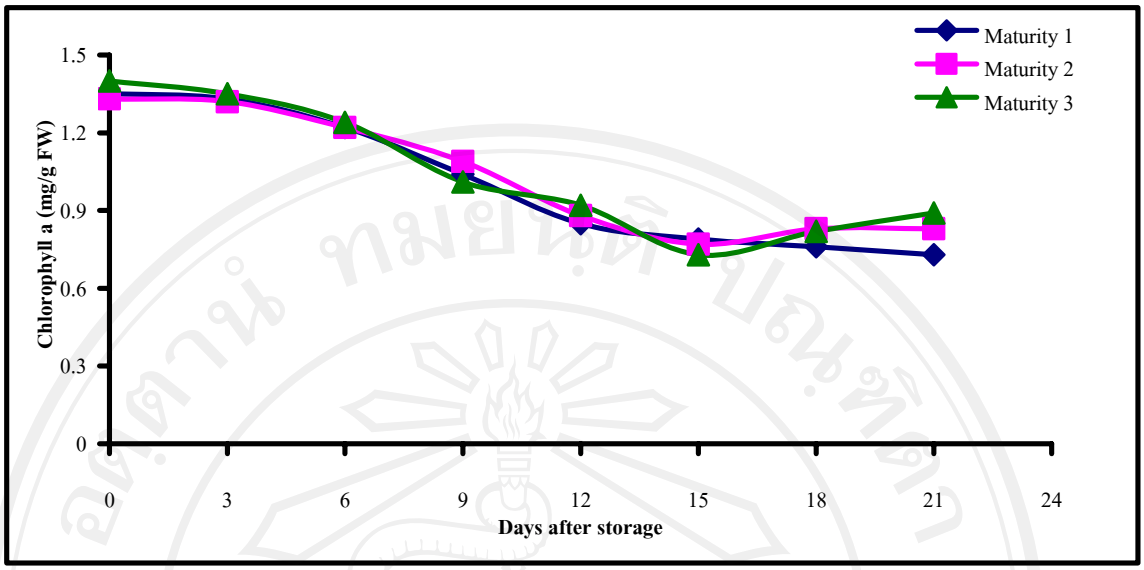


Figure 69 Changes in the chlorophyll a content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

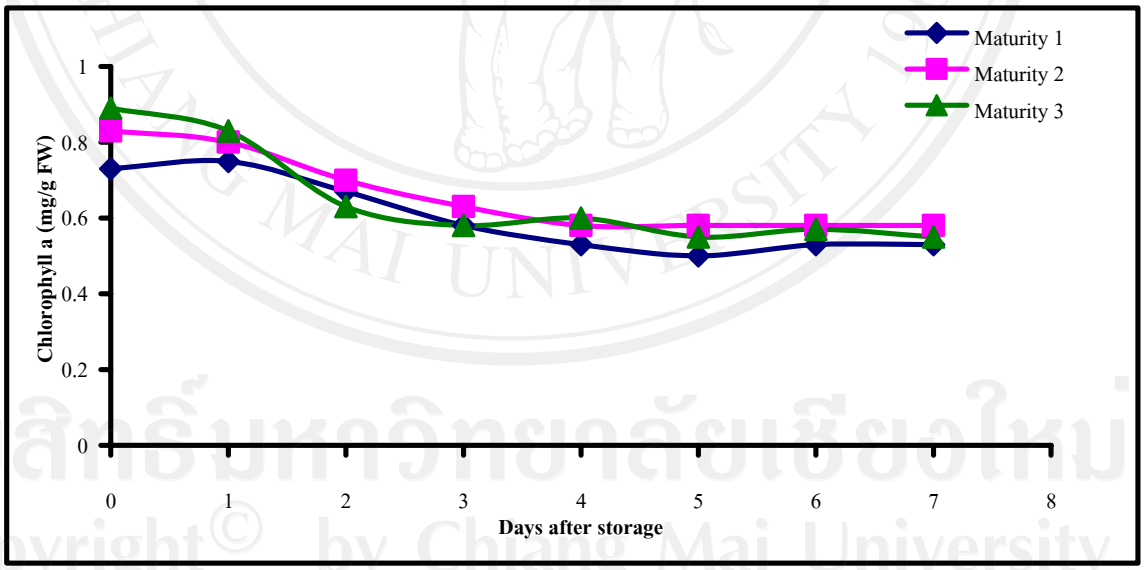


Figure 70 Changes in the chlorophyll a content of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90%RH for 21 days

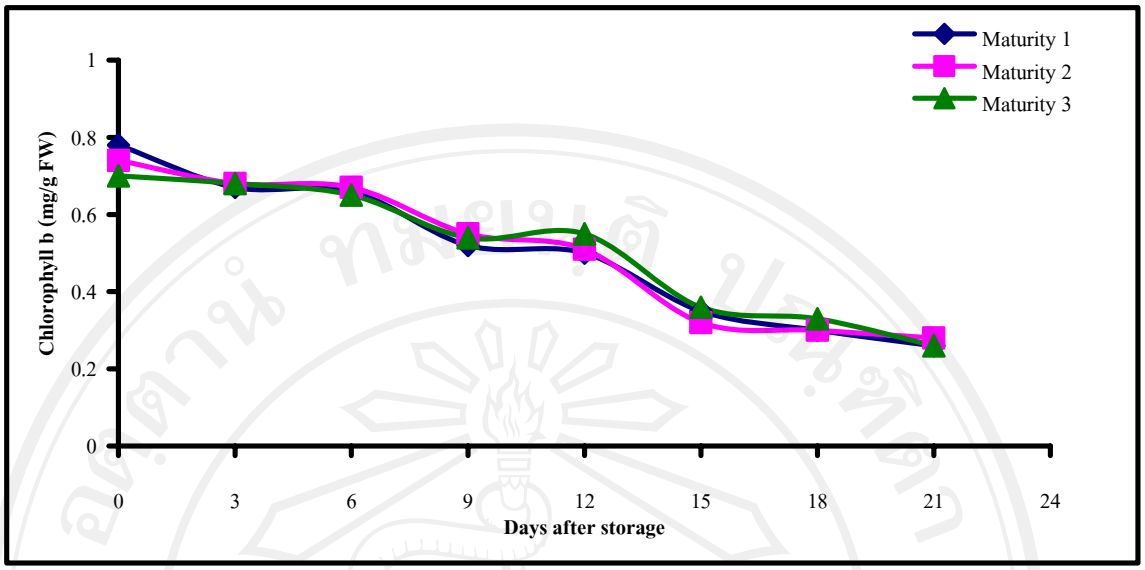


Figure 71 Changes in the chlorophyll b content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

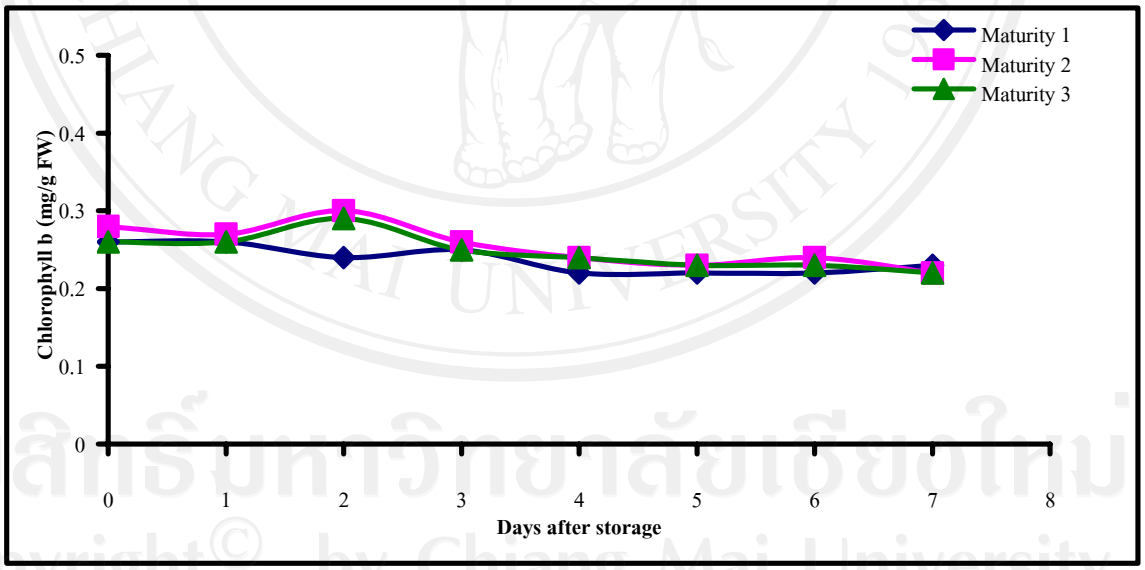


Figure 72 Changes in the chlorophyll b content of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

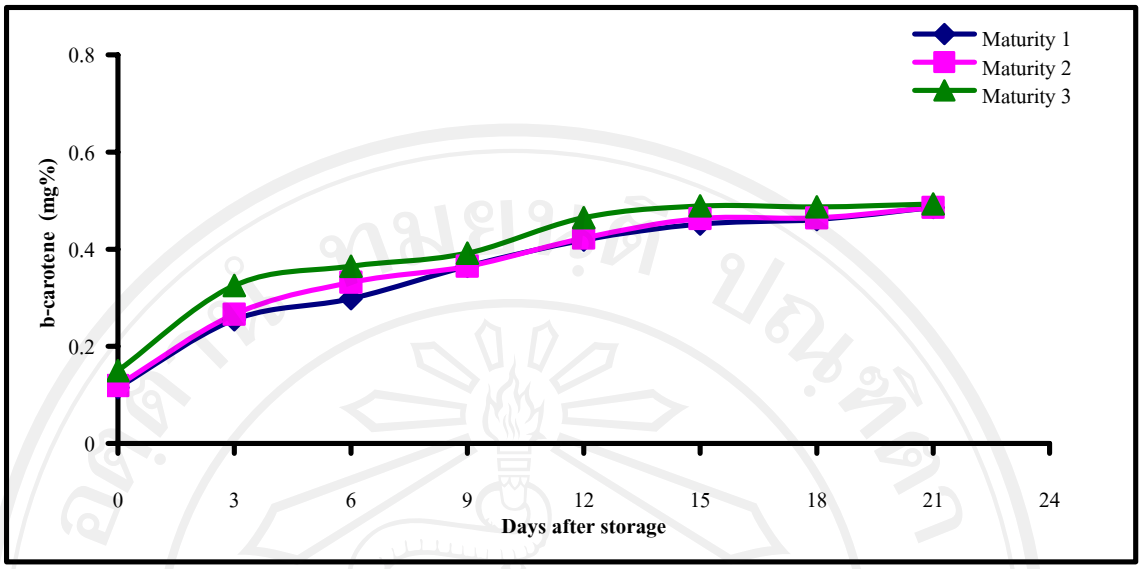


Figure 73 Changes in the β-carotene content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

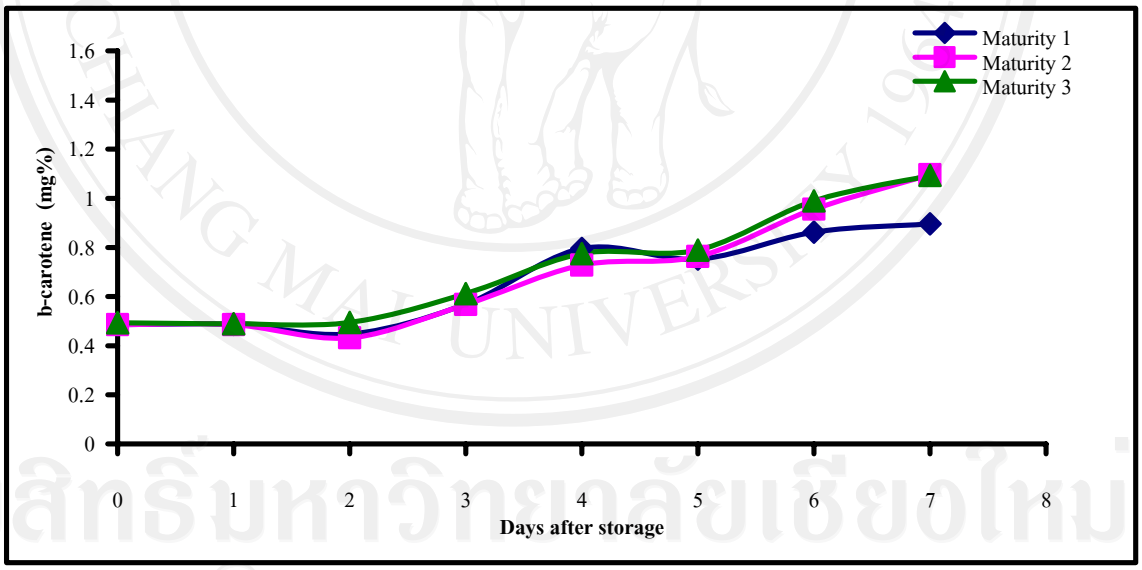


Figure 74 Changes in the β-carotene content of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13˚C, 85-90% RH for 21 days

Respiration rate

After storage at 13˚C for 12 days, the respiration rate of the fruit at different maturities was not significantly different, ranging between 75.69-76.32 mg CO_2/kg.hr^{-1} (Table 21). However, the fruit at Maturity 3 tended to exhibit higher respiration rate than the others. At the first day of storage, the respiration rate of the fruit decreased from the beginning, after that it rapidly increased to peak at day 18 (Figure 75, Appendix Table 72). At the beginning of storage at 25˚C, the respiration rate of the fruit at Maturity 3 showed the highest (90.03 mg CO_2/kg.hr^{-1}), significantly different with Maturity 1 and 2 (80.02 and 80.56 mg CO_2/kg.hr^{-1}, respectively). However, after storage for 7 days, the respiration rate of the fruit was not significantly different (Table 22). The respiration rate of the fruit at Maturity 1 and 3 increased to peak at day 3, while the fruit at Maturity 2 increased to peak at day 4 (Figure 76, Appendix Table 73).

Ethylene production

The ethylene production of the fruit at Maturity 3 was highest (1.78 µl C_2H_4/kg.hr^{-1}), significantly different with Maturity 1 and 2 (1.35 and 1.20 µl C_2H_4/kg.hr^{-1}, respectively) when storage at 13˚C for 12 days (Table 21). The ethylene production of the fruit at Maturity 1 and 3 increased to peak at day 15 (1.95 and 1.94 µl C_2H_4/kg.hr^{-1}, respectively), while the fruit at Maturity 2 increased to peak at day 18 of storage (1.86 µl C_2H_4/kg.hr^{-1}) (Figure 77, Appendix Table 74). However, the ethylene production of the fruit did not differ either during storage at 25˚C for 0 or 7 days (Table 22). The ethylene production of the fruit at Maturity 1 and 3 increased to peak at day 2 (2.51 and 2.48 µl C_2H_4/kg.hr^{-1}, respectively) while the fruit at Maturity 2 increased to peak at day 3 (2.37 µl C_2H_4/kg.hr^{-1}) (Figure 78, Appendix Table 75).

Table 21 Effects of maturity on respiration rate and ethylene production of 'Keaw Morakot' mango fruit stored at 13˚C, 85-90% RH for 12 days

Treatments	Respiration rate ($mg\ CO_2/kg.hr^{-1}$)	Ethylene production ($\mu l\ C_2H_4/kg.hr^{-1}$)
Maturity 1	76.32^{ns}	1.35^{b}
Maturity 2	76.32	1.20^{b}
Maturity 3	75.69	1.78^{a}
CV (%)	15.84	12.07

* Means within the same column followed by different letters differ significantly at $\rho<0.05$
ns = non-significant

Table 22 Effects of maturity on respiration rate and ethylene production of 'Keaw Morakot' mango fruit stored at 25˚C, 70-75% RH for 0 and 7 days, after storage at 13˚C, 85-90% RH for 21 days

Treatments	Respiration rate ($mg\ CO_2/kg.hr^{-1}$)	Ethylene production ($\mu l\ C_2H_4/kg.hr^{-1}$)
0 days		
Maturity 1	80.02^{b}	1.81^{ns}
Maturity 2	80.56^{b}	1.82
Maturity 3	90.03^{a}	1.88
CV (%)	15.27	10.33
7 days		
Maturity 1	200.34^{ns}	1.81^{ns}
Maturity 2	202.43	1.83
Maturity 3	195.23	1.87
CV (%)	17.25	13.56

* Means within the same column followed by different letters differ significantly at $\rho<0.05$
ns = non-significant

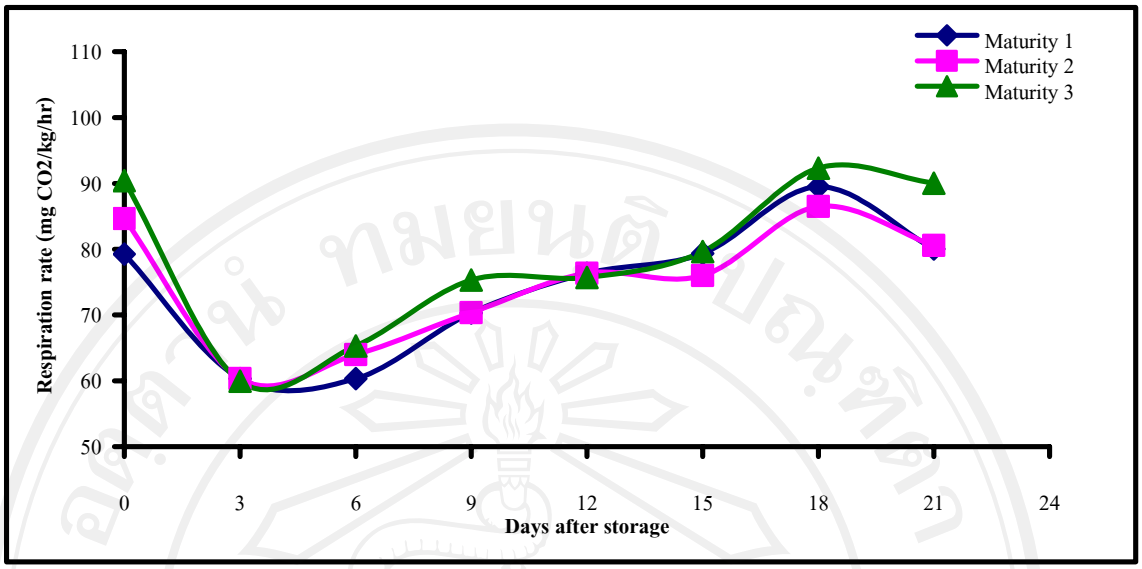


Figure 75 Changes in the respiration rate of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

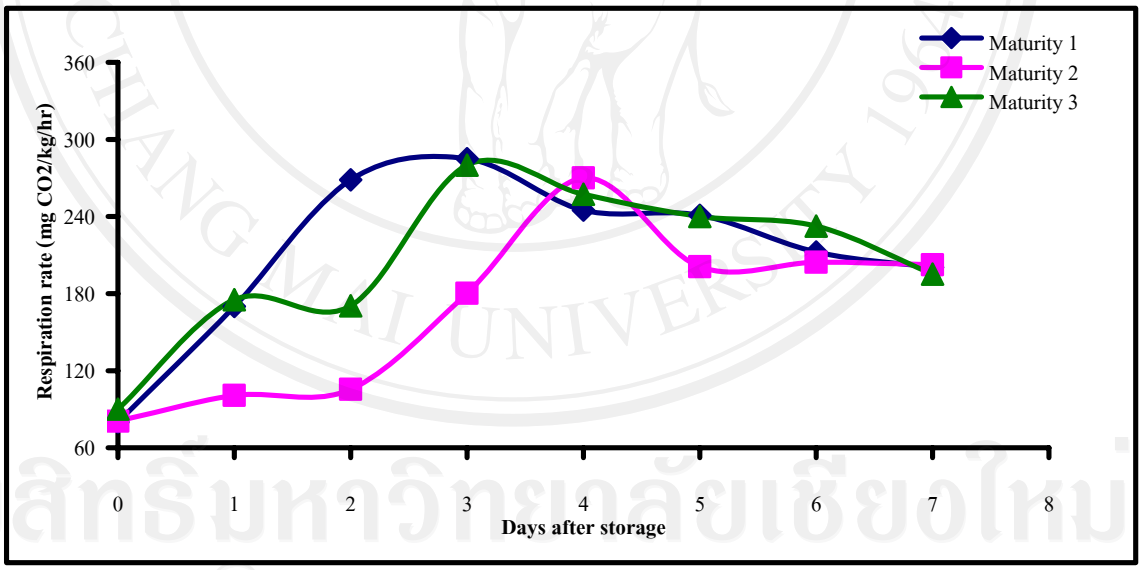


Figure 76 Changes in the respiration rate of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

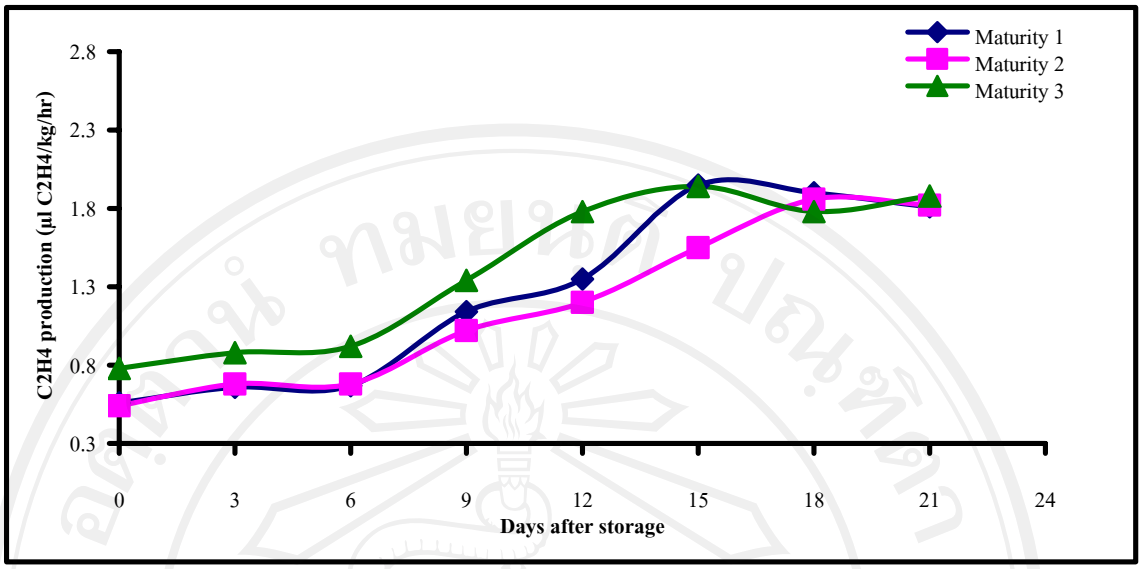


Figure 77 Changes in the ethylene production of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

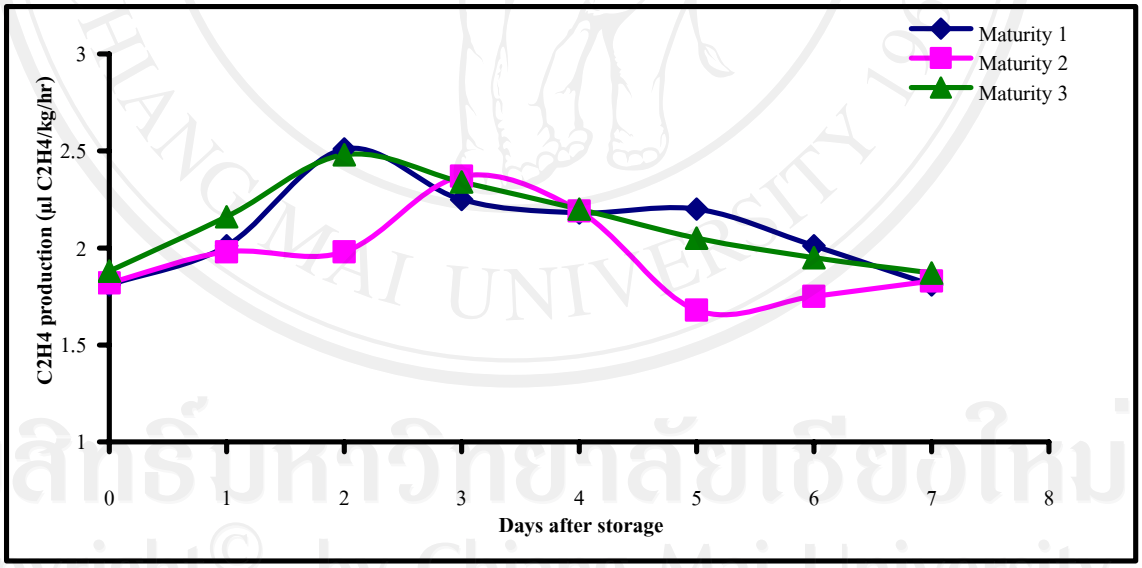


Figure 78 Changes in the ethylene production of 'Keaw Morakot' mango fruit stored at 25°C, 70-75%RH, after storage at 13°C, 85-90% RH for 21 days

WSP content

The WSP content of the fruit at Maturity 2 was lowest (2.85 g D-galcturonic acid/100 g AIS), differed with Maturity 1 and 3 (3.58 and 3.45 g D-galcturonic acid/100 g AIS, respectively) when storage at 13˚C for 12 days (Table 23). During storage, the WSP content of the fruit at Maturity 1 and 3 increased after 12 days while Maturity 2 increased after 15 days (Figure 79, Appendix Table 76). The fruit at Maturity 2 had also the lowest content (5.22 g D-galcturonic acid/100 g AIS) at the beginning of storage at 25˚C, and differed with Maturity 1 and 3 (5.68 and 5.70 g D-galcturonic acid/100 g AIS, respectively). However, after storage for 7 days, the WSP content of the fruit had no significant differences (Table 24). The WSP content of the fruit increased during the 0-6 days, as the Maturity 3 tended to increase more than the others (Figure 80, Appendix Table 77).

PG activity

After storage at 13˚C for 12 days, the PG activity of the fruit at Maturity 2 was lowest (269.64 nmole D-galacturonic acid/mg protein/min), differed with Maturity 1 and 3 (272.41 and 272.65 nmole D-galacturonic acid/mg protein/min, respectively) (Table 23). The PG activity of the fruit rapidly increased during 6-9 days of storage, after that there was a little change (Figure 81, Appendix Table 78). However, at the beginning of storage at 25˚C, the PG activity of the fruit was not significantly different but, the fruit at Maturity 2 had lowest PG activity (312.67 nmole D-galacturonic acid/mg protein/min), and differed with Maturity 1 and 3 (320.89 and 319.62 nmole D-galacturonic acid/mg protein/min, respectively) after storage for 7 days (Table 24). The PG activity of Maturity 1 and 3 rapidly increased during 2-3 days, while Maturity 2, during 3-4 days of storage, after that it slowly increased (Figure 82, Appendix Table 79).

PME activity

The PME activity of the fruit at Maturity 2 was lowest (225.05 μmole acetic acid/mg protein/min), differed with Maturity 1 and 3 (235.45 and 233.32 μmole acetic acid/mg protein/min, respectively) (Table 23). The PME activity of the fruit slowly increased during 0-9 days, after that it decreased (Figure 83, Appendix Table 80). At the beginning of storage at 25˚C, the fruit at Maturity 3 had the highest PME activity (235.00 μmole acetic acid/mg protein/min), significantly different with Maturity 1 and 2 (225.21 and 226.30 μmole acetic acid/mg protein/min, respectively). However, for 7 days, the PME of the fruit was not significantly

different (Table 24). The PME activity tended to increase during 0-3 days, after that it rapidly decreased (Figure 84, Appendix Table 81).

Sensory evaluation

After storage for 21 days at 13˚C and kept at 7 days for ripening, the fruit at Maturity 2 had highest score of texture (4.33 scores), significantly different with Maturity 1 (3.50 scores) and Maturity 3 (3.62 scores). Although a consistency (3.50-3.76 scores), feeling (3.60-3.65 scores) and taste (4.15-4.35 scores) were not significantly different, the fruit at Maturity 2 tended to have highest scores of these. The fruit at Maturity 2 had also lower score of off-odor (2.35 scores) than Maturity 1 (2.85 scores) and Maturity 3 (2.90 scores), but not significantly different (Table 25).

Table 23 Effects of maturity on WSP content, PG and PME activities of 'Keaw Morakot' mango fruit stored at 13˚C, 85-90% RH for 12 days

Treatments	WSP content (g D-gal./100g AIS)	PG activity (nmole D-galacturonic acid/mg protein/min)	PME activity (μmole acetic acid/mg protein/min)
Maturity 1	3.58[a]	272.41[a]	235.45[a]
Maturity 2	2.85[b]	269.64[b]	225.05[b]
Maturity 3	3.45[a]	272.65[a]	233.23[a]
CV (%)	6.38	10.05	11.55

* Means within the same column followed by different letters differ significantly at $\rho<0.05$
ns = non-significant

Table 24 Effects of maturity on WSP content, PG and PME activities of 'Keaw Morakot' mango fruit stored at 25˚C, 70-75% RH for 0 and 7 days, after storage at 13˚C, 85-90% RH for 21 days

Treatments	WSP content (g D-gal./100g AIS)	PG activity (nmole D-galacturonic acid/mg protein/min)	PME activity (µmole acetic acid/mg protein/min)
0 days			
Maturity 1	5.68[a]	268.39[ns]	225.21[b]
Maturity 2	5.22[b]	269.64	226.30[b]
Maturity 3	5.70[a]	270.02	235.00[a]
CV (%)	8.25	11.08	10.35
7 days			
Maturity 1	8.59[ns]	320.89[a]	113.88[ns]
Maturity 2	8.32	312.67[b]	119.47
Maturity 3	8.52	319.62[a]	112.22
CV (%)	12.56	11.35	9.03

* Means within the same column followed by different letters differ significantly at $\rho<0.05$
ns = non-significant

Table 25 Effects of maturity on texture, consistency, feeling, taste and off-odor of 'Keaw Morakot' mango fruit stored at 25˚C, 70-75% RH for 7 days, after storage at 13˚C, 85-90% RH for 21 days

Treatments	Texture	Consistency	Feeling	Taste	Off-odor
Maturity 1	3.50[b]	3.60[ns]	3.65[ns]	4.25[ns]	2.85[ns]
Maturity 2	4.33[a]	3.76	3.65	4.35	2.35
Maturity 3	3.62[b]	3.50	3.60	4.15	2.90
CV (%)	3.05	12.78	0.56	8.35	12.33

* Means within the same column followed by different letters differ significantly at $\rho<0.05$
ns = non-significant

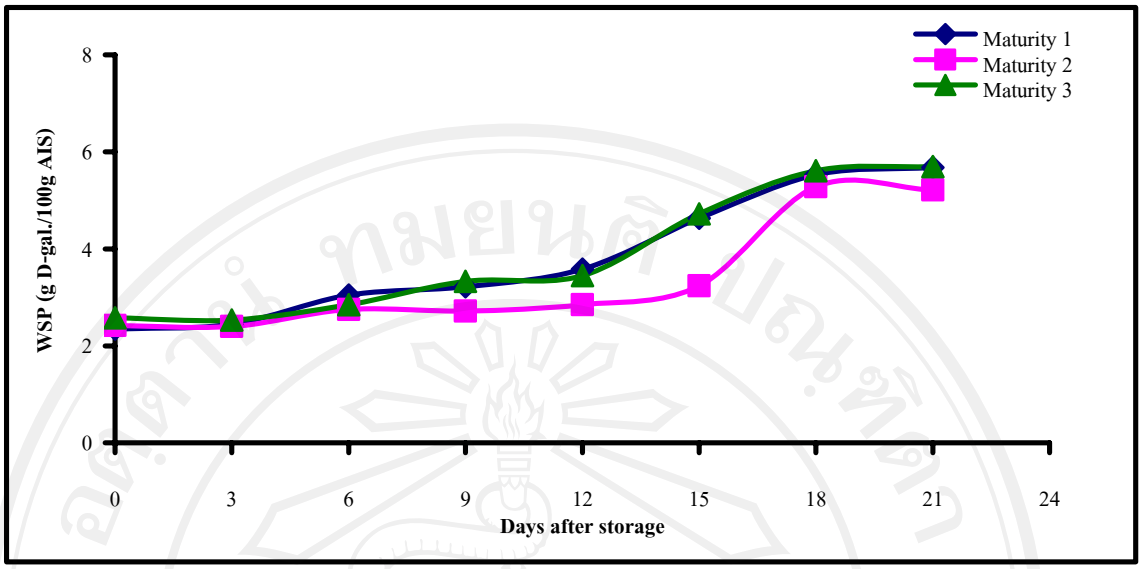


Figure 79 Changes in the WSP content of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

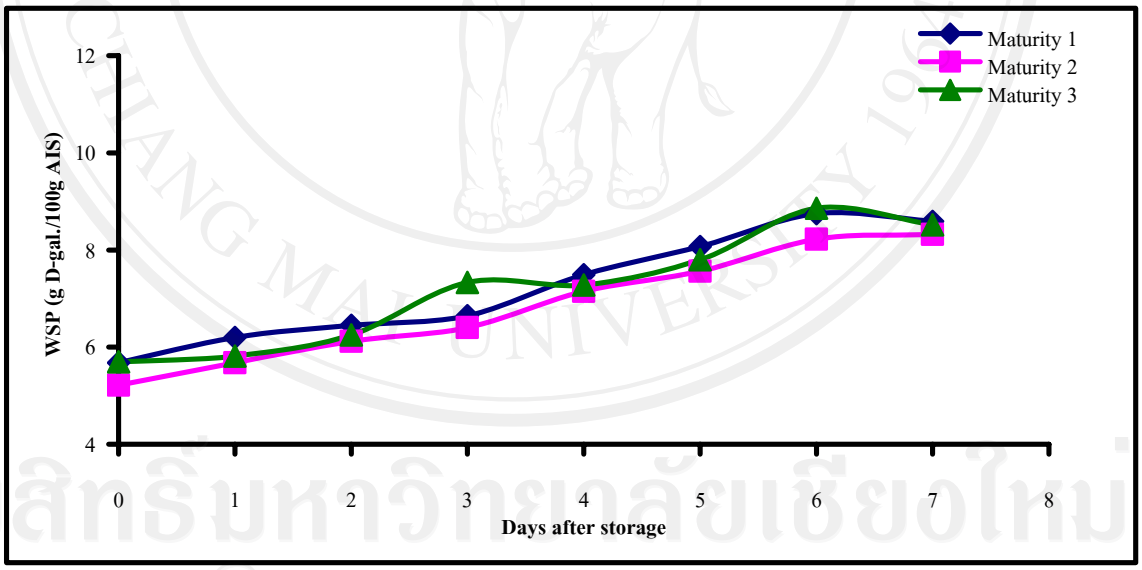


Figure 80 Changes in the WSP of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

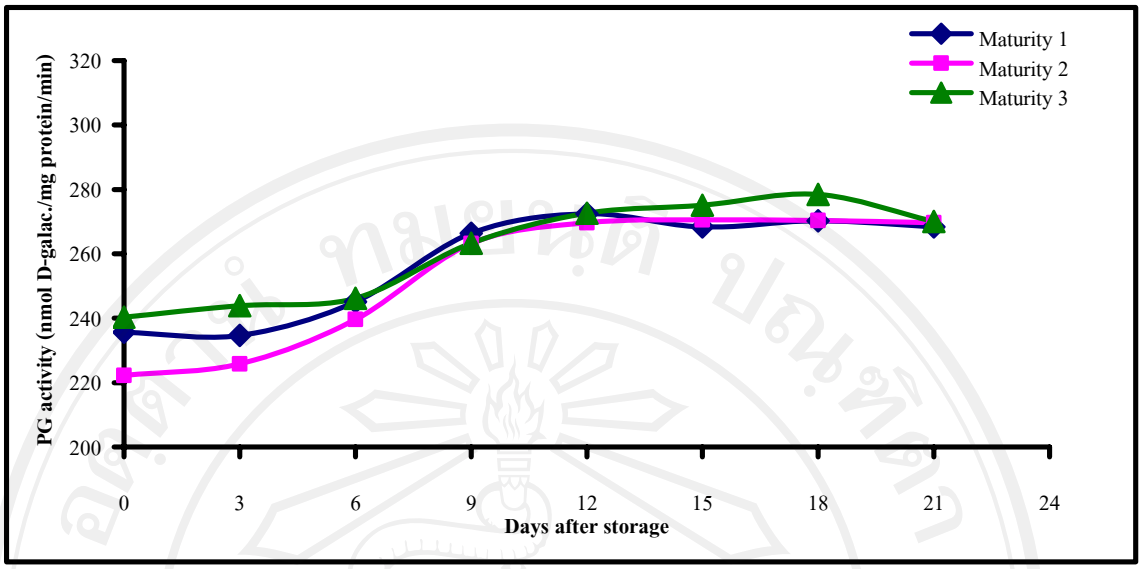


Figure 81 Changes in the PG activity of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

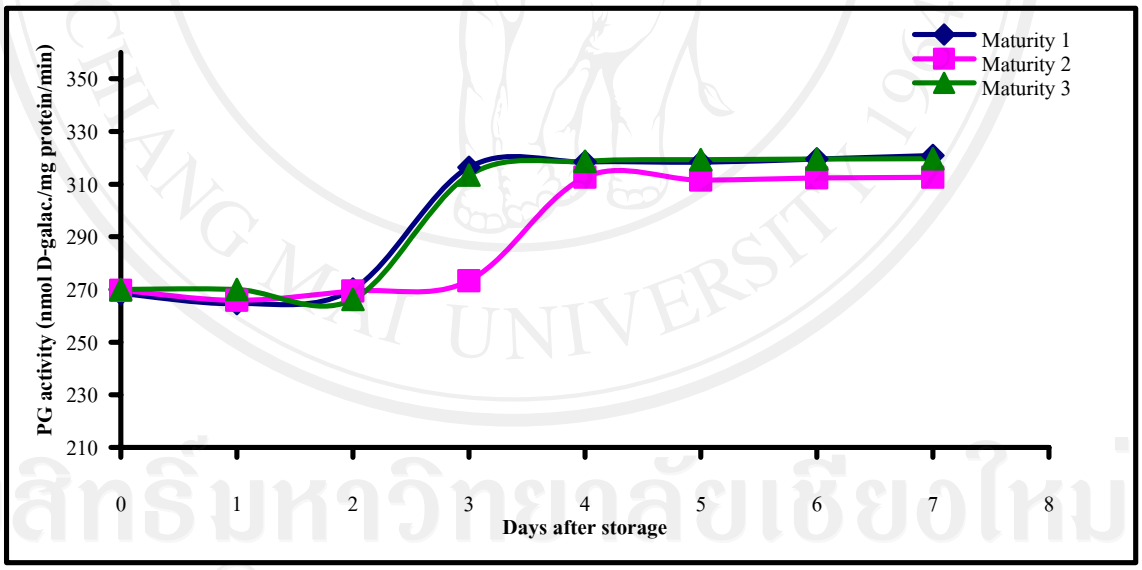


Figure 82 Changes in the PG activity of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

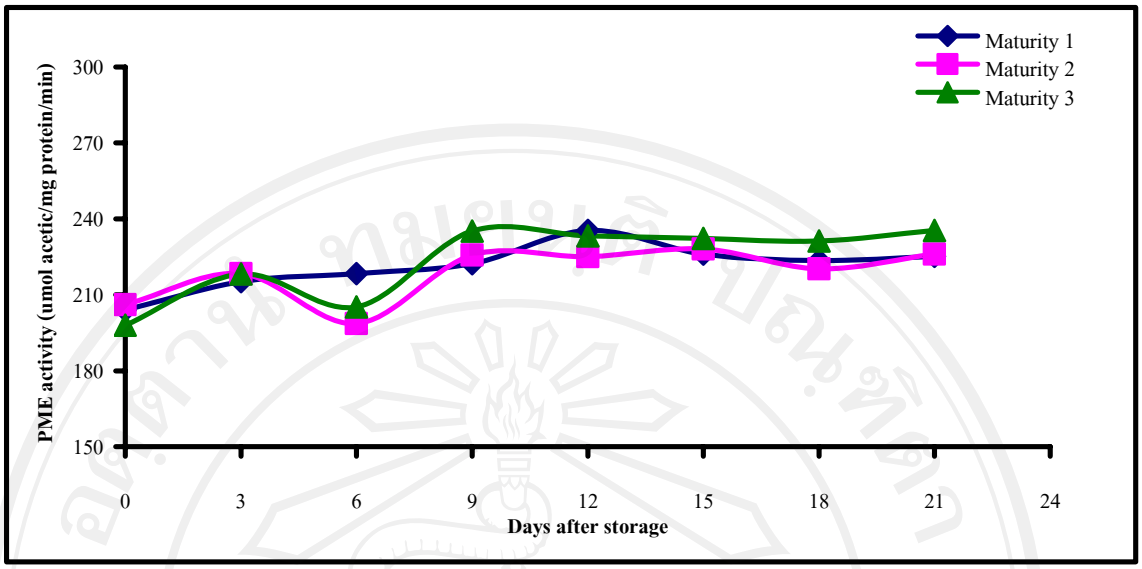


Figure 83 Changes in the PME activity of 'Keaw Morakot' mango fruit stored at 13°C, 85-90% RH

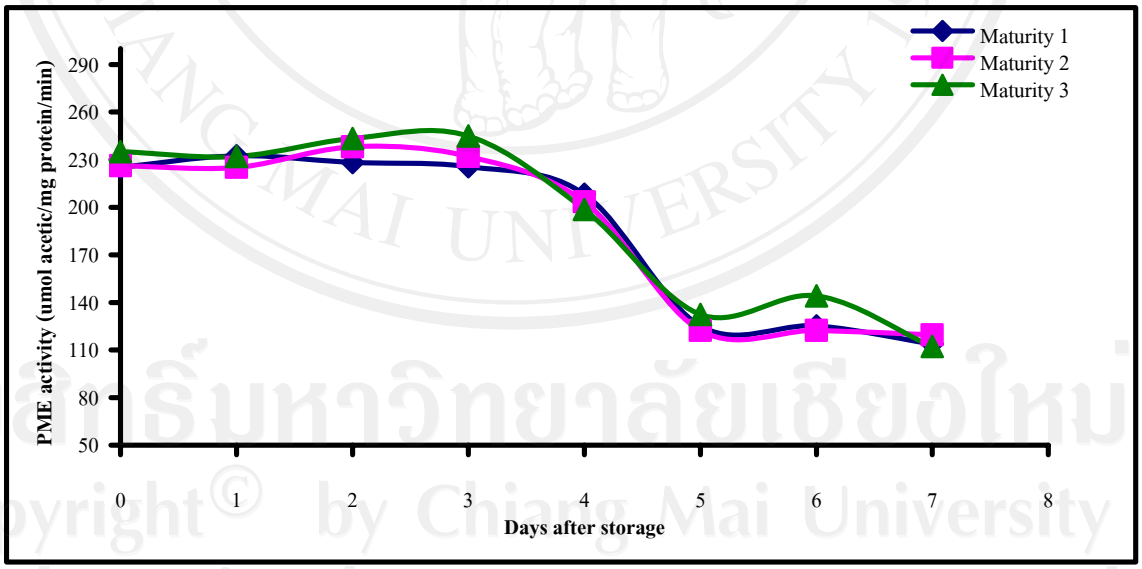


Figure 84 Changes in the PME activity of 'Keaw Morakot' mango fruit stored at 25°C, 70-75% RH, after storage at 13°C, 85-90% RH for 21 days

Effects of 1-MCP on the changes of quality and enzyme activity during ripening of 'Keaw Morakot' mango fruit at low temperature

Firmness

The firmness of harvested mango fruit cv. Keaw Morakot was 111.45 Newton. After storage for 12 days, the fruit which were treated with 1000 nl/l 1-methylcyclopropene (1-MCP) had higher firmness (95.25 Newton) than 0 and 500 nl/l 1-MCP treated fruit, but only significantly different with 0 nl/l 1-MCP (86.56 Newton) (Table 26). During 6-21 days of storage, the 1000 nl/l 1-MCP could delay the fruit softening better than 500 and 0 nl/l 1-MCP, respectively (Figure 85 and Appendix Table 82). The 1-MCP treated fruit for 12 hours of exposure had more firmness (91.43 Newton) than 6 hours of exposure (88.94 Newton) (Table 26). During storage, the 12 hours of exposure delayed the fruit softening better than 6 hours of exposure (Figure 85 and Appendix Table 82).

Color changes of pulp and peel

The L* value of the harvested mango pulp was 77.73. Although concentrations and exposure times of 1-MCP used were not effective to delay the reduction of the L* value of pulp at storage for 12 days (Table 26), but the fruit which were treated with 1000 nl/l 1-MCP and 12 hours of exposure tended to have a reduction of the pulp L* value less than the other concentrations and 6 hours, respectively (Figure 86, Appendix Table 83). Although the peel L* values were not siginificantly different (Table 26), but the 500 and 1000 nl/l and 12 hours of exposure 1-MCP treated fruit tended to have higher L* values than 0 nl/l and 6 hours of exposure, respectively (Figure 87, Appendix Table 84).

The ºH value of pulp at the beginning of storage was 82.52. After storage for 12 days, the ºH value of the 1000 nl/l 1-MCP treated fruit (75.44) differed with 0 nl/l 1-MCP (71.96). Similarly, the 1-MCP treated fruit for 12 hours (74.50) differed with 6 hours (73.15) (Table 26). After 6 days of storage, the 500 and 1000 nl/l 1-MCP and 12 hours of exposure delayed the reduction of the ºH value more than 0 nl/l 1-MCP and 6 hours, respectively (Figure 88, Appendix Table 85). However, the ºH value of peel was not significantly different, and had little changes during storage (Table 26, Figure 89, Appendix Table 86).

Chroma value of pulp at the beginning of stoage was 46.68. After storage for 12 days, the chroma value of 1000 nl/l 1-MCP treated fruit (41.92) differed with 0 nl/l 1-MCP (34.92).

Similarly, the pulp chroma value of the 1-MCP treated fruit for 12 hours (41.72) differed with 6 hours (36.51) (Table 26). The 500 and 1000 nl/l 1-MCP and 12 hours of exposure time could delay the reduction of the pulp chroma values than 0 nl/l 1-MCP and 6 hours, respectively (Figure 90, Appendix Table 87). For the peel chroma value, there was no significant difference (Table 26). The peel chroma value tended to increase a little during 3-6 days, rapidly decreased during 6-12 days of storage (Figure 91, Appendix Table 88).

Table 26 Effects of 1-MCP on firmness, L*, ºH and chroma values of pulp and peel of 'Keaw Morakot' mango fruit stored at 13˚C, 85-90% RH, for 0 and 12 days

Treatments	Firmness	L*		ºH		Chroma	
	(Newton)	pulp	peel	pulp	peel	pulp	peel
0 days	111.45	73.73	56.52	82.52	168.87	46.68	32.27
12 days							
0 nl/l 1-MCP	86.56^{b}	67.49^{ns}	54.52^{ns}	71.96^{b}	169.87^{ns}	34.92^{b}	31.73^{ns}
500 nl/l 1-MCP	91.71^{ab}	67.74	55.31	74.38^{a}	169.02	40.49^{a}	31.66
1000 nl/l 1-MCP	95.29^{a}	68.81	55.57	75.44^{a}	168.87	41.92^{a}	31.77
CV (%)	8.26	4.12	3.56	3.32	1.25	5.68	4.32
6 hours	88.94^{y}	67.44^{ns}	54.59^{ns}	73.15^{y}	169.42^{ns}	36.51^{y}	31.65^{ns}
12 hours	91.43^{x}	68.59	55.68	74.70^{x}	169.08	41.72^{x}	31.78
CV (%)	10.22	3.69	6.89	1.32	3.22	2.98	1.03

* Means within the same column followed by different letters differ significantly at $\rho<0.05$
ns = non-significant

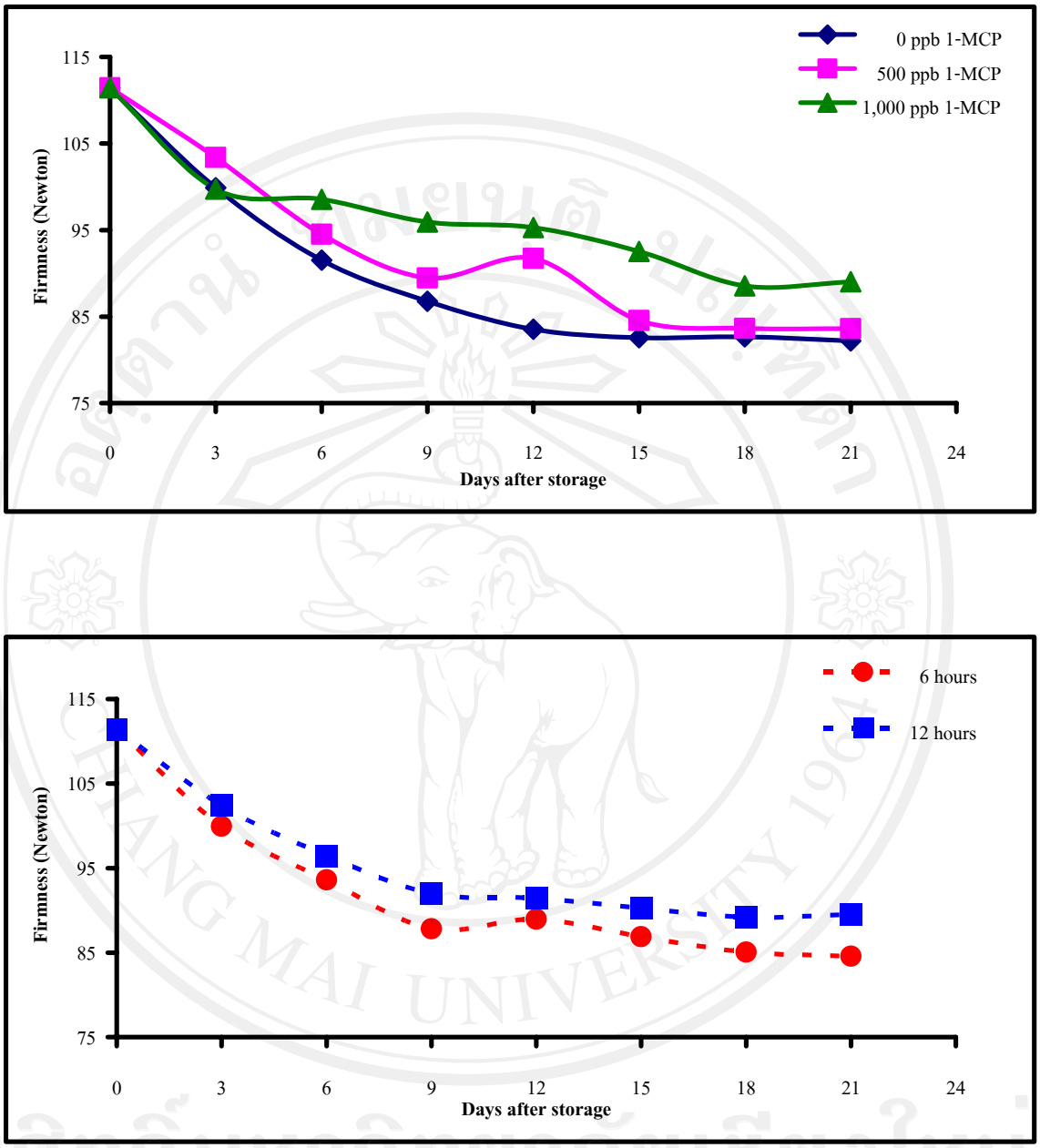


Figure 85 Changes in the firmness of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90%RH

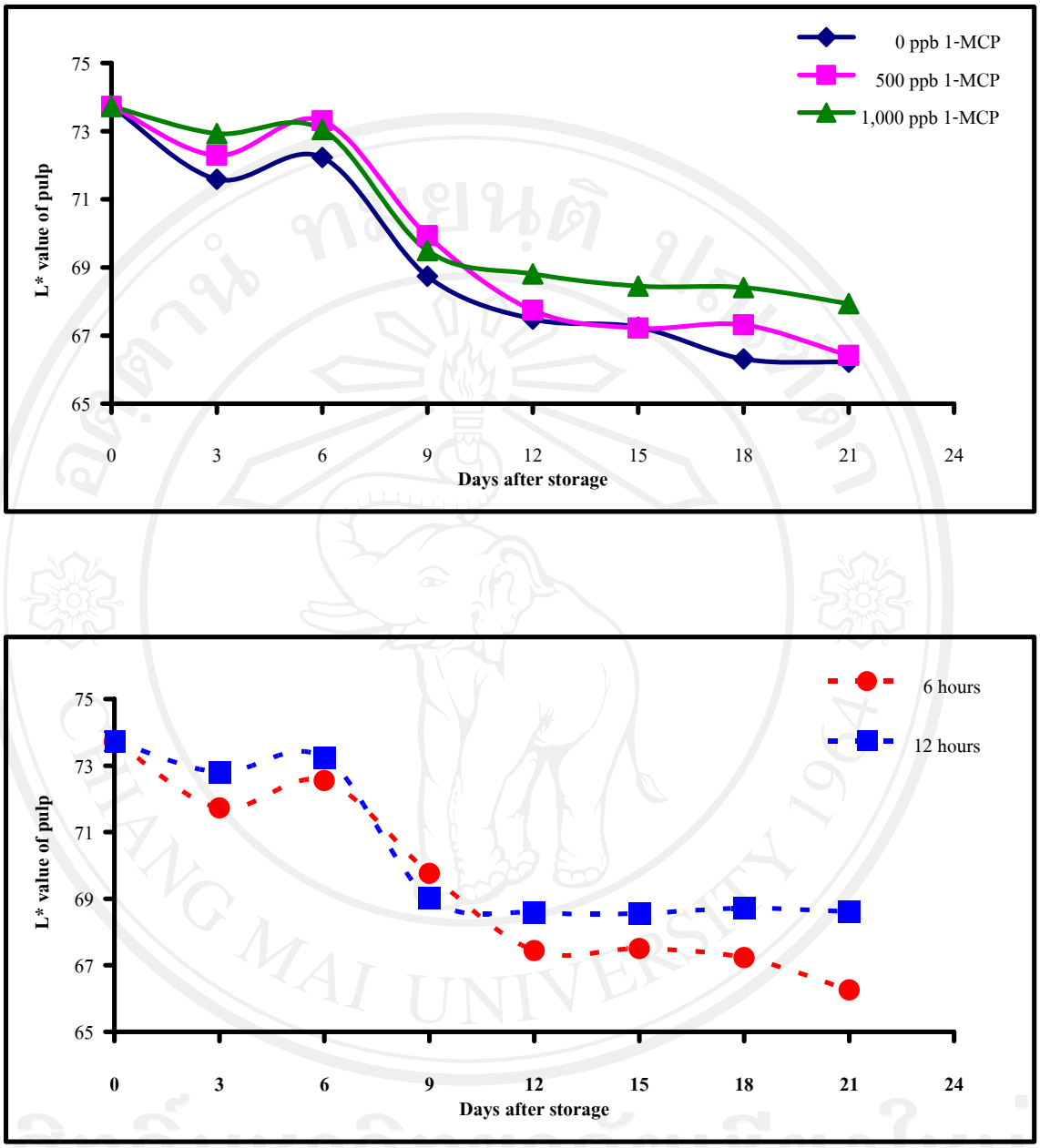
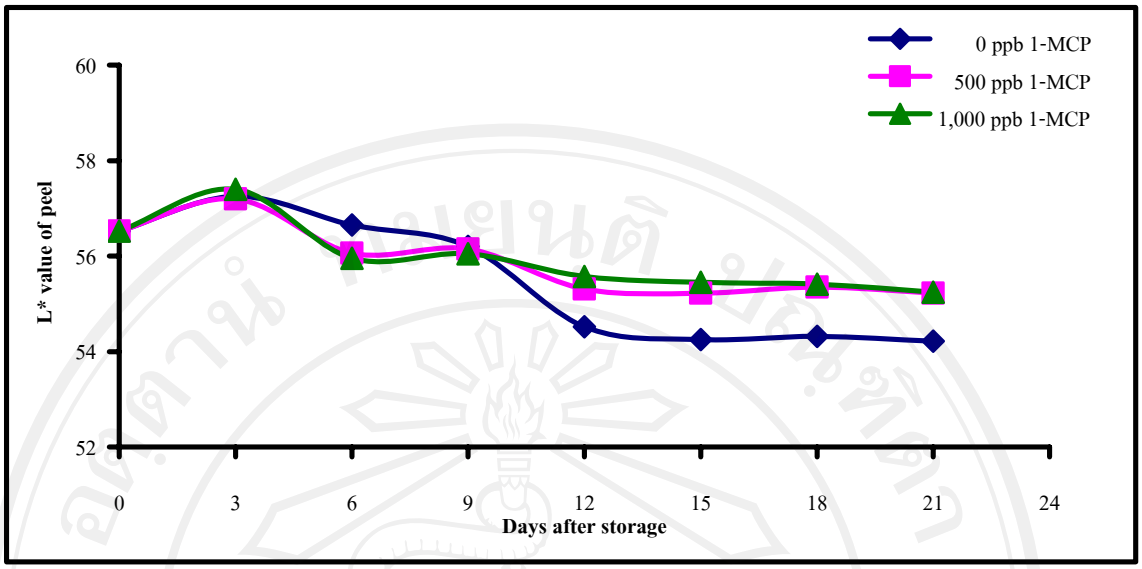


Figure 86 Changes in the L* value of 'Keaw Morakot' mango pulp treated with 1-MCP during storage at 13°C, 85-90%RH



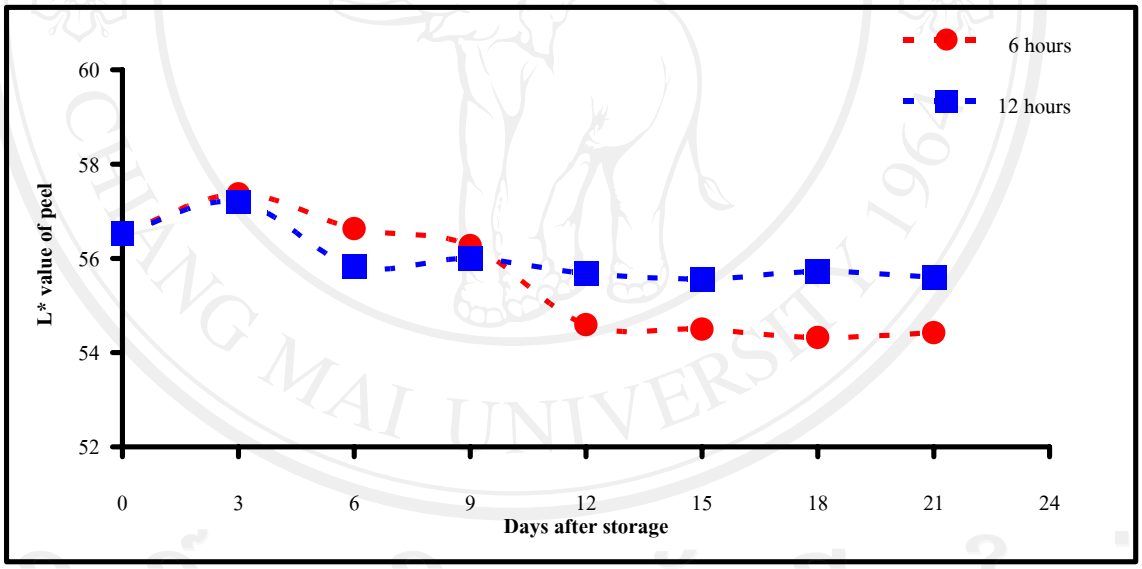


Figure 87 Changes in the L* value of 'Keaw Morakot' mango peel treated with 1-MCP during storage at 13°C, 85-90%RH

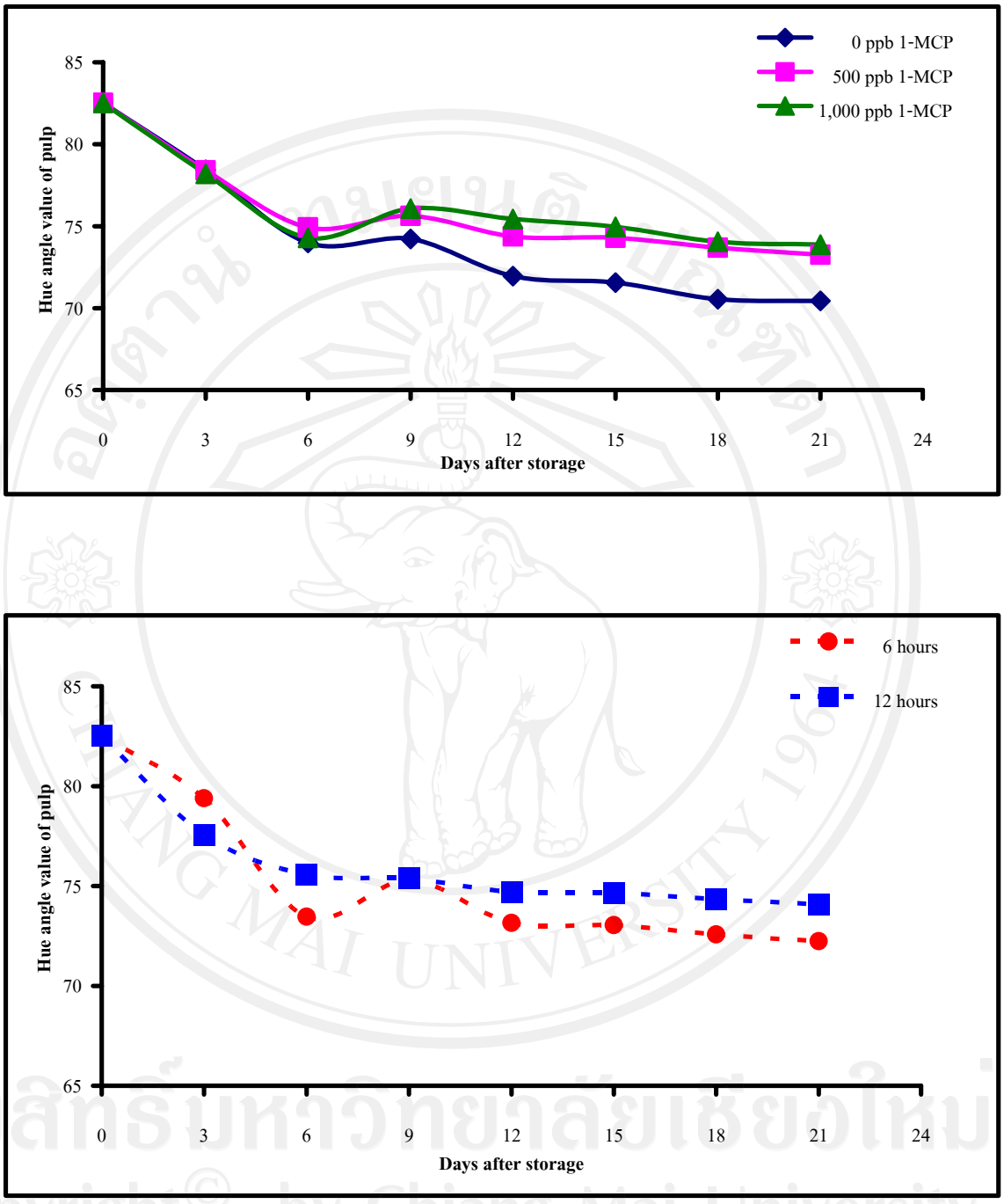


Figure 88 Changes in the ºH value of 'Keaw Morakot' mango pulp treated with 1-MCP during storage at 13°C, 85-90%RH

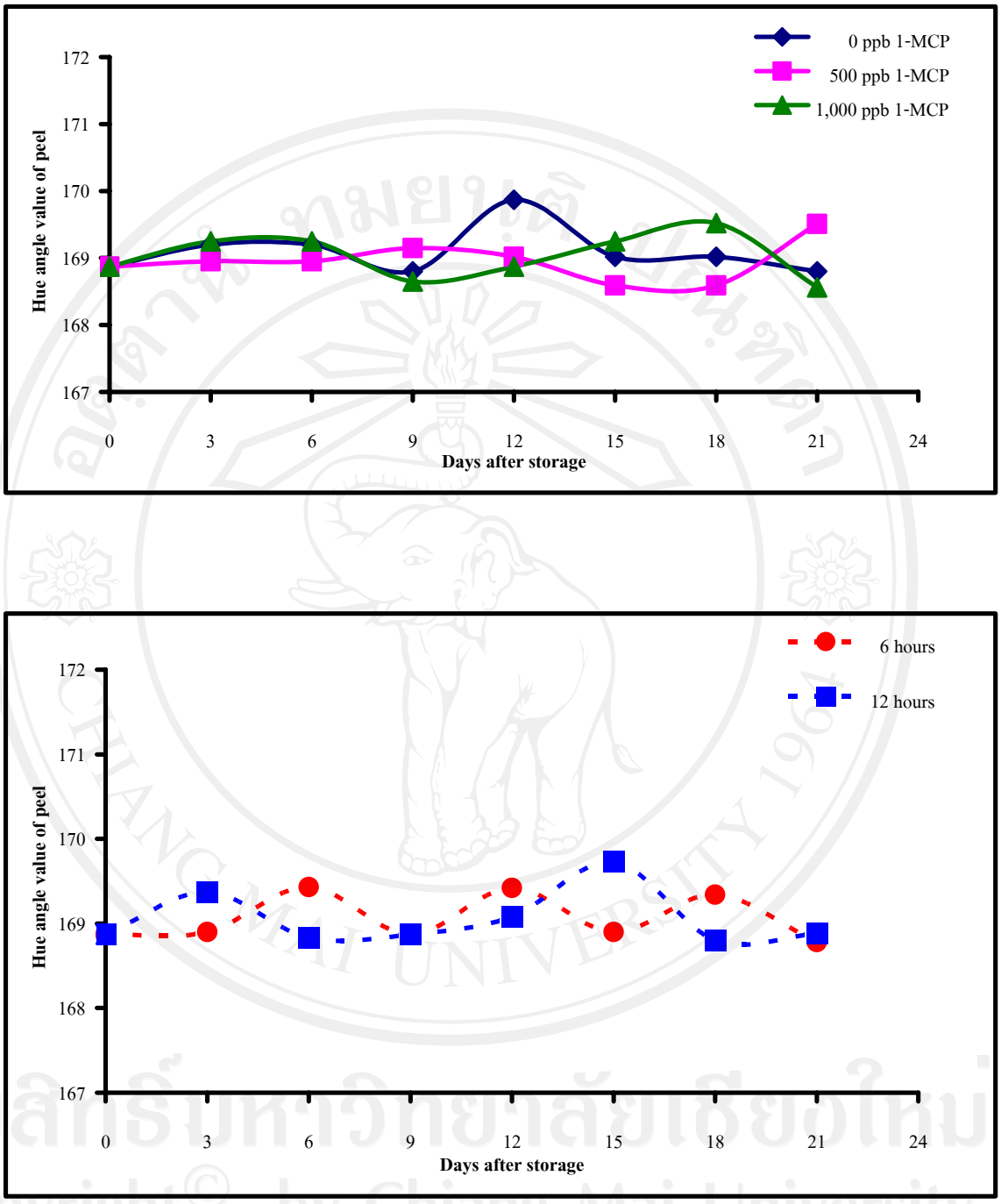


Figure 89 Changes in the ºH value of 'Keaw Morakot' mango peel treated with 1-MCP during storage at 13°C, 85-90%RH

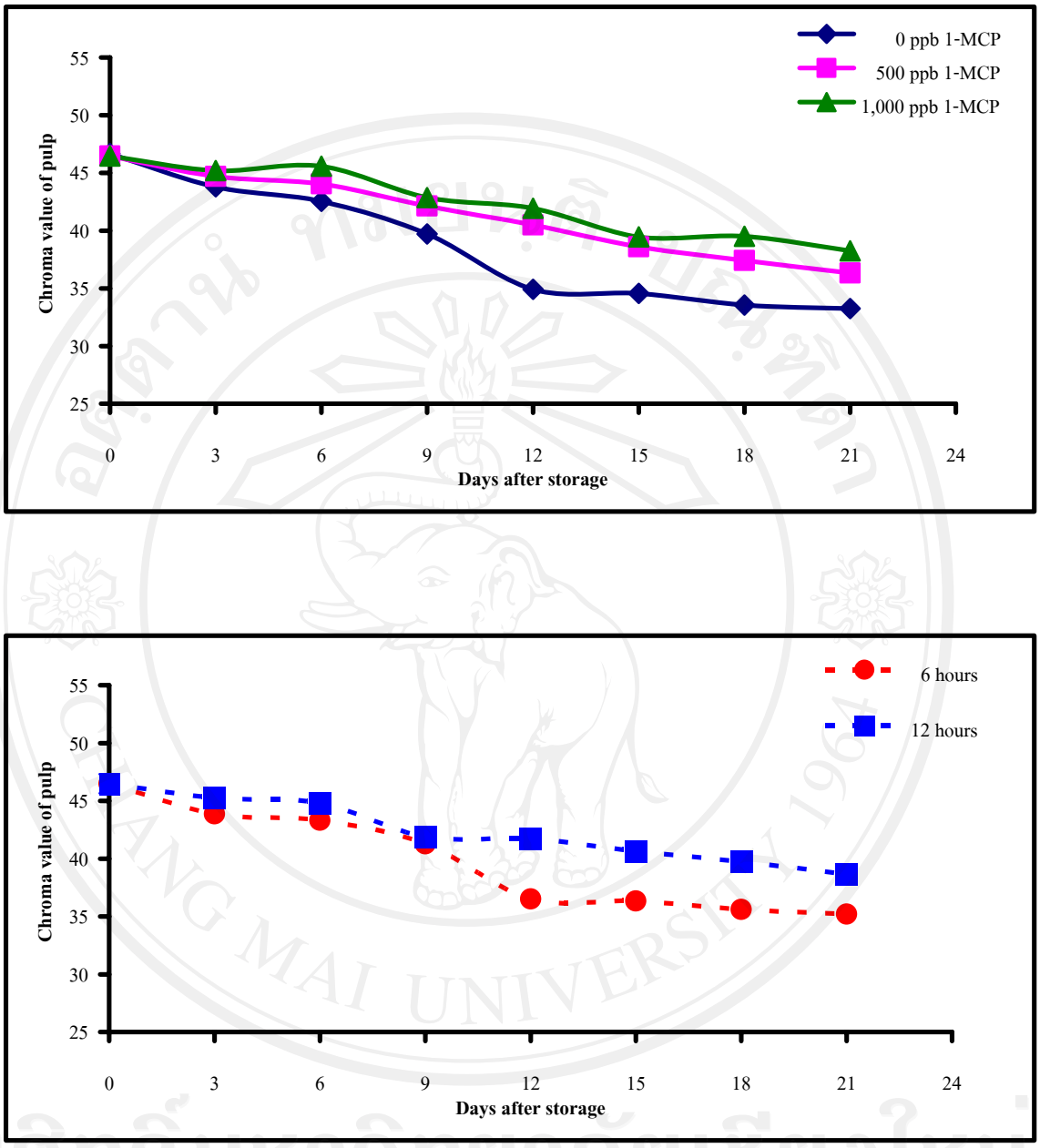


Figure 90 Changes in the chroma value of 'Keaw Morakot' mango pulp treated with 1-MCP during storage at 13°C, 85-90%RH

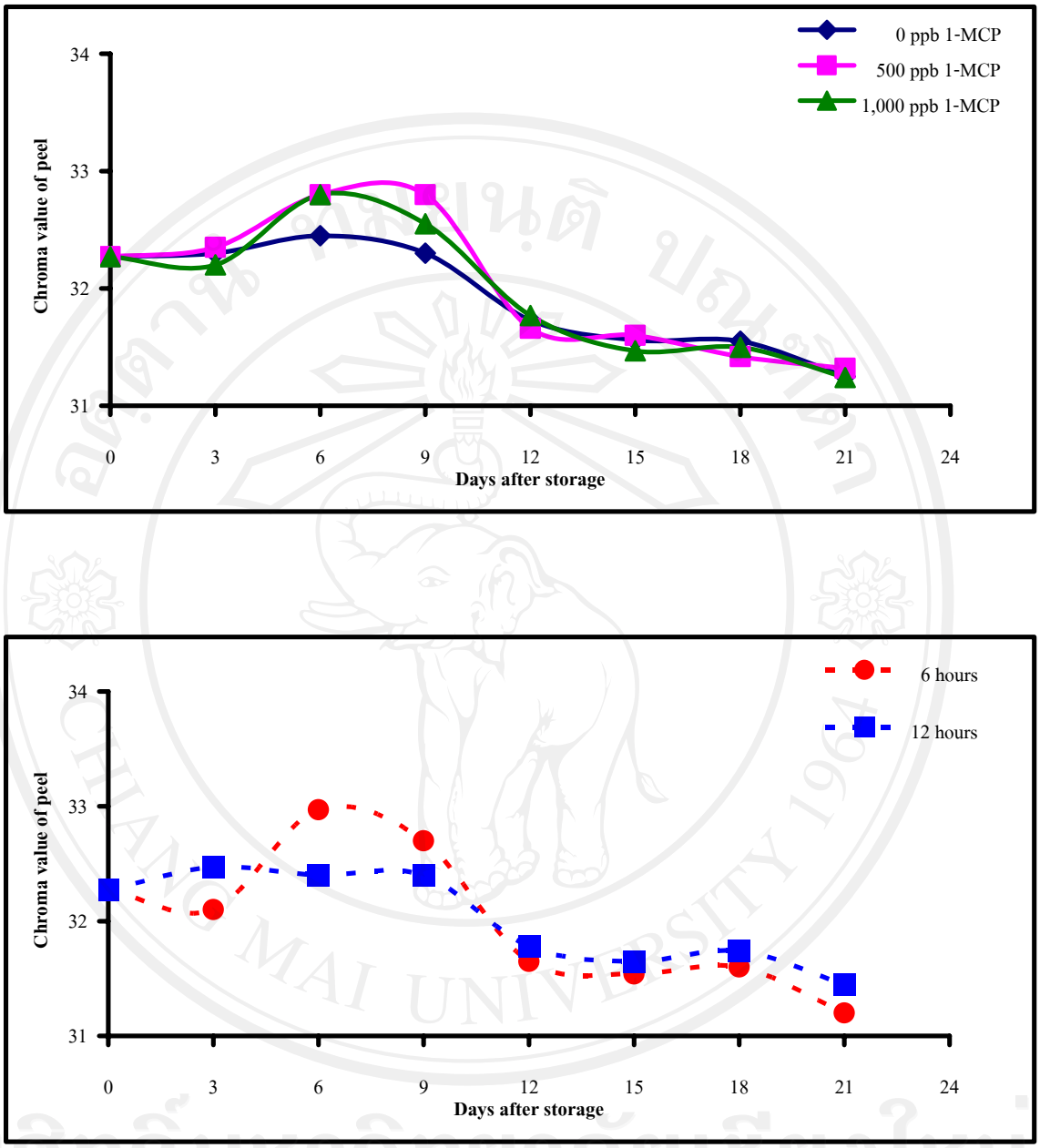


Figure 91 Changes in the chroma value of 'Keaw Morakot' mango peel treated with 1-MCP during storage at 13°C, 85-90%RH

TSS content

The TSS content of the harvested mango fruit was 8.65%. After storage for 12 days, the 1000 1-MCP treated fruit had lowest TSS content (10.05%) which differed with 0 and 500 nl/l 1-MCP (11.52 and 11.21%, respectively). Similarly, the TSS content of the fruit treated with 1-MCP for 12 hours (9.85%) differed with 6 hours (11.81%) (Table 27). The TSS of fruit tended to increase after 9 days of storage, as the 1000 1-MCP and 12 hours of exposure increased less than the other concentrations and 6 hours, respectively (Figure 92 and Appendix Table 89).

Glucose content

The glucose content of the harvested fruit was 0.46 g/100g FW. After storage for 12 days, the glucose contents of the fruit treated with different concentrations and exposure times of 1-MCP were not significantly different, being 0.52-0.54 and 0.53-0.54 g/100g FW, respectively (Table 27). The glucose content increased a little after 6 days of storage (Figure 93 and Appendix Table 90).

Fructose content

The fructose content of the harvested fruit was 2.22 g/100g FW. The fructose content of the 1000 nl/l 1-MCP treated fruit was lowest (2.38 g/100g FW) and significantly different with 0 nl/l 1-MCP (2.50 g/100g FW). Similarly, the fructose content of the 12 hours 1-MCP treated fruit was 2.23 g/100g FW, and significantly different with 6 hours which was 2.50 g/100g FW (Table 27). The 1000 nl/l 1-MCP and 12 hours of exposure delayed the increase of fructose content better than 0 nl/l 1-MCP and 6 hours, respectively (Figure 94 and Appendix Table 91).

Sucrose content

The sucrose content of the harvested fruit was 5.242 g/100g FW. 1-MCP treatments (500 and 1000 nl/l 1-MCP) could delay increase of the sucrose content better than untreated (0 nl/l). After storage for 12 days, the sucrose content of 1000 nl/l 1-MCP treated fruit was 6.241 g/100g FW, and differed with 0 nl/l 1-MCP treated fruit which was 7.422 g/100g FW. The sucrose content of the 12 hours 1-MCP treated fruit was 6.033 g/100g FW, significantly different with 6 hours which was 7.850 g/100g FW (Table 27). Using 1000 nl/l 1-MCP and 12 hours of exposure delayed the increase of sucrose content better than 0 nl/l 1-MCP and 6 hours of exposure, respectively (Figure 95 and Appendix Table 92).

Table 27 Effects of 1-MCP on TSS, glucose, fructose and sucrose contents of 'Keaw Morakot' mango fruit stored at 13˚C, 85-90% RH, for 0, 12 and 21 days

Treatments	TSS (%)	Glucose (g/100g FW)	Fructose (g/100g FW)	Sucrose (g/100g FW)
0 days	8.65	0.460	2.222	5.242
12 days				
0 nl/l 1-MCP	11.52[a]	0.542[ns]	2.495[a]	7.422[a]
500 nl/l 1-MCP	11.21[a]	0.532	2.432[ab]	6.956[ab]
1000 nl/l 1-MCP	10.05[b]	0.524	2.375[b]	6.241[b]
CV (%)	10.50	22.60	11.33	7.25
6 hours	11.81[x]	0.535[ns]	2.502[x]	7.850[x]
12 hours	9.85[y]	0.528	2.232[y]	6.033[y]
CV (%)	9.98	19.65	15.31	10.14

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

ns = non-significant

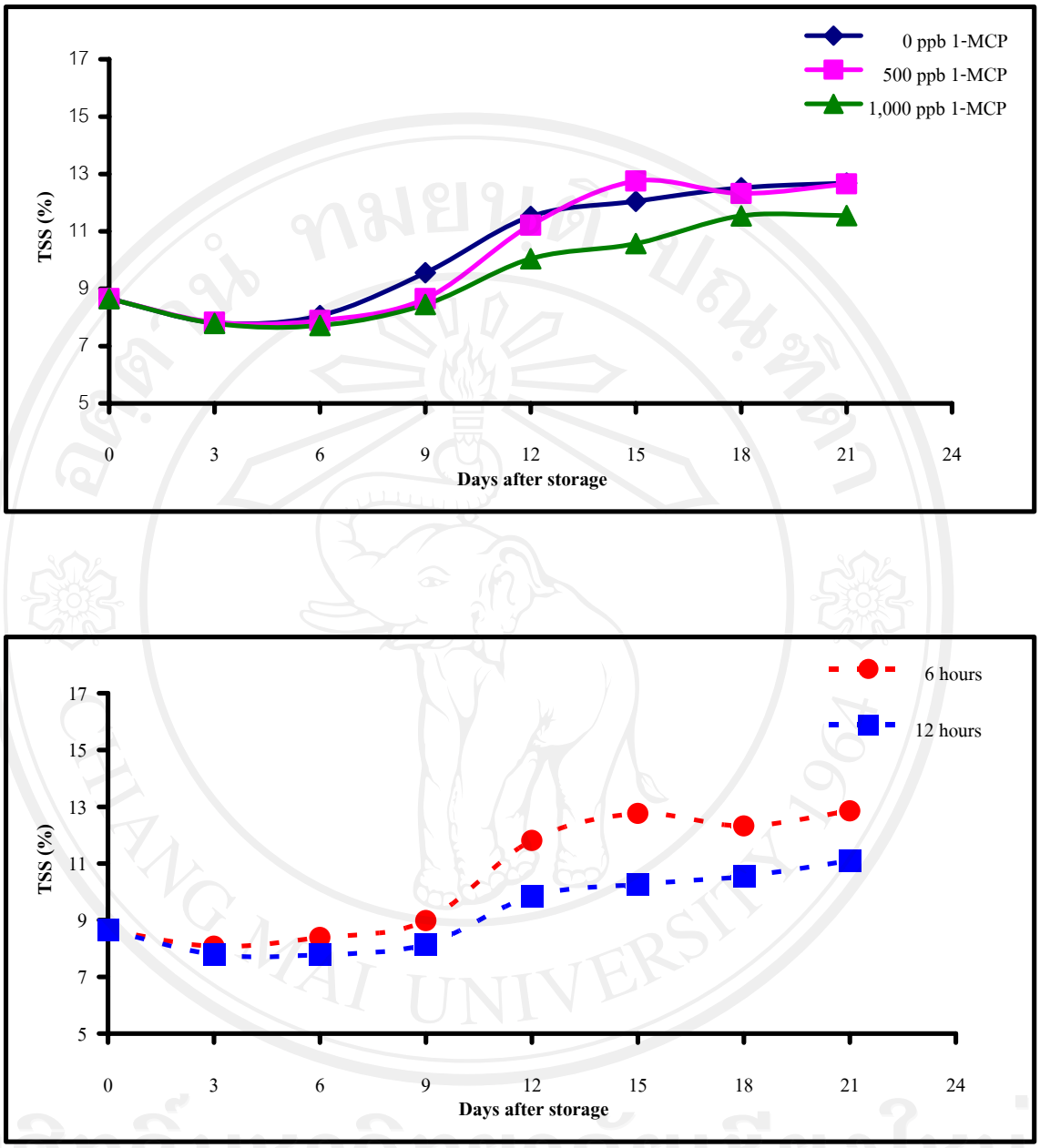


Figure 92 Changes in the TSS content of 'Keaw Morakot' mango fruit treated with 1-MCP during

storage at 13°C, 85-90% RH

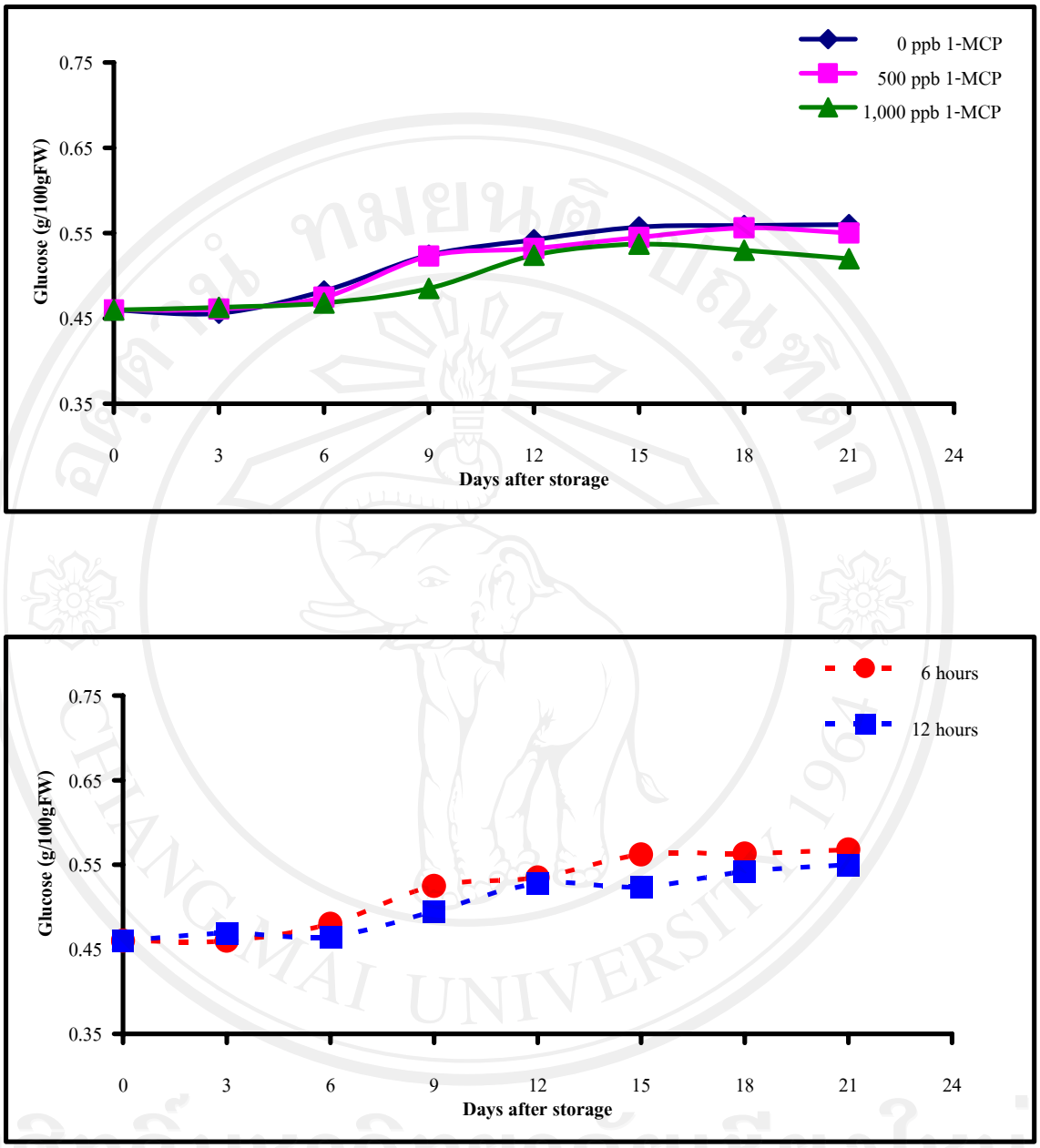


Figure 93 Changes in the glucose content of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

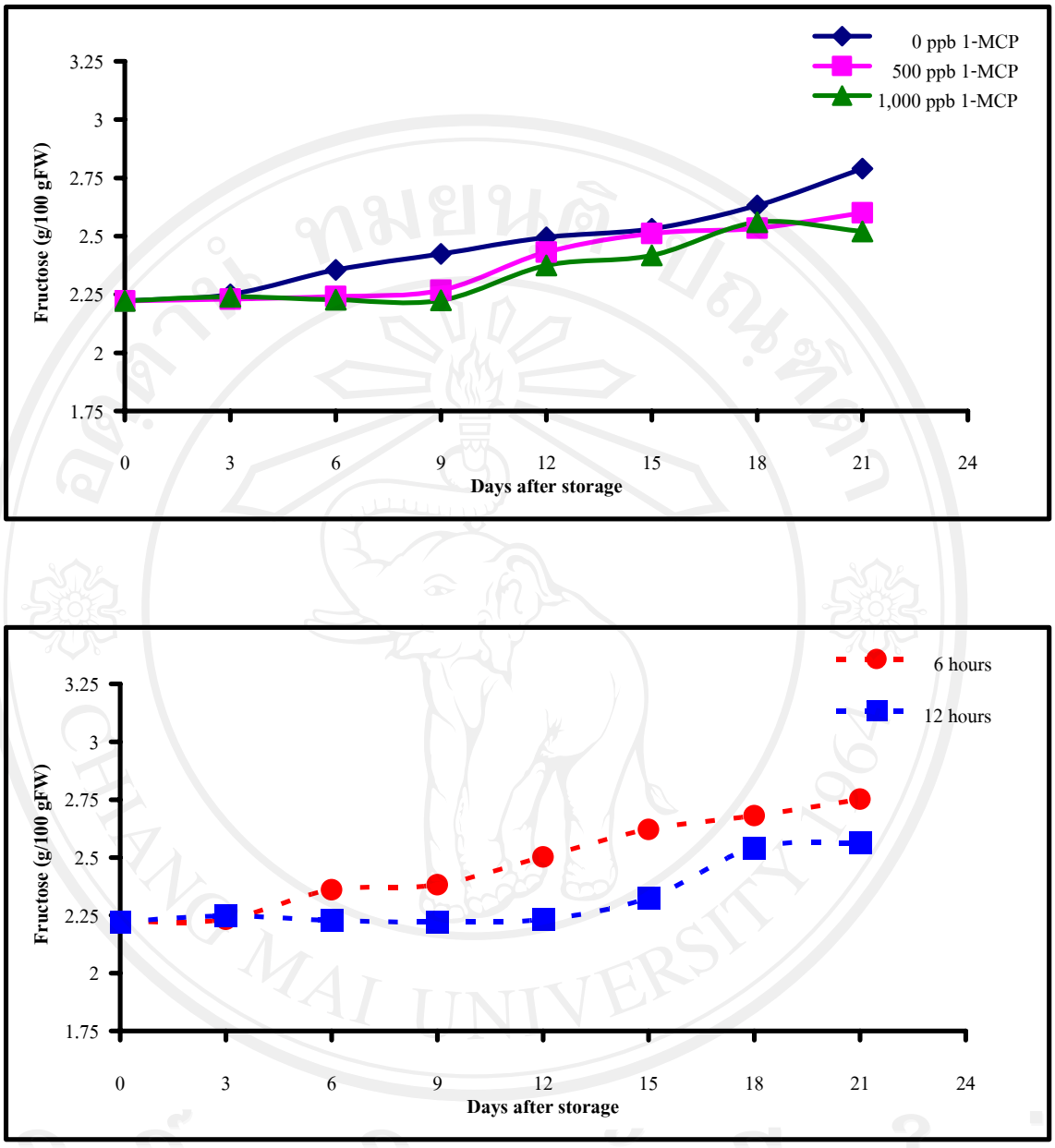


Figure 94 Changes in the fructose content of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

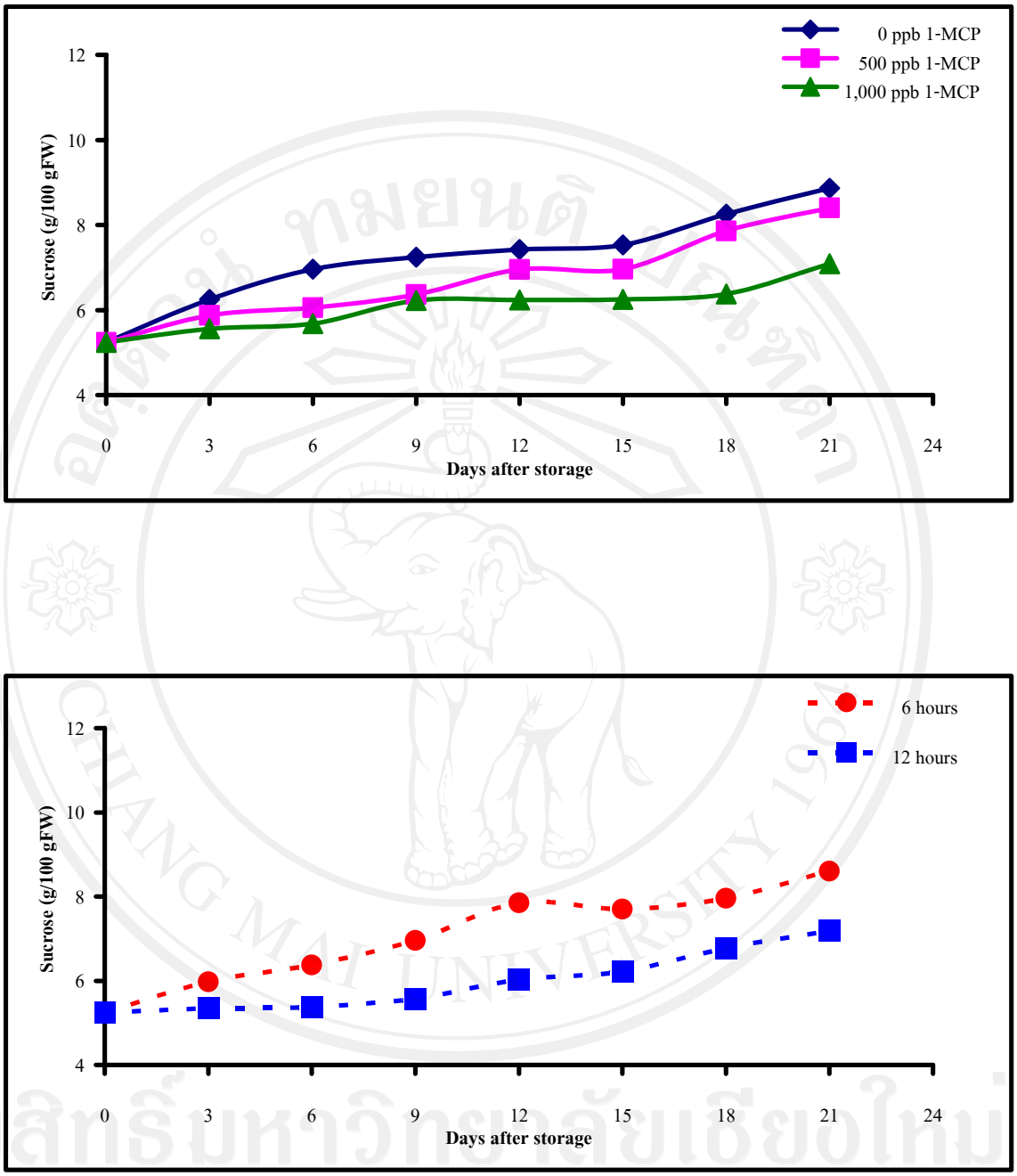


Figure 95 Changes in the sucrose content of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

pH value

The pH value of the mango fruit was 3.40 at harvest. After storage for 12 days, the 1000 1-MCP treated fruit had lowest pH (4.05) and differed with 500 and 0 nl/l 1-MCP (4.24 and 4.37, respectively) (Table 28). The pH increased during long-term storage, as the 1000 nl/l 1-MCP treated fruit tended to increase less than 500 and 0 nl/l 1-MCP, respectively (Figure 96 and Appendix Table 93). The pH of the 12 hours 1-MCP treated fruit (4.15) differed with 6 hours (4.45) (Table 28). The 12 hours of exposure time was better in delaying the pH increase than 6 hours (Figure 96 and Appendix Table 93).

TA content

The TA content of the harvested mango fruit was 0.92%. 1-MCP treatments (500 and 1000 nl/l 1-MCP) could delay reduction of the TA content better than untreated (0 nl/l). After storage for 12 days, the TA content of the 500 and 1000 nl/l 1-MCP treated fruit were 0.82 and 0.85%, respectively, and differed with 0 nl/l 1-MCP treated fruit which was 0.77%. The TA content of the 12 hours 1-MCP treated fruit were 0.88%, significantly different with 6 hours which was 0.79% (Table 28). The TA content decreased during long-term storage. The 1000 nl/l 1-MCP and 12 hours of exposure delayed the reduction of the TA content better than 500 and 0 nl/l and 6 hours, respectively (Figure 97 and Appendix Table 94).

Citric acid content

The citric acid content of the harvested fruit was 0.37 g/100g FW. 1-MCP treatments (500 and 1000 nl/l 1-MCP) could delay reduction of the citric acid content better than untreated (0 nl/l). After storage for 12 days, the citric acid content of the 500 and 1000 nl/l 1-MCP treated fruit were 0.30 and 0.31 g/100g FW, respectively, and differed with 0 nl/l 1-MCP treated fruit which was 0.28 g/100g FW. The 12 hours 1-MCP treated fruit was 0.31 g/100g FW, significantly different with 6 hours which was 0.30 g/100g FW (Table 28). The citric acid content decreased during storage. The 1000 nl/l 1-MCP and 12 hours of exposure delayed the reduction of citric acid content better than 0 nl/l 1-MCP and 6 hours, respectively (Figure 98 and Appendix Table 95).

Malic acid content

The malic acid content of the fruit was 0.31 g/100g FW at harvest. After storage for 12 days, the malic acid content of the fruit (0.25-0.26 g/100g FW) was not significantly different (Table 28). The malic acid content decreased after 6 days of storage. The 1000 nl/l 1-MCP and 12 hours of exposure time tended to delay the reduction of malic acid content better than the other concentrations and 6 hours, respectively (Figure 99 and Appendix Table 96).

Vitamin C content

At harvest, the vitamin C content of the fruit was 157.99 mg/100 ml. 1-MCP treatments (500 and 1000 nl/l 1-MCP) tended to delay the vitamin C content loss better than untreated (0 nl/l). After storage for 12 days, the vitamin C contents of 1000, 500 and 0 nl/l 1-MCP treated fruit were 150.24, 145.69 and 139.89 mg/100 ml, respectively. However, there was only the 1000 nl/l 1-MCP treated fruit differed with 0 nl/l 1-MCP treated fruit. The 12 hours 1-MCP treated fruit was 148.50 mg/100 ml, significantly different with 6 hours which was 142.33 mg/100 ml (Table 28). The 1000 nl/l 1-MCP and 12 hours of exposure delayed the reduction of vitamin C content better than 0 nl/l 1-MCP and 6 hours, respectively (Figure 100 and Appendix Table 97).

Table 28 Effects of 1-MCP on pH value, titrable acid, citric acid, malic acid and vitamin C contents of 'Keaw Morakot' mango fruit stored at 13˚C, 85-90% RH, for 0 and 12 days

Treatments	pH	TA (% as citric acid)	Citric acid (g/100g FW)	Malic acid (g/100g FW)	Vitamin C (mg/100 ml)
0 days	3.40	0.92	0.37	0.31	157.99
12 days					
0 nl/l 1-MCP	4.37^{a}	0.77^{b}	0.28^{b}	0.25^{ns}	139.89^{b}
500 nl/l 1-MCP	4.24^{b}	0.82^{a}	0.30^{a}	0.26	145.69^{ab}
1000 nl/l 1-MCP	4.05^{c}	0.85^{a}	0.31^{a}	0.26	150.24^{a}
CV (%)	0.47	14.07	10.42	17.60	10.03
6 hours	4.45^{x}	0.79^{y}	0.30^{y}	0.26^{ns}	142.33^{y}
12 hours	4.15^{y}	0.88^{x}	0.31^{x}	0.26	148.50^{x}
CV (%)	1.98	7.63	15.33	16.89	5.92

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

ns = non-significant

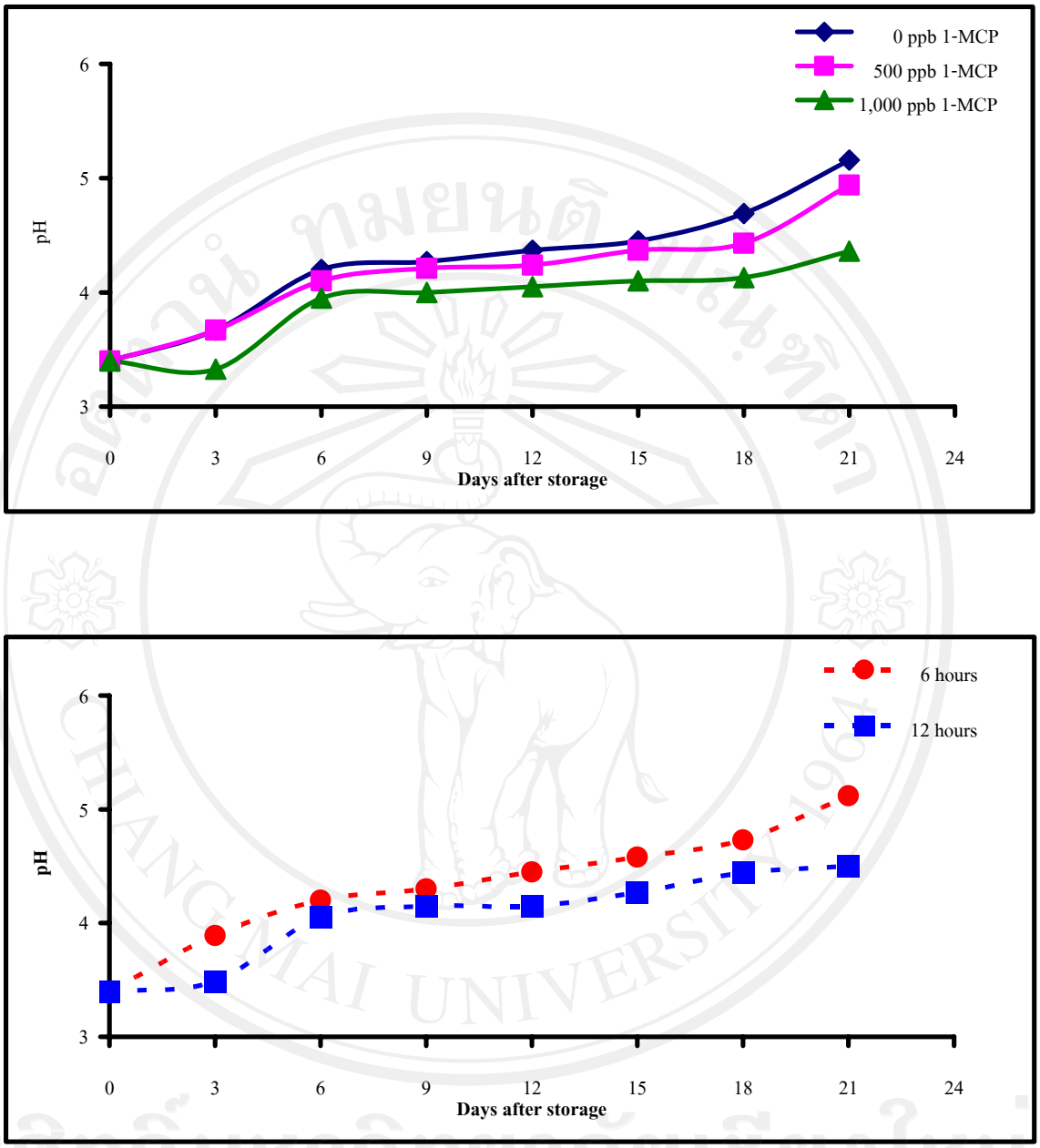


Figure 96 Changes in the pH value of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

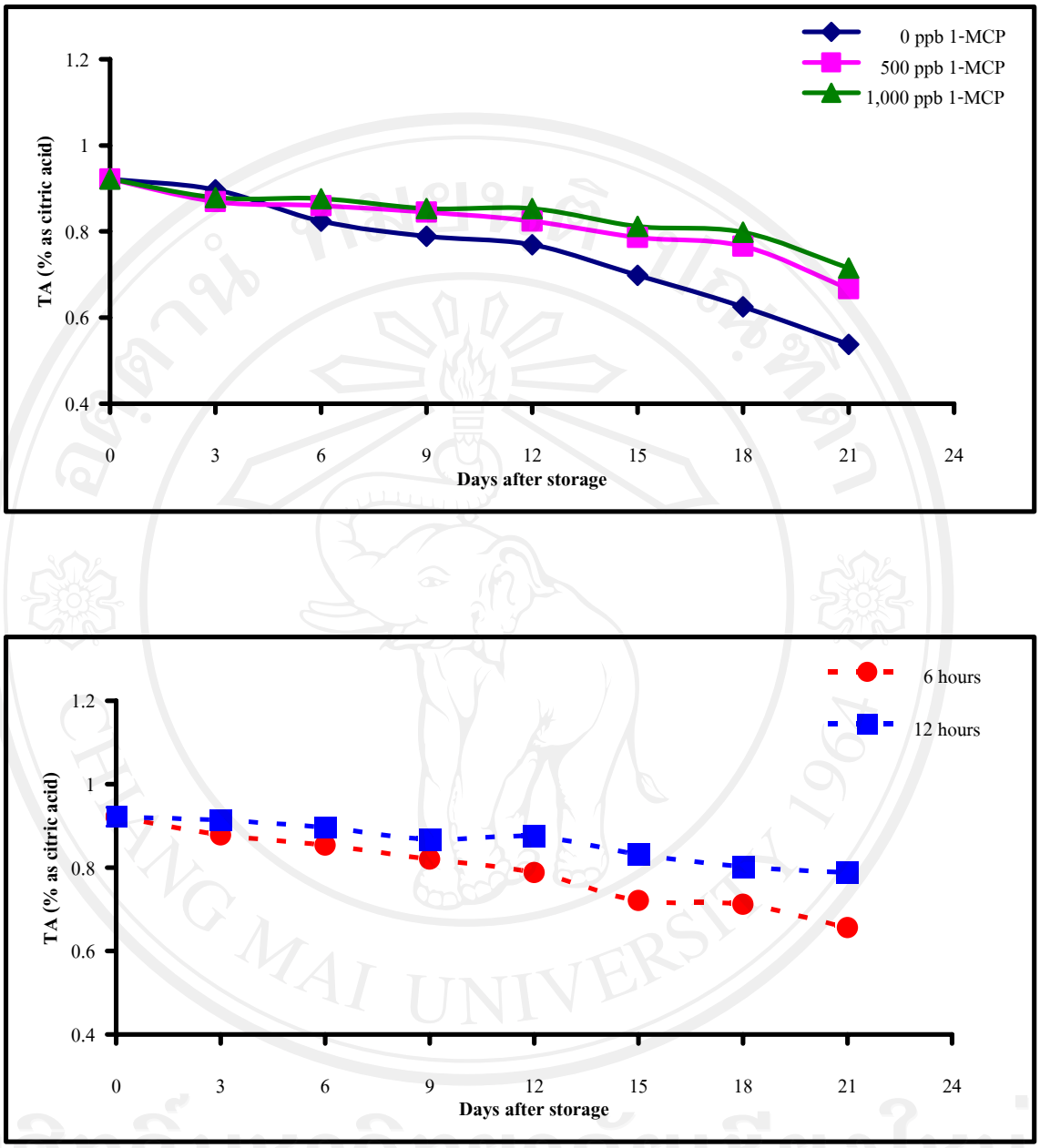


Figure 97 Changes in the TA content of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

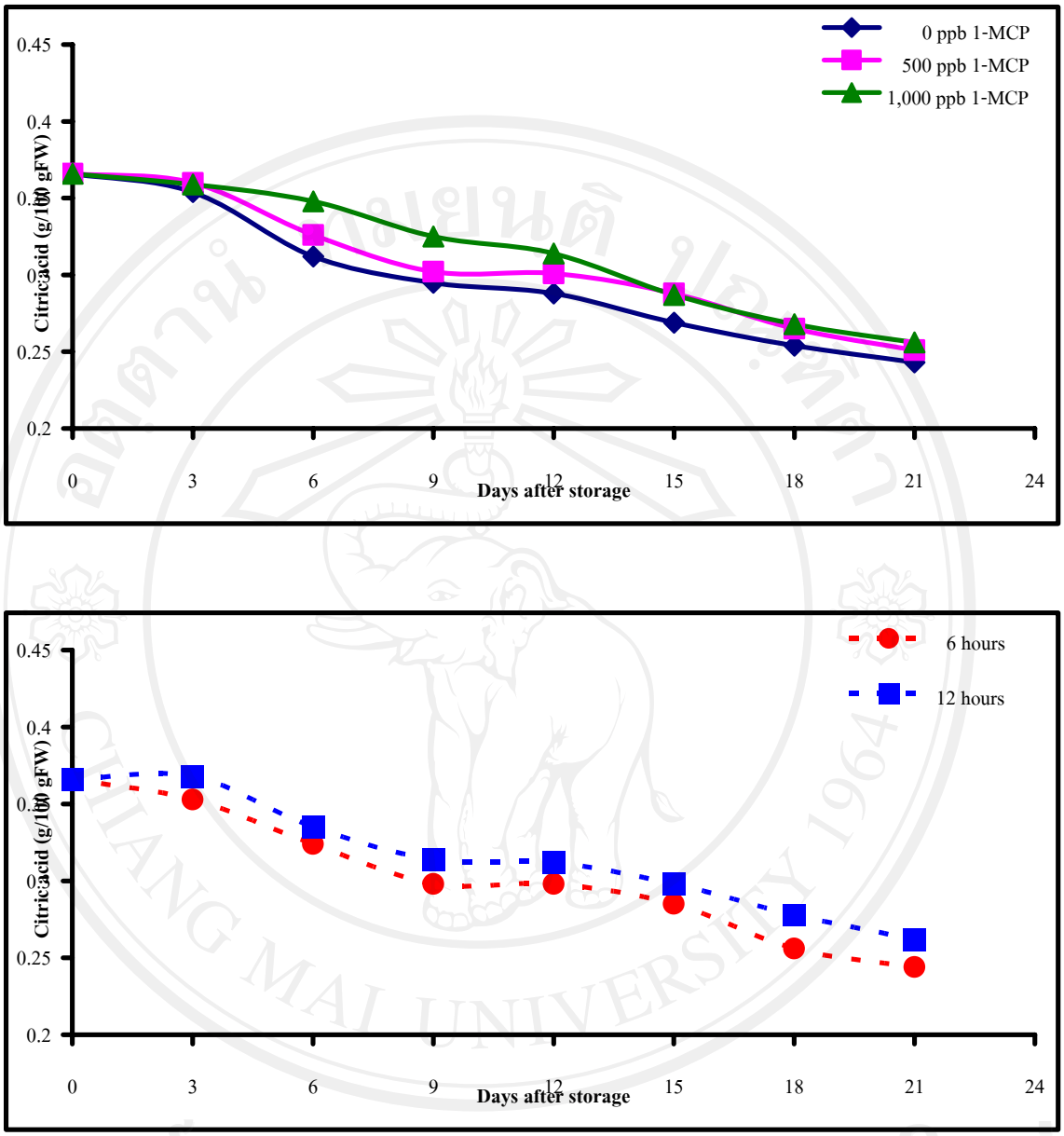
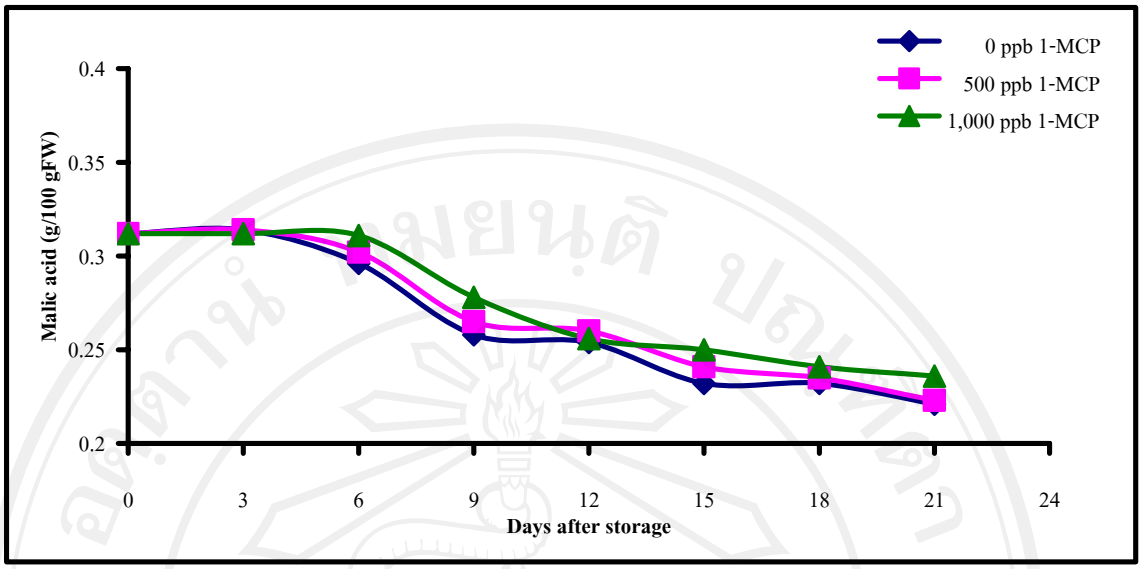


Figure 98 Changes in the citric acid content of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH



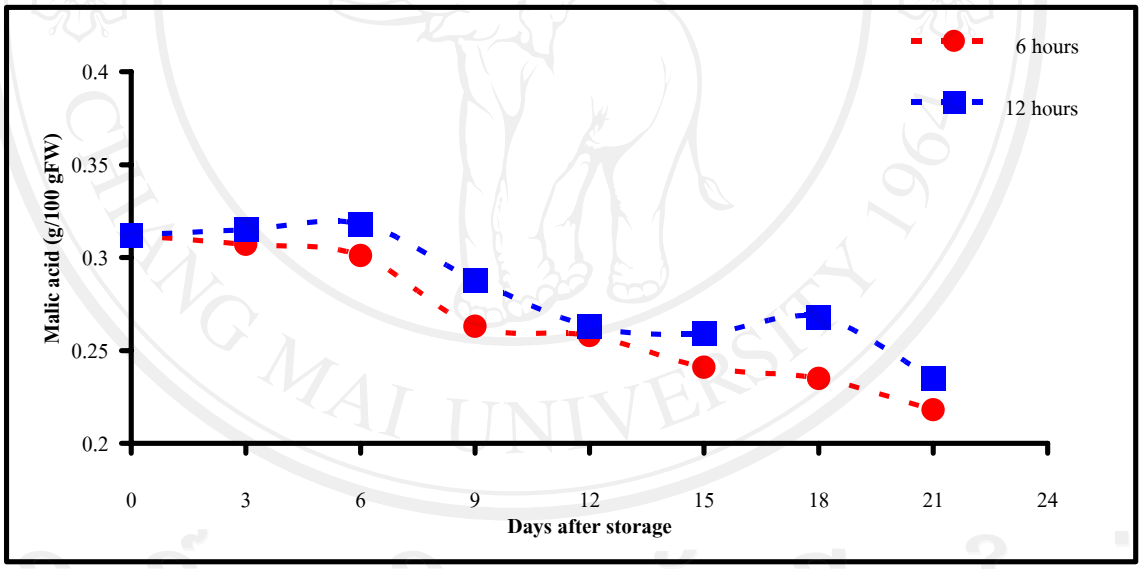


Figure 99 Changes in the malic acid content of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

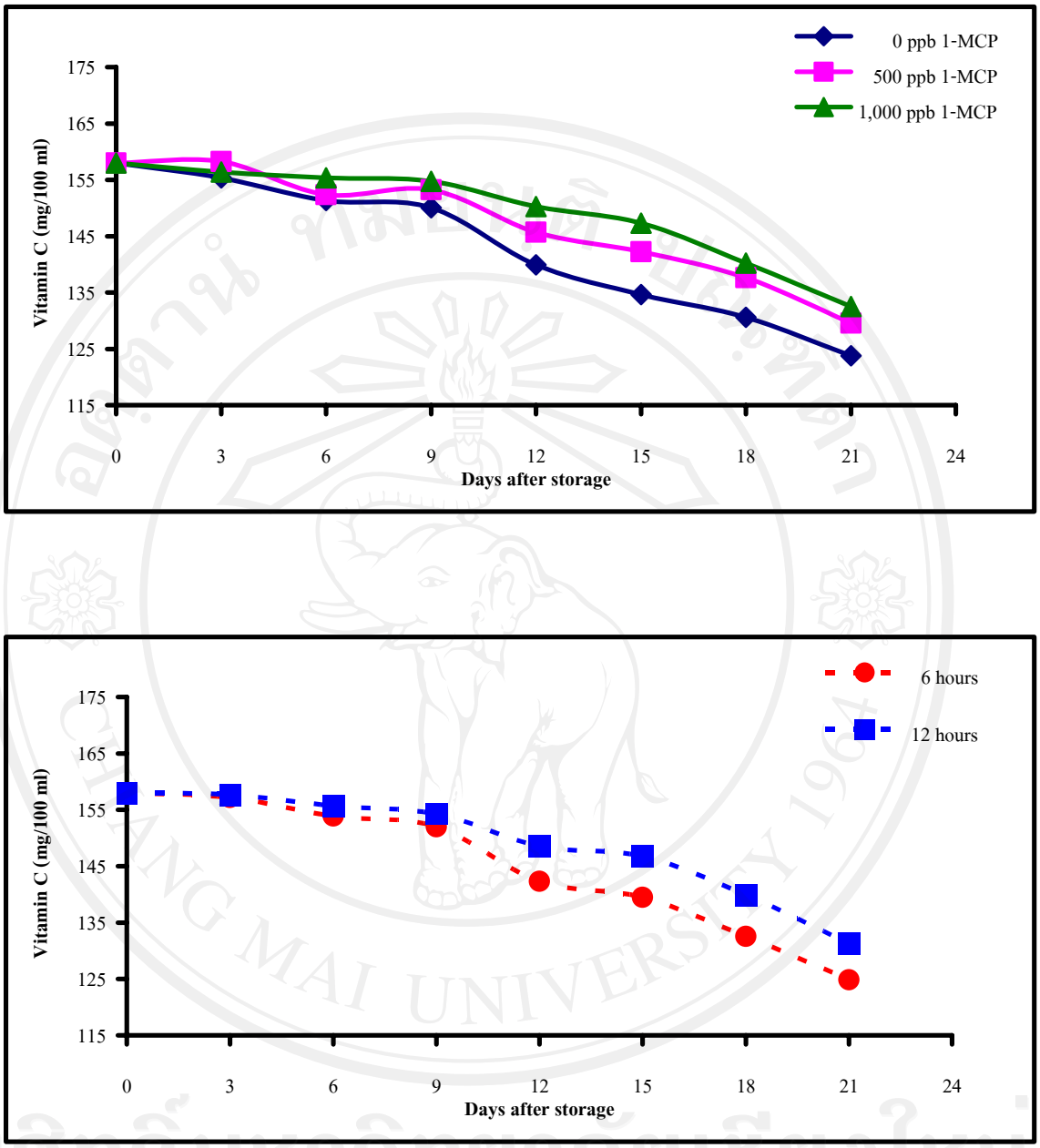


Figure 100 Changes in the vitamin C content of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

Dry matter content

The dry matter of the harvested fruit was 24.06%. After storage for 12 days, the dry matter of the fruit (23.99-24.82%) had no significant differences (Table 29). The dry matter increased a little during 0-9 days of storage but after that it decreased. However, the 1000 nl/l 1-MCP and 12 hours of exposure tended to have effectiveness in delaying the reduction of dry matter comparing with the other concentrations and 6 hours, respectively (Figure 101 and Appendix Table 98).

Starch content

At harvest, the starch content of the fruit was 6.22%. After storage for 12 days, the 1000 nl/l 1-MCP treated fruit had the highest content (5.63%), significantly different with 500 and 0 nl/l 1-MCP (5.37 and 5.41%, respectively). The starch content of the 12 hours 1-MCP treated fruit was 5.91%, significantly different with 6 hours which was 5.38% (Table 29). The 1000 nl/l 1-MCP and 12 hours of exposure delayed the reduction of starch content better than 500 and 0 nl/l 1-MCP and 6 hours, respectively (Figure 102 and Appendix Table 99).

Chlorophylls content of peel

The total chlorophyll, chlorophyll a and b contents of the harvested fruit peel were 2.07, 1.33 and 0.74 mg/g FW, respectively. After storage for 12 days, the chlorophylls had no significant differences. (Table 29, Appendix Table 100-102). The total chlorophyll and chlorophyll a tended to decrease during 0-15 days of storage. The 1000 nl/l 1-MCP and 12 hours of exposure had lower decrease of total chlorophyll and chlorophyll a than 0 and 500 nl/l 1-MCP and 6 hours, respectively (Figure 103-104, Appendix Table 100-101). The chlorophyll b decreased during storage (Figure105, Appendix Table 102).

β-carotene content of pulp

The β-carotene content of the fruit pulp was 0.12 mg% at harvest. After storage for 12 days, the 1000 nl/l 1-MCP treated fruit had the lowest content (0.34 mg%), significantly different with 0 and 500 nl/l 1-MCP (0.44 and 0.43 mg%, respectively). The β-carotene content of the 12 hours 1-MCP treated fruit was 0.35 mg%, significantly different with 6 hours which was 0.47 mg% (Table 29). The β-carotene content of the 1000 nl/l 1-MCP and 12 hours of exposure had lower increase than 0 and 500 nl/l 1-MCP and 6 hours, respectively (Figure 106 and Appendix Table 103).

Table 29 Effects of 1-MCP on dry matter, starch, chlorophylls and β-carotene contents of 'Keaw Morakot' mango fruit stored at 13˚C, 85-90% RH, for 0 and 12 days

Treatments	Dry matter (%)	Starch (%)	Chlorophylls (mg/g FW)			β-carotene (mg%)
			total	a	b	
0 days	24.06	6.22	2.07	1.33	0.74	0.12
12 days						
0 nl/l 1-MCP	23.99^{ns}	5.41^{b}	1.25^{ns}	0.85^{ns}	0.40^{ns}	0.44^{a}
500 nl/l 1-MCP	24.82	5.37^{b}	1.39	0.98	0.41	0.43^{a}
1000 nl/l 1-MCP	24.01	5.63^{a}	1.47	1.02	0.45	0.34^{b}
CV (%)	12.35	8.75	4.02	2.08	1.42	4.66
6 hours	24.01^{ns}	5.38^{y}	1.39^{ns}	0.95^{ns}	0.39^{ns}	0.47^{x}
12 hours	24.75	5.91^{x}	1.48	1.03	0.45	0.35^{y}
CV (%)	16.25	9.28	3.65	1.98	1.98	5.98

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

ns = non-significant

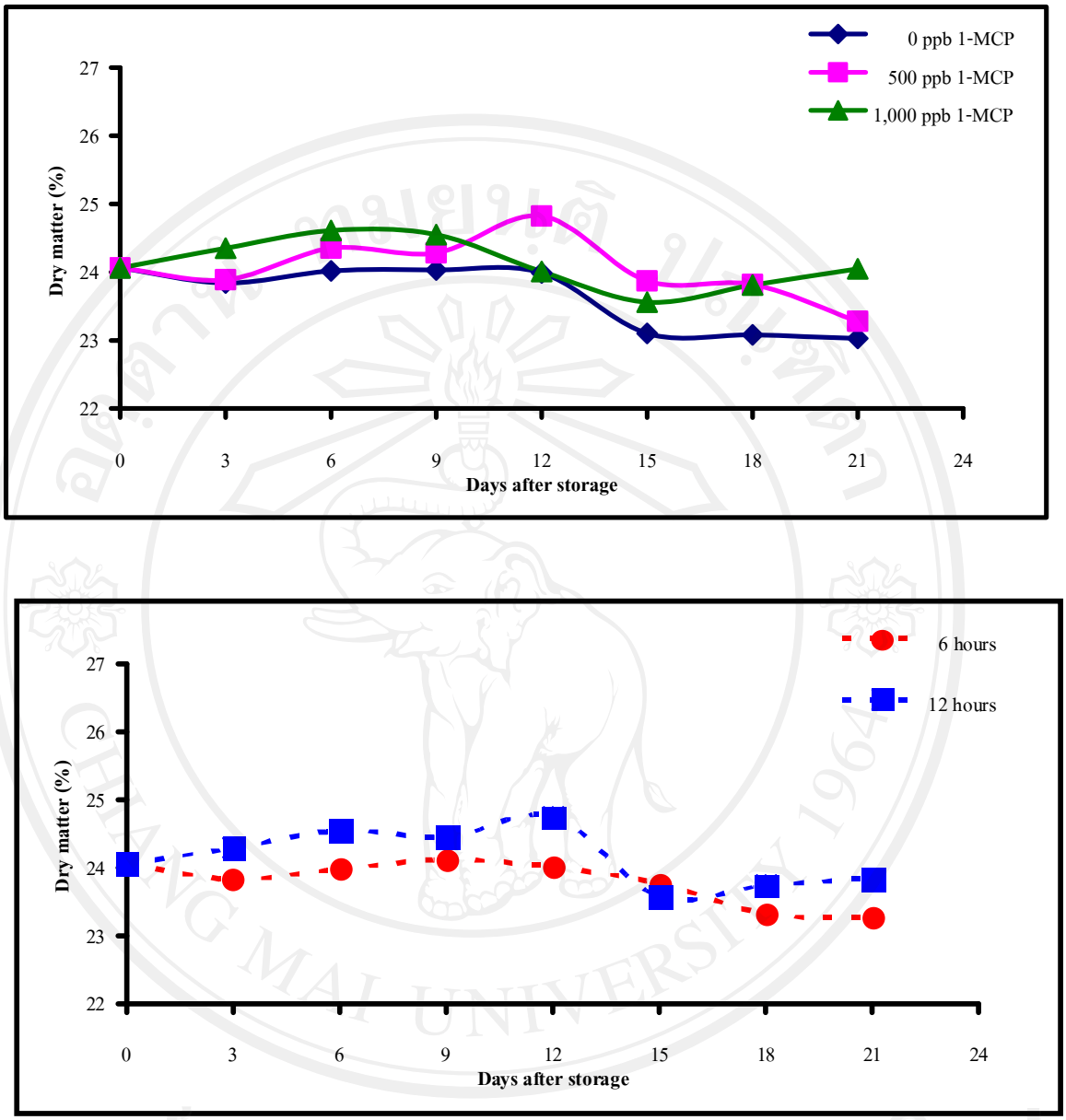


Figure 101 Changes in the dry matter content of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

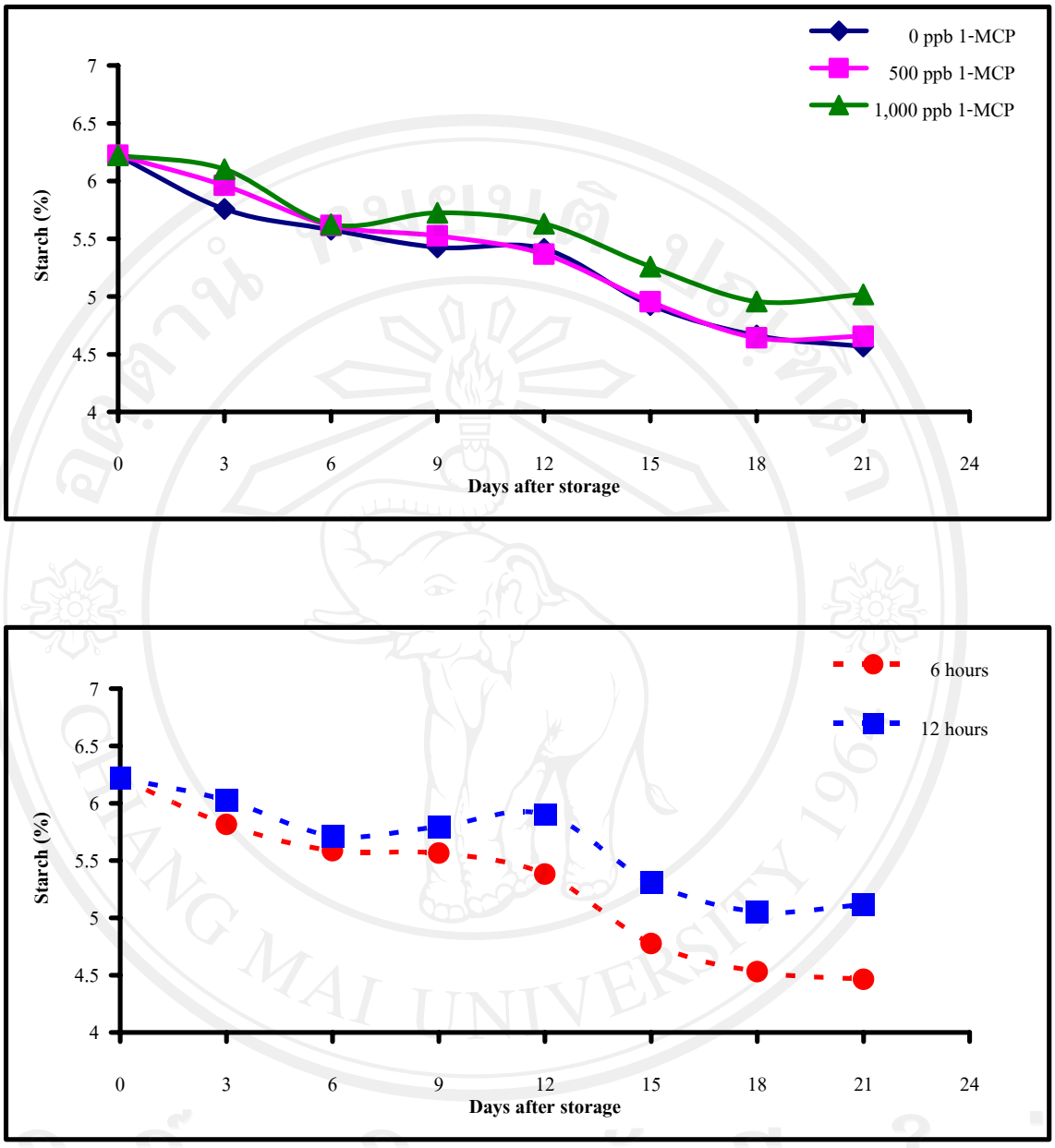


Figure 102 Changes in the starch content of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

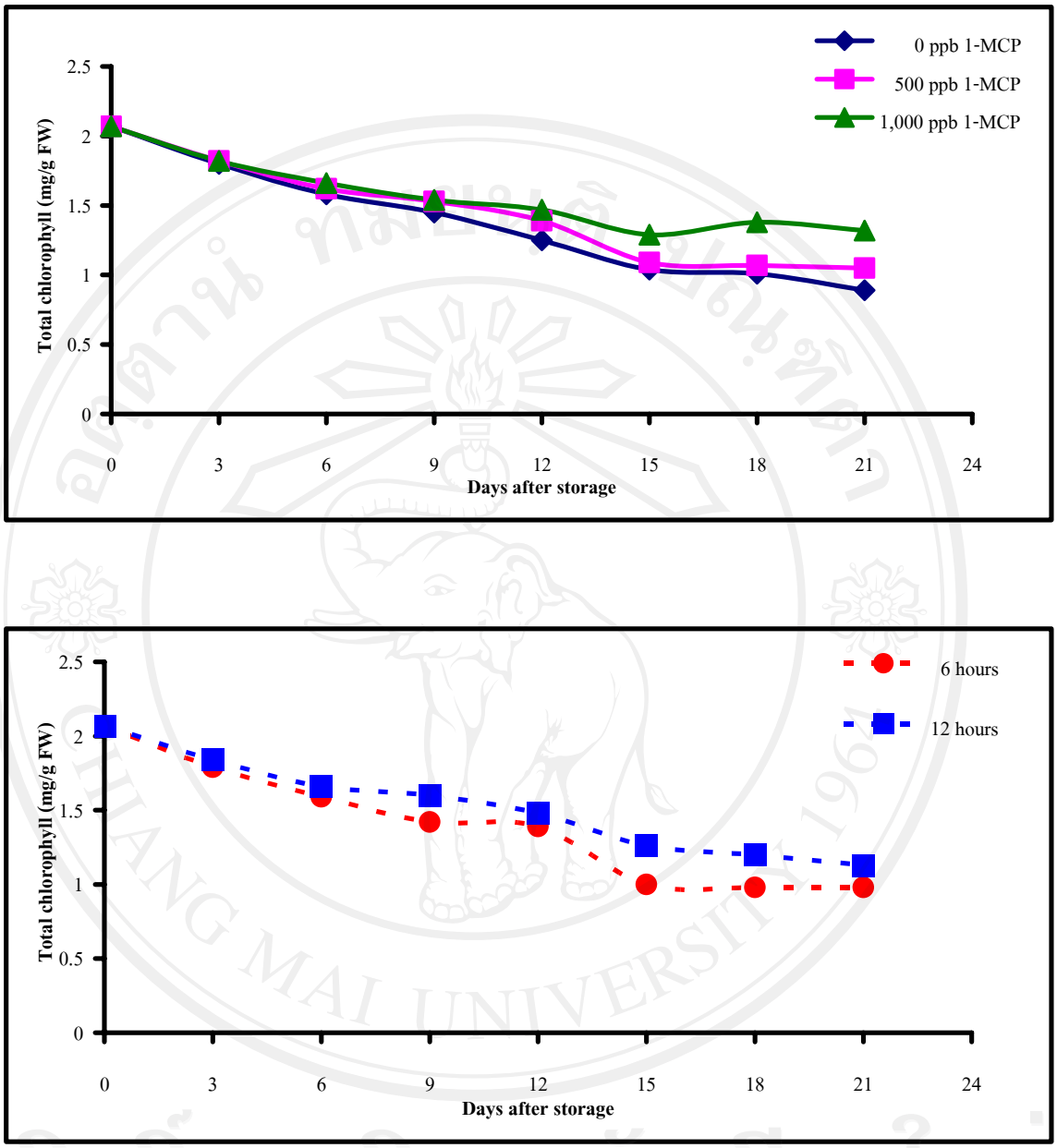


Figure 103 Changes in the total chlorophyll content of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

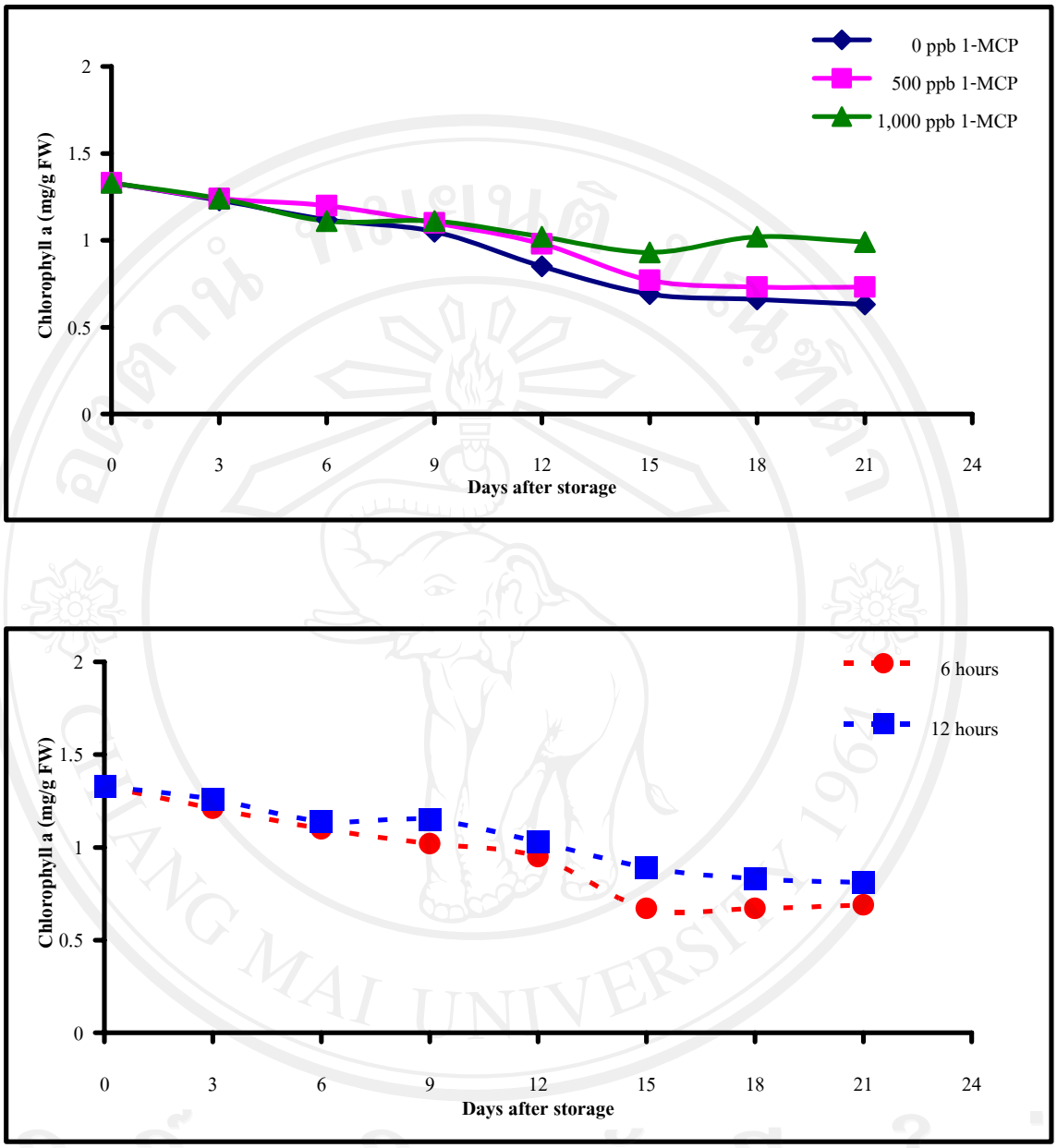
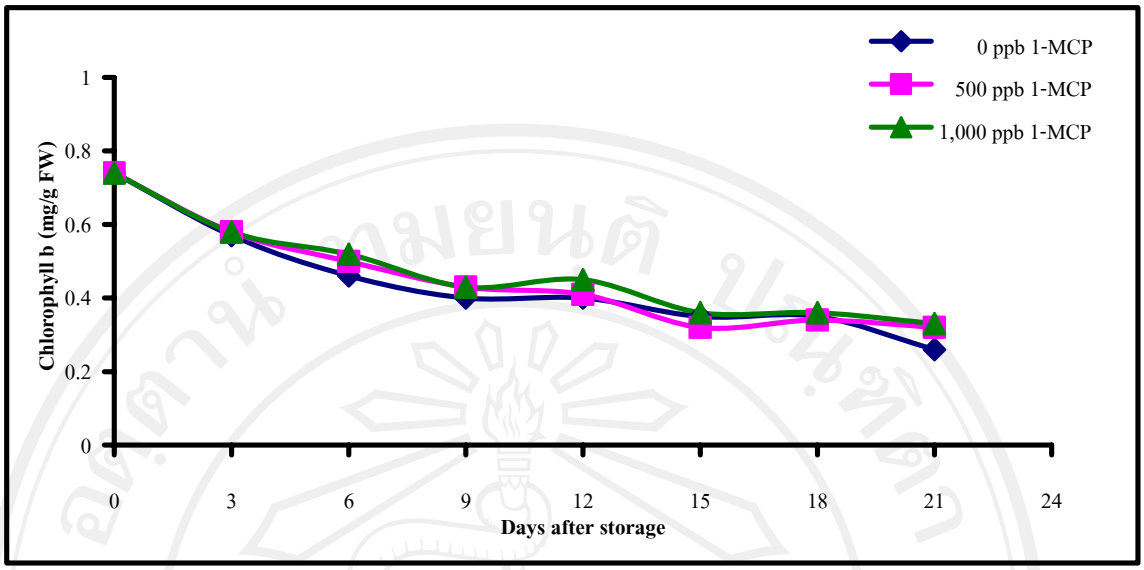


Figure 104 Changes in the chlorophyll a content of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH



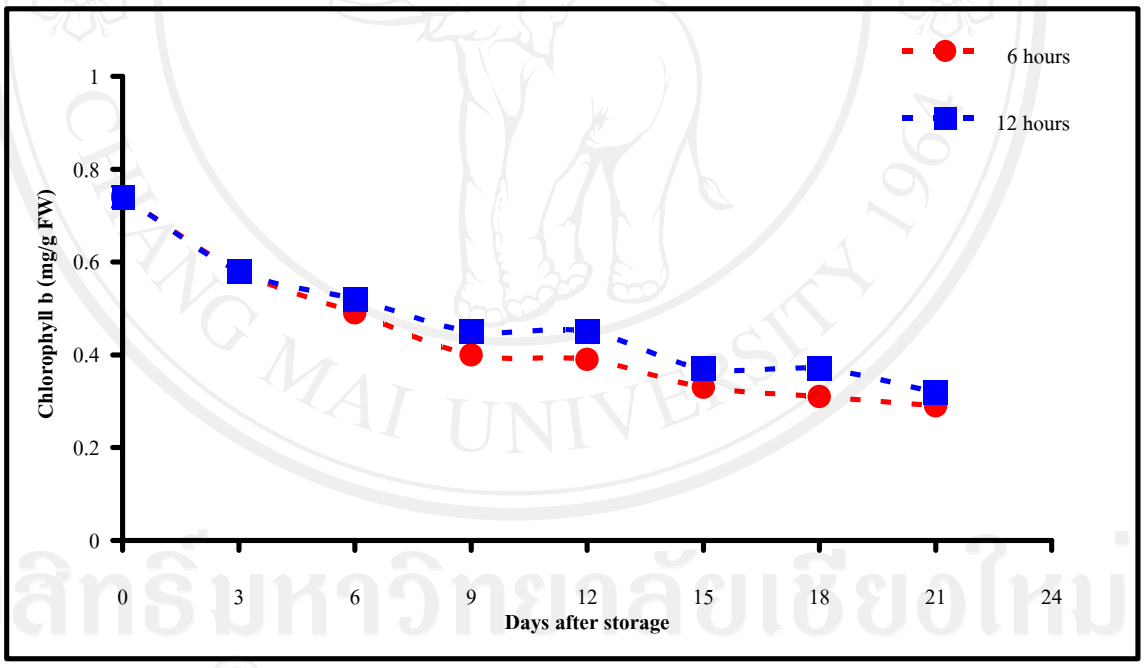


Figure 105 Changes in the chlorophyll b content of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

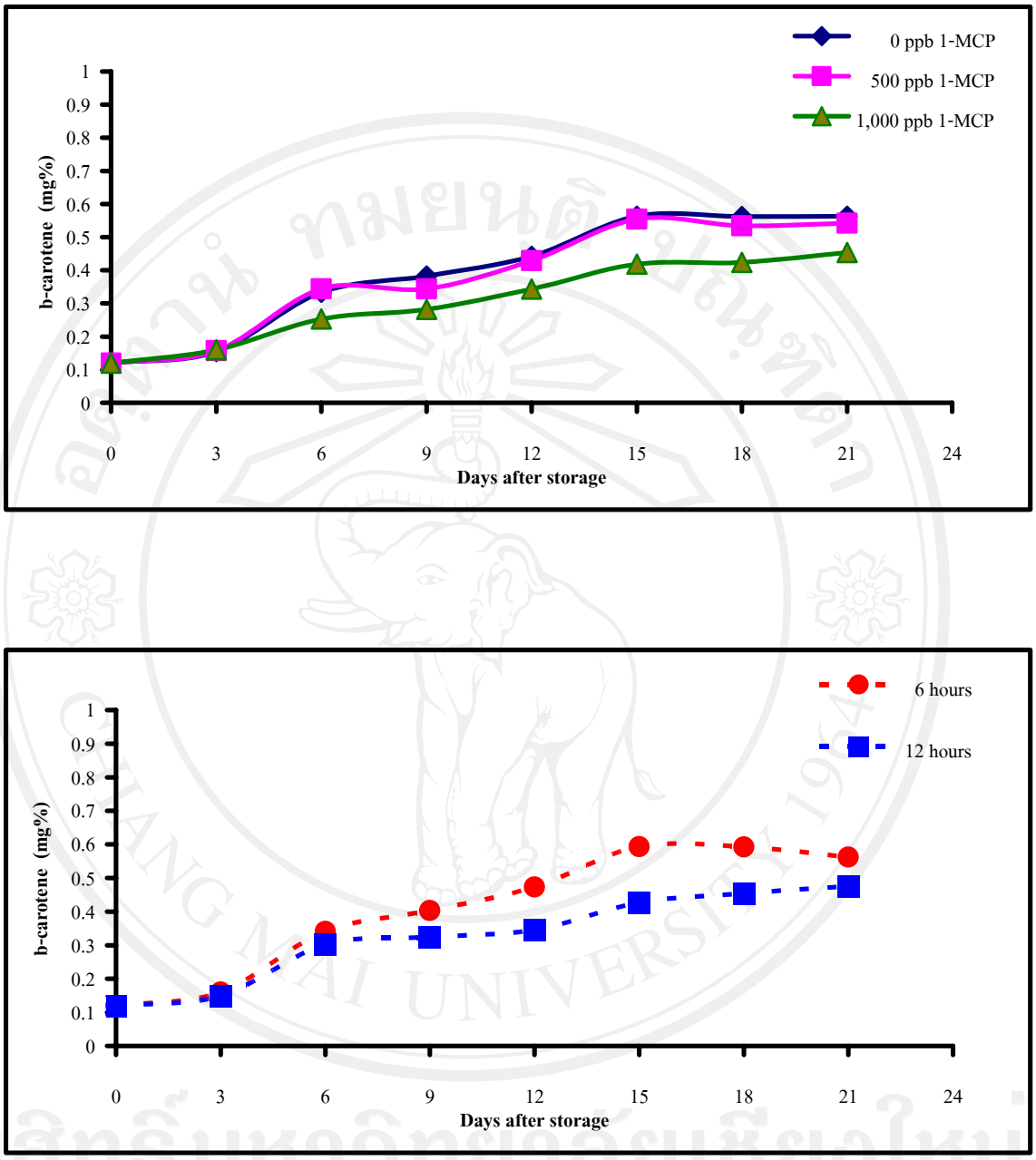


Figure 106 Changes in the β-carotene content of 'Keaw Morakot' mango fruit treated with 1-MCP
during storage at 13°C, 85-90% RH

Respiration rate

The respiration rate of the harvested fruit was 38.35 mg CO_2/kg.hr^{-1}. 1-MCP treatments (500 and 1000 nl/l 1-MCP) could delay the increase of respiration rate better than untreated (0 nl/l). After storage for 12 days, the respiration rate of 1000 and 500 nl/l 1-MCP treated fruit were 60.05 and 63.81 mg CO_2/kg.hr^{-1}, respectively, and differed with 0 nl/l 1-MCP which was 76.12 mg CO_2/kg.hr^{-1}. The respiration rate of the 12 hours 1-MCP treated fruit (60.45 mg CO_2/kg.hr^{-1}) differed with 6 hours (69.88 mg CO_2/kg.hr^{-1}) (Table 30). During storage, the respiration rate of the fruit treated with 0 and 500 nl/l 1-MCP and 6 hours of exposure increased to peak at day 15, while 1000 nl/l 1-MCP and 12 hours of exposure, at day 18 (Figure 107 and Appendix Table 104).

Ethylene production

The ethylene production of the harvested fruit was 0.88 µl C_2H_4/kg.hr^{-1}. After storage for 12 days, the 1000 nl/l 1-MCP treated fruit had the lowest ethylene production (2.05 µl C_2H_4/kg.hr^{-1}), significantly different with 500 and 0 nl/l 1-MCP treated fruit (2.61 and 2.82 µl C_2H_4/kg.hr^{-1}, respectively). The ethylene production of 12 hours 1-MCP treated fruit was 2.27 µl C_2H_4/kg.hr^{-1}, significantly different with 6 hours which was 2.81 µl C_2H_4/kg.hr^{-1} (Table 30). The ethylene production of the fruit treated with 0 and 500 nl/l 1-MCP and 6 hours of exposure increased to peak at day 12, while 1000 nl/l 1-MCP and 12 hours of exposure time, at day 15 (Figure 108 and Appendix Table 105).

Table 30 Effects of 1-MCP on respiration rate and ethylene production of 'Keaw Morakot' mango fruit stored at 13˚C, 85-90% RH, for 0 and 12 days

Treatments	**Respiration rate ($mg\ CO_2/kg.hr^{-1}$)**	**Ethylene production ($\mu l\ C_2H_4/kg.hr^{-1}$)**
0 days	38.35	0.88
12 days		
0 nl/l 1-MCP	76.12^{a}	2.82^{a}
500 nl/l 1-MCP	63.81^{b}	2.61^{a}
1000 nl/l 1-MCP	60.05^{b}	2.05^{b}
CV (%)	6.76	15.56
6 hours	69.88^{x}	2.81^{x}
12 hours	60.45^{y}	2.27^{y}
CV (%)	8.63	10.12

* Means within the same column followed by different letters differ significantly at $\rho<0.05$

ns = non-significant

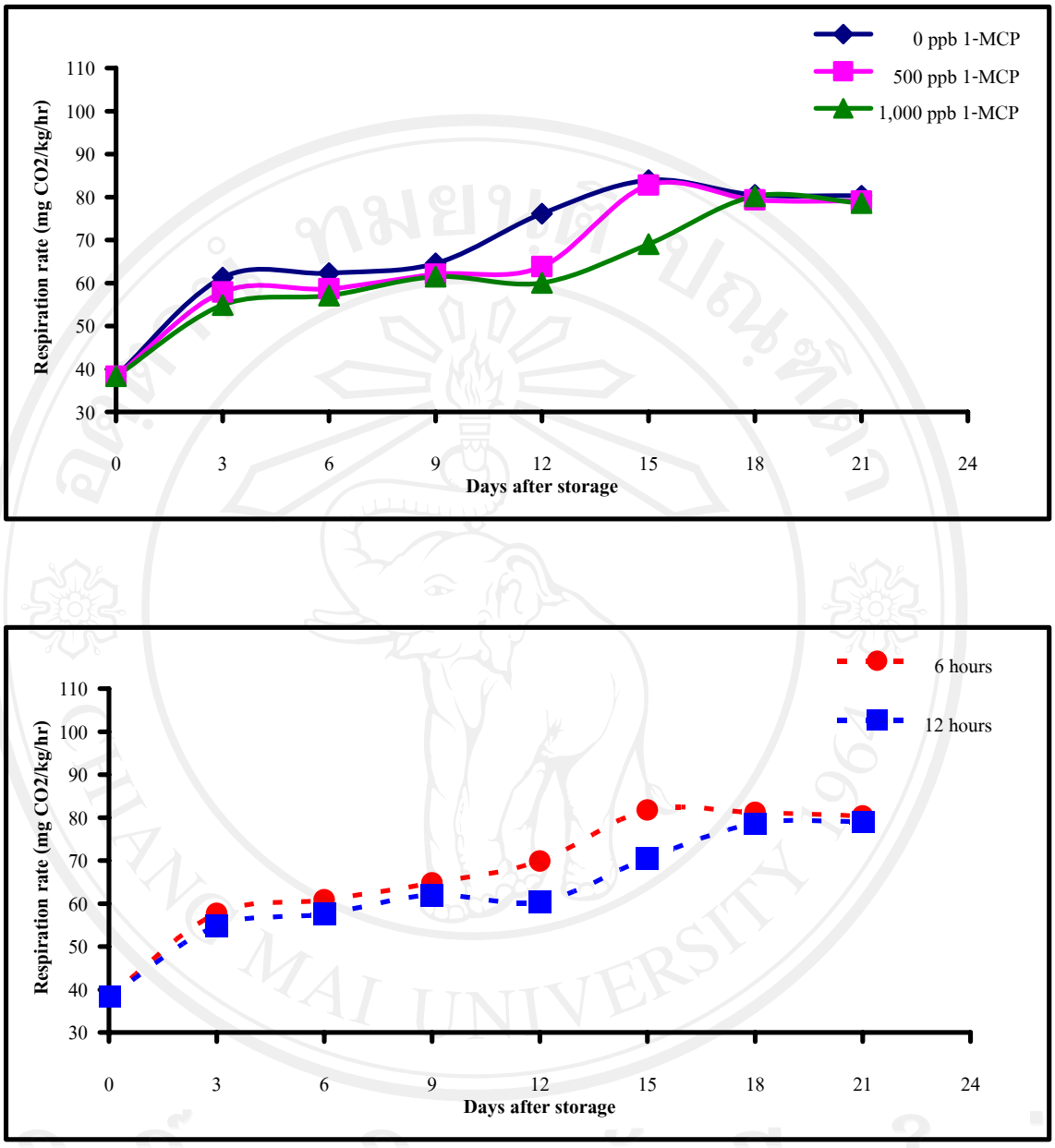


Figure 107 Changes in the respiration rate of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

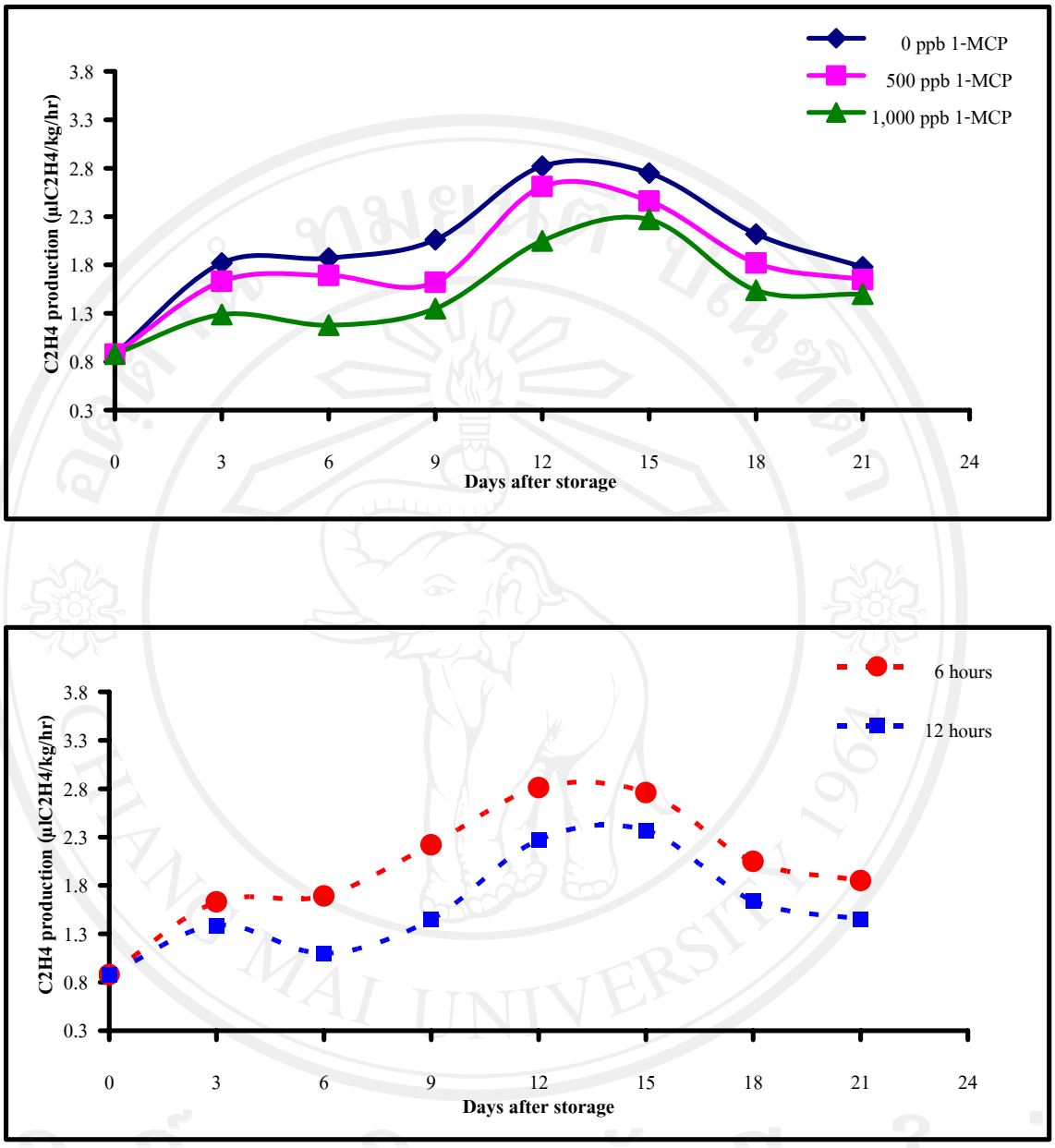


Figure 108 Changes in the ethylene production of 'Keaw Morakot' mango fruit treated with 1- MCP during storage at 13°C, 85-90% RH

WSP content

The WSP content of the harvested fruit was 2.42 g D-galacturonic acid/100g AIS. After storage for 12 day, the WSP of the 1000 nl/l 1-MCP treated fruit (2.35 g D-galacturonic acid/100g AIS) differed with 500 and 0 nl/l 1-MCP treated fruit (2.61 and 2.62 g D-galacturonic acid/100g AIS, respectively). Similarly, the WSP content of 12 hours 1-MCP treated fruit (2.40 g D-galacturonic acid/100g AIS) differed with 6 hours 1-MCP treated fruit (2.80 g D-galacturonic acid/100g AIS) (Table 31). The WSP content increased a littlte during 0-15 days and rapidly increased during 15-18 days of storage. The 1000 1-MCP and 12 hours of exposure time had effectiveness in delaying of WSP increase compared with 0 nl/l 1-MCP and 6 hours, respectively (Figure 109 and Appendix Table 106).

PG activity

At harvest, the PG activity of the fruit was 230.27 nmole D-galacturonic acid/mg protein/min. After storage for 12 days, the PG activity of the 1-MCP treated fruit (274.65-277.95 nmole D-galacturonic acid/mg protein/min) had no significant differences (Table 31). The PG activity increased during 0-15 days of storage, after that it tended to be consistent. The 1000 nl/l 1-MCP and 12 hours of exposure time tended to reduce the PG activity better than 0 nl/l 1-MCP and 6 hours, respectively (Figure 110 and Appendix Table 107).

PME activity

The PME activity of the harvested fruit was 206.12 µmole acetic acid/mg protein/min. After storage for 12 days, the PME activity of the 1000 nl/l 1-MCP treated fruit (254.31 µmole acetic acid/mg protein/min) differed with 500 and 0 nl/l 1-MCP treated fruit (262.25 and 265.21 µmole acetic acid/mg protein/min, respectively). Similarly, the PME activity of the 12 hours 1-MCP treated fruit (252.35 µmole acetic acid/mg protein/min) differed with 6 hours 1-MCP treated fruit (272.08 µmole acetic acid/mg protein/min) (Table 31). The PME activity rapidly increased during 6-9 days, but it rapidly decreased during 9-15 days of storage. The 1000 nl/l 1-MCP and 12 hours tended to reduce the PME activity better than 0 nl/l 1-MCP and 6 hours, respectively (Figure 111 and Appendix Table 108).

Table 31 Effects of 1-MCP on WSP content, PG and PME activities of 'Keaw Morakot' mango fruit stored at 13˚C, 85-90% RH, for 0 and 12 days

Treatments	WSP content (g D-galacturonic acid/100g AIS)	PG activity (nmole D-galacturonic acid/mg protein/min)	PME activity (µmole acetic acid/mg protein/min)
0 days	2.42	230.27	206.12
12 days			
0 nl/l 1-MCP	2.62[a]	276.12[ns]	265.21[a]
500 nl/l 1-MCP	2.61[a]	277.81	262.25[a]
1000 nl/l 1-MCP	2.35[b]	275.05	254.31[b]
CV (%)	10.52	19.40	9.24
6 hours	2.80[x]	277.95[ns]	272.08[x]
12 hours	2.40[y]	274.65	252.35[y]
CV (%)	3.03	17.33	10.98

* Means within the same column followed by different letters differ significantly at $\rho<0.05$
ns = non-significant

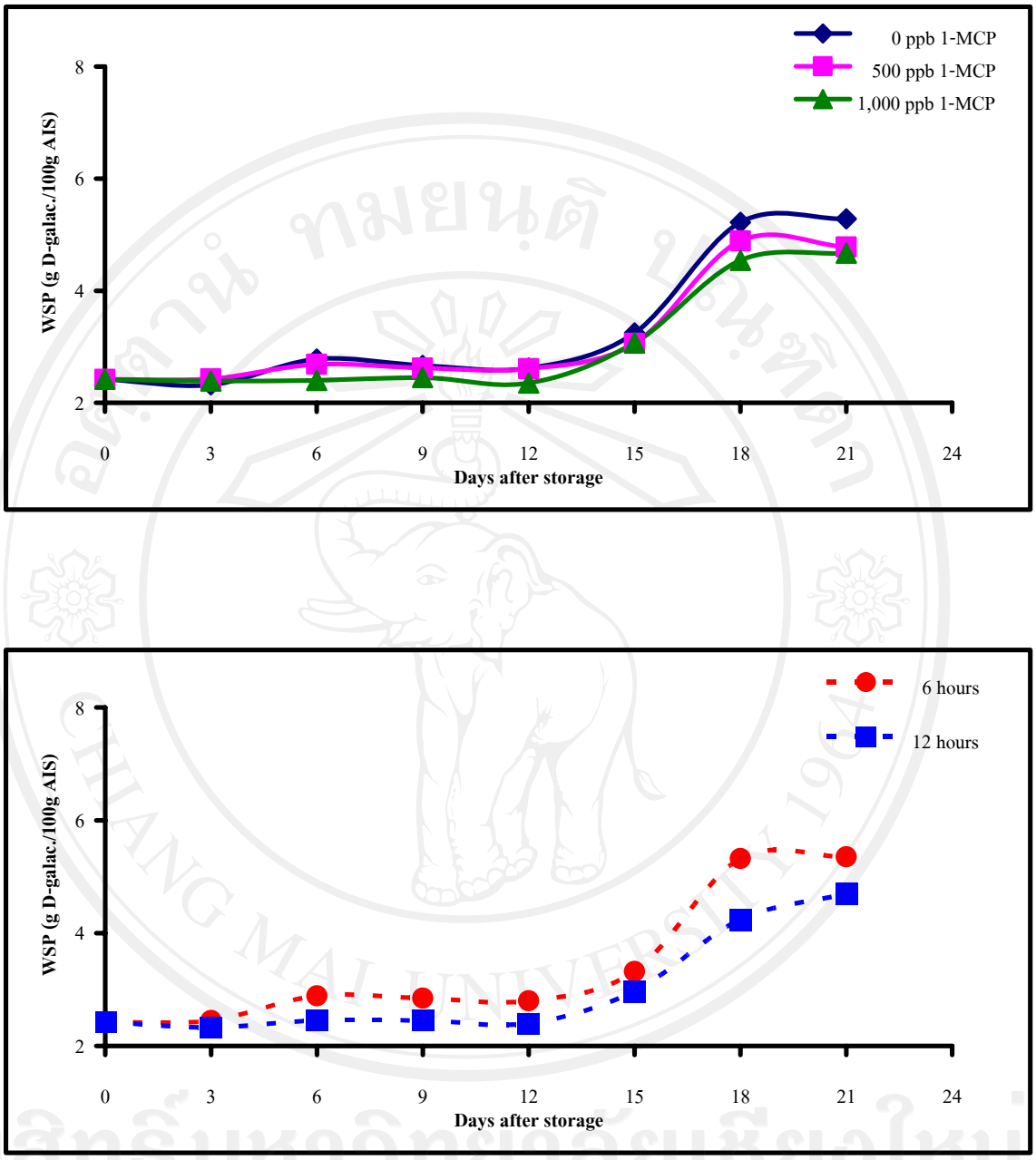


Figure 109 Changes in the WSP content of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

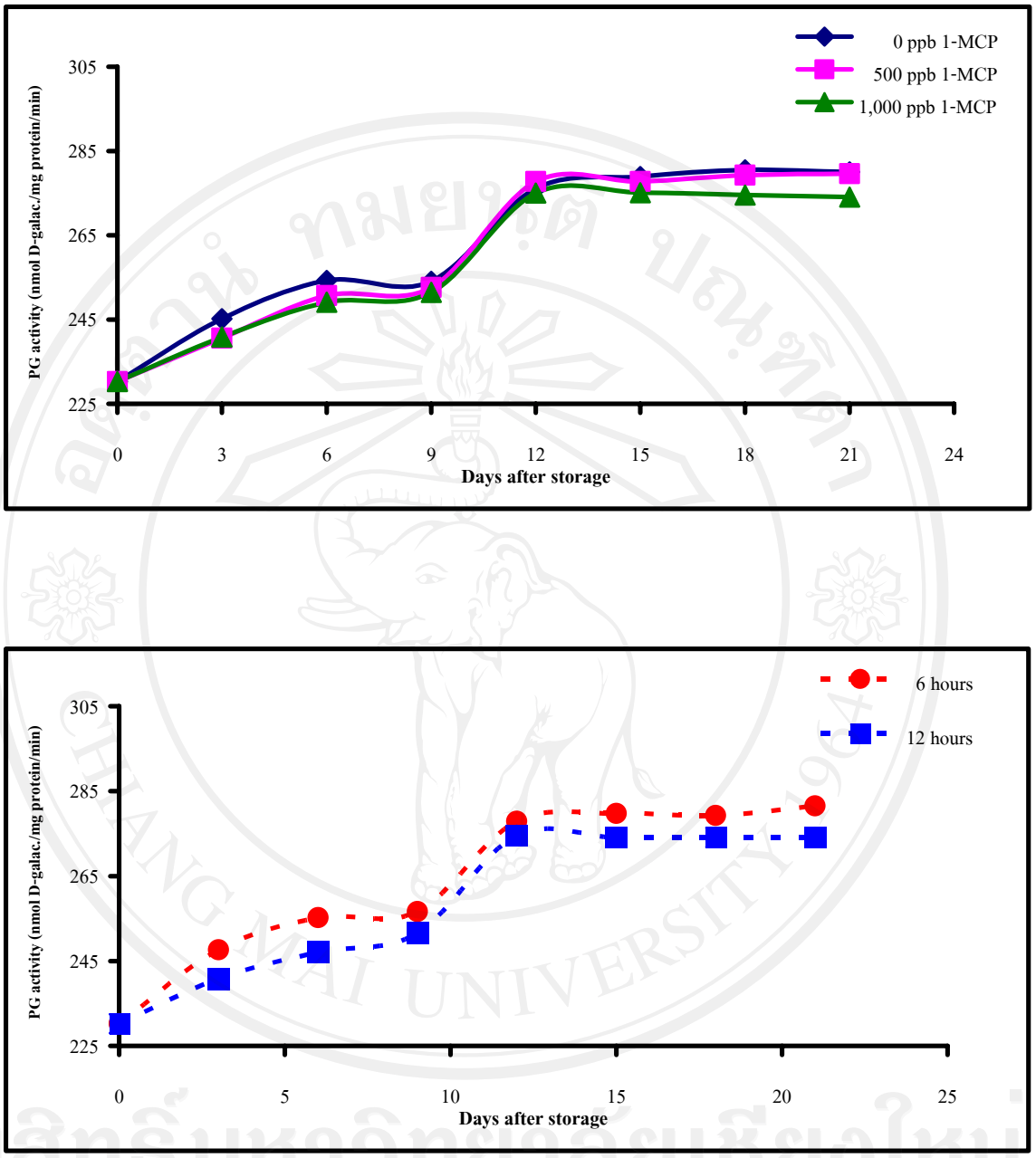


Figure 110 Changes in the PS activity of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH

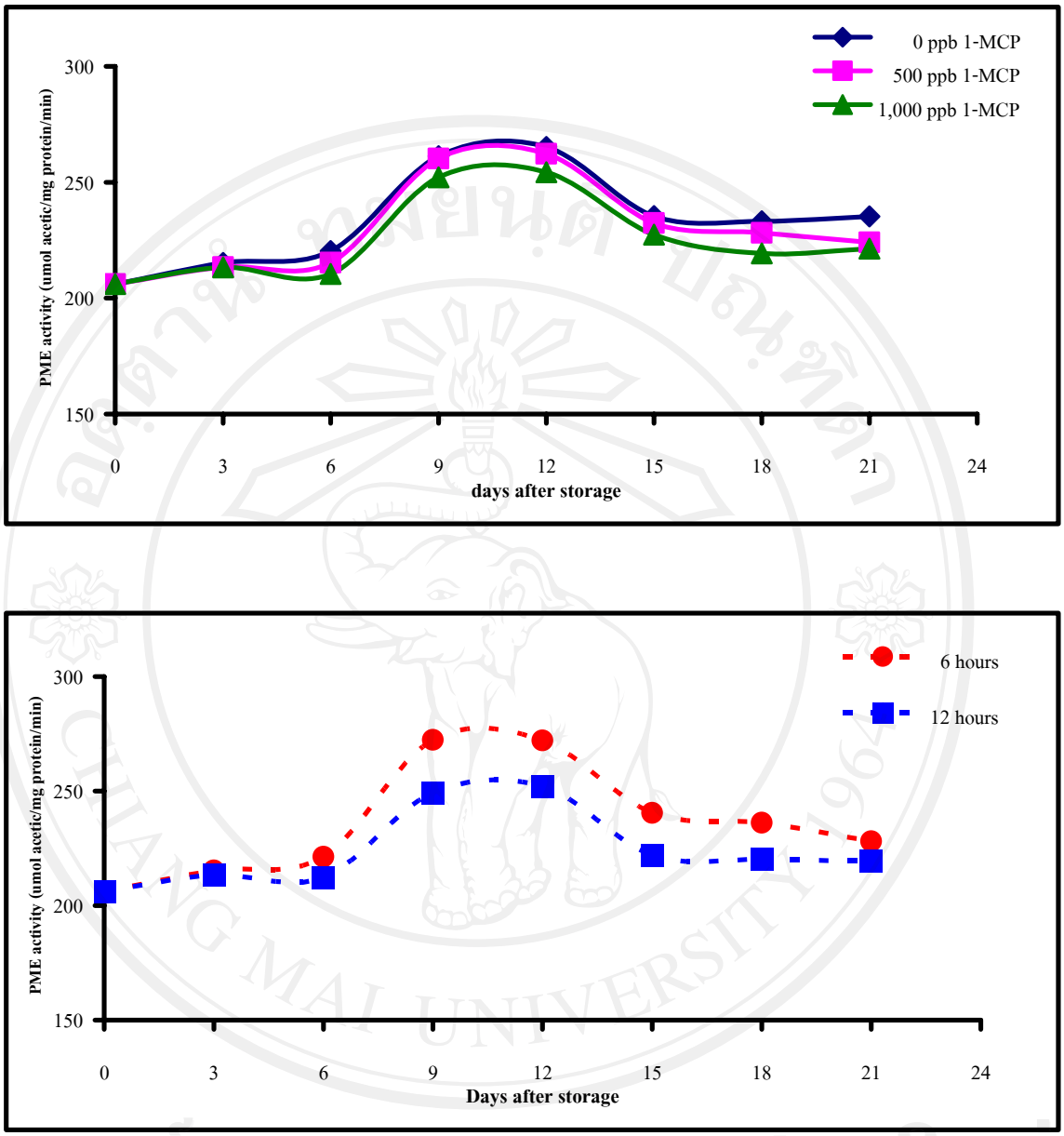


Figure 111 Changes in the PME activity of 'Keaw Morakot' mango fruit treated with 1-MCP during storage at 13°C, 85-90% RH