Impact of Postharvest Treatments on Storage Life and Quality of "Mexican" Lime

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ABSTRACT

The present work was carried out on "Mexican" lime (*Citrus aurantifolia* Swing.) during 2004 and 2005 seasons. The purpose of the present study was to investigate the effect of hot water, calcium chloride and sodium chloride on storage life and quality of "Mexican" lime. Fruits were subjected to the following treatments: T_1) water dipping at ambient temperature (≈ 20℃); T_2) hot water dipping at 55℃; T_3) hot water dipping containing sodium chloride, 1% (W/V) at 55℃; T_4) hot water dipping containing sodium chloride, 2 % (W/V) at 55℃; T_5) hot water dipping containing calcium chloride, 1% (W/V) at 55℃; T_6) hot water dipping containing calcium chloride, 2% (W/V) at 55℃. Fruits were subjected to water dipping for 5 min. Treated fruits were stored in cold room at 12℃, relative humidity (RH) was maintained at 90 %. The obtained results revealed that dipping fruits in hot water with sodium chloride 1% & 2% was effective in prolonging the shelf- life two weeks more than the other treatments in both seasons. The weight loss increased with increasing storage period in both seasons. The fruits dipping in hot water at 55℃ significantly had a measurable influence in reducing the percentages of loss in fruit weight at ambient temperature (≈ 20℃). The lowest values of weight loss were detected with fruits dipped in hot water containing calcium chloride 2 %, while the highest values were detected with fruits dipped in water at ambient temperature in both seasons. Fruits dipped in water at ambient temperature and hot water at 55℃ degreened after four weeks, while fruits dipped in hot water with sodium chloride (1% & 2%) or calcium chloride (1%&2%) reached yellow color after eight weeks. Fruits dipped in hot water with calcium chloride 1% or 2% have significant high values of juice %, TSS and technological index at ten weeks of storage period compared with other treatments in both seasons. All treatments had no effect on the values of fruit acidity and vitamin C. However, vitamin C significantly decreased with increasing the storage duration.

Key words: "Mexican" lime - hot water dipping - sodium chloride - calcium chloride

1. INTRODUCTION

The citrus acreage in the Kingdom of Saudi Arabia is about 11206 hectares and total production is about 172440 tons of fruits. Lemons and limes account for 30 percent of citrus grown in the kingdom (Agric. Stat. Year book, 2005). Citrus fruits are essential component of some human nutritional requirements such as vitamins, minerals and organic acids. Postharvest decay is the major factor limiting the extension of storage life of many fresh fruits. All fresh fruits for domestic or export markets should be free of dirt, dust, pathogens and chemicals before they are packaged. In recent years, the consumers awareness has increased, brought about a resurgence of interest in the use of non-chemical treatments for the preservation of fresh products (Fallik, 2004). The heat treatment appears to

be one of the most promising means for postharvest control of decay to inhibit ripening processes, thus extending storability and marketing of fresh products (Lurie, 1998a; Ben Yehoshua *et al.*, 2000 and Paull & Chen, 2000). Heat as postharvest treatment, is applied for citrus fruits and mainly done by immersing fruits in a hot water bath (Fallik *et al.*, 2004 and Schirra *et al.*, 2004). Hot water temperature and dipping period affected on storage life (Lurie, 1998b) and lime fruit quality (Gould and McGuire, 2006). Schirrra and D'hallewin (1997) found that pre-storage dipping of Frontune mandarins in hot water reduced decay and stimulated shelf life. Dipping lime fruits in hot water at 55°C for 5 minutes gave a good result of storage life for 60 days during storage at 13°C, while only 40 days at 49°C. Soaking the lime fruits in hot water containing sodium chloride resulted in more green skin, were able to store for 70 days and juice composition slightly changed (Boontawee, 2005). Heat water treatments of "Star Ruby" grapefruit reduced postharvest decay development, did not affect fruit weight loss, and had no effect on fruit skin color and quality (Porat *et al.*, 2000). Calcium and heat treatments applied before storage have been shown to protect fruit against stress of cold storage. Dipping various fruit crops particularly citrus fruits in calcium compounds effectively prolonged shelf – life and caused a reduction in the percentage of loss in fruit weight, decayed fruits, total soluble solids as well as total and reducing sugars (Roux and Slocum, 1982 and Roovaiah, 1987). Thus, exogenous calcium chloride treatment reduced mechanical damage and increased storability of lemon (Martinez-Romero *et al.*, 1999) and "Montréal" Clementine's (Schirra and Mulas, 1994). In addition, dipping "Valencia" orange fruits for five minutes prolonged the shelf life without adverse effects on quality (Abdelaziz *et al.*, 2000). Other investigations in apple (Wassel *et al.* 1996); pear (Akl *et al.*, 1994); peach (Guarinoni *et al.*, 2000) and plum (Zuzunaga *et al.*, 2000) have shown similar results.

The objective of this work was to study the effect of hot water, calcium chloride and sodium chloride treatments on quality and storage life of "Mexican" lime.

2. MATERIAL AND METHODS

2.1. Plant material

The present work was carried out on "Mexican" lime (*Citrus aurantifolia,* Swing.) during 2004 and 2005 seasons. Seven - years old orchard trees were budded on Macrophylla (*Citrus macrophylla,* Wester) rootstock, grown in the Agricultural Experimental and Research Station (Deyrab) of the Faculty of Food and Agricultural Sciences – King Saud University, Riyadh. The trees received standard horticultural practices. Fruits harvested randomly by the first week of September in both seasons, when commercially mature [35 mm diameter ± 2mm in the light green

stage, according to Kader and Arpaia (2000)]. Fruits were immediately delivered to the laboratory after harvest.

2.2. Treatments and storage conditions.

Defect-free lime fruits were selected and placed into boxes then grouped into six treatments (ten boxes containing 50 fruits each individually numbered). Each fruit group was subjected to one of the following treatments: T_1) water dip at ambient temperature (≈ 20℃); T_2) hot water dip at 55℃; T_3) hot water dip containing sodium chloride, 1% (W/V) at 55℃; T_4) hot water dip containing sodium chloride, 2 % (W/V) at 55℃; T_5) hot water dip containing calcium chloride, 1 % (W/V) at 55℃; T_6) hot water dip containing calcium chloride, 2 % (W/V) at 55℃. Fruits were subjected to water dipping for 5 min, and left to dry at room temperature for about 2h. The bath was kept at constant required temperature (55℃) by electronic thermostat and thermometer probe as described by Rodove *et al.* (1995). Treated fruits were stored in cold room at 12℃. Relative humidity (RH) was maintained at 90 % and ventilation in the cold room was programmed automatically.

2.3. Quality analysis

Samples of ten fruits from each replicate were evaluated at initial time and at every two weeks interval during the storage period (10 fruits × 5 replicates × 6 treatments). The fruits skin color was evaluated by Minolta Chroma Meter CR-400 in CIE L* a* b* mode under CIE Standard Illuminant. Changes in hue angle (h°) and Chroma (C*) were calculated as $h° = \arctan(b^*/a^*)$ and $C^* = (a^{*2} + b^{*2})^{1/2}$ (McGuire, 1992). Two readings per fruit were taken for each side. Weight loss percentage was measured during storage period for numbered 10 fruits in each replicate (five replicates × six treatments). The weight loss was expressed as percent of the initial weight of the fruits. The juice was extracted from fruits with a motor-driven hand reamer (Ssntos, No.11). The juice content as percentage of fruit weight was recorded. The percentage of total soluble solids (TSS) was determined in fruit juice using BRX-242 digital refractometer. The technological index (T_I) was determined using the following equation: T_I = (TSS × % juice)/100 (Kluge *et al.*, 2003). Juice acidity percentage (estimated as citric acid equivalent) was determined by titration with NaOH and phenolphthalein indicator. Ascorbic acid (vitamin C) was determined by titration with 2,6 dichlorophenol-endophenol blue dye and expressed as ascorbic acid (ml per 100 ml of juice) (A.O.A.C., 1986).

2.4. Statistical analysis

Treatments were arranged in a completely randomized design. Each treatment (six treatments) involved five replications of ten fruits each.

Statistical analysis was performed with SAS's software package version 6.03 (SAS Institute, 1988).

3 - RESULTS AND DISCUSSION

3.1. Shelf- life of fruits

It is clear from the obtained data in Tables (1 to 8) that dipping "Mexican" lime fruits in hot water with sodium chloride 1% & 2% (T_3 & T_4) were effective in prolonging the shelf- life for two weeks more than the other treatments (T_1, T_2, T_5 and T_6) in both seasons. The effect of hot water with sodium chloride on extending storage duration may be attributed to its effect in reducing the decay developments during postharvest storage. These results are in agreement with those obtained by Boontawee (2005). He reported that soaking lime fruits in hot water containing sodium chloride were able to extend the storage period to 70 days.

3.2. Percentage of fruit weight loss

The percentages of cumulative weight loss of "Mexican" lime fruits during storage period are presented in Table (1) during 2004 and 2005 seasons. The weight loss increased with increasing - storage period in both seasons. Fruit dipping in hot water at 55°C (T_2 to T_6) had a significantly influence in reducing the percentages of loss in fruit weight compared with that water dipping at ambient temperature (≈ 20°C). The lowest value of weight loss was detected in fruits dipped in hot water containing calcium chloride 2 % (T_6), while the highest value was detected in fruits dipped in water at ambient temperature (T_1) in both seasons. The percentages of loss in fruit weight were reduced by 25.6 % and 31.1 % in T_6 compared to T_1 after 10 weeks of storage period in both seasons, respectively. The weight loss is a result of direct water loss from the fruit tissue and partially from the respiration process. The mode of action of the hot water dip in reducing the percentages of loss in fruit weight could be due to melting the fruit epicuticular waxes and thus covered and sealed the stomata and cracks on the fruit surface. This sealing of cracks or natural openings reduced weight loss. Moreover, the hot water treatments inhibit respiration rate and ethylene evolution (Schirrra and D'hallewin, 1997; Porat *et al*., 2000, Ilic *et al*., 2001 and Fallik, 2004). Fruits treated with calcium chloride resulted in reduction of respiration rate and ethylene production (Serrano *et al*., 2004). Weight loss is a consequence of fruit dehydration due to changes in surface transfer resistance to water vapor, in respiration rate, and the occurrence of small fissures connecting the internal and external atmospheres (Woods, 1990). In this sense, calcium dip applications have shown to be effective in terms of membrane functionality and integrity maintenance, with lower losses of phospholipids and proteins and reduced ion leakage (Lester and Grusak, 1999), which could be responsible for the lower weight loss found in calcium treated fruits. Accordingly, heat

treatments have been shown to reduce the ripening related membrane changes, such as microviscosity, and the increase in fatty acid saturation (Lurie *et al*., 1995), and then lower weight loss would occur. These results agree with those of Schirrra and D'hallewin (1997); Abdelaziz *et al*., (2000), Zuzunaga *et al*., (2000) and Boontawee (2005), who reported that fruits dipping in hot water with calcium chloride or sodium chloride reduced, weight loss.

Table (1): Influence of hot water, calcium chloride and sodium chloride on weight loss % of "Mexican" lime during 2004 and 2005 cold storage periods.

Treatment*	Storage duration (weeks)							Mean
	0	2	4	6	8	10	12	
				2004				
T_1	-	4.67	7.60	9.40	11.37	13.85	-	9.38
T_2	-	3.41	6.04	8.10	10.73	12.55	-	8.17
T_3	-	2.33	5.10	7.51	9.53	11.87	12.79	8.19
T_4	-	2.96	5.99	8.02	10.06	11.59	12.93	8.59
T_5	-	3.22	5.92	8.50	10.47	12.39	-	8.10
T_6	-	2.99	5.11	6.61	8.82	10.30	-	6.77
Mean	-	3.26	5.96	8.02	10.16	12.01	12.86	
$LSD_{0.05}$		T = 0.21		D = 0.19		T*D = 0.48		
				2005				
T_1	-	4.17	7.20	9.60	12.07	14.15	-	9.44
T_2	-	3.25	5.87	.46	11.13	12.75	-	8.29
T_3	-	2.54	4.85	7.82	10.32	11.96	13.05	8.42
T_4	-	3.15	5.69	8.54	10.37	11.74	13.27	8.79
T_5	-	3.54	5.63	8.86	10.02	12.11	-	8.03
T_6	-	3.21	4.96	6.85	8.75	9.85	-	6.72
Mean	-	3.31	5.68	8.36	10.44	12.09	13.16	
$LSD_{0.05}$		T = 0.34		D = 0.27		T *D = 0.54		

* Treatments: T_1) water dipping at ambient temperature (≈ 20℃); T_2) hot water dipping at 55℃; T_3) hot water dipping containing sodium chloride, 1% (W/V) at 55℃; T_4) hot water dipping containing sodium chloride, 2 % (W/V) at 55℃; T_5) hot water dipping containing calcium chloride, 1% (W/V) at 55℃; T_6) hot water dipping containing calcium chloride, 2% (W/V) at 55℃.

3.3. The fruit skin color

It is evident from Tables (2 & 3) that the values of hue angel (h°) decreased with increase in storage period. While, the Chroma (C*) increased in both seasons. Hue angles deviating more from 90° represent greener fruit, whereas values nearer to 90°, represent yellower fruit. Chroma defines the color intensity, presenting values around zero for neutral color (gray) and values around 60 for bright color (McGuire, 1992). Fruits dipped in water at ambient temperature (T_1) and hot water at 55°C (T_2) degreened after four weeks while, fruits dipped in hot water with sodium chloride (T_3 & T_4) or calcium chloride (T_5 & T_6) reached yellow color after eight weeks. Goldschmidt (1997) stated that the chlorophyll degradation is an event that can be regulated by ethylene. Consequently, the loss of green skin color of "Mexican" lime could be blocked by inhibitors of ethylene action. Fruits treated with hot water and calcium chloride reduced the respiration rate and ethylene production (Serrano *et al.*, 2004). Lime fruits soaked in hot water containing sodium chloride had more green skin and were able to store for 70 days (Boontawee, 2005). The inhibition of degreening during the heat treatment appears to be due to the absence of the chlorophyll oxidase enzyme resulting in the retention of chlorophyll in the peel (Blackbourn *et al.*, 1989).

3.4. Juice %

It is clear from the data in Table (4) that dipping "Mexican" lime fruits in hot water with calcium chloride 1% or 2% (T_5 & T_6) have significant high values of juice % at ten weeks of storage period compared with other treatments. The juice % was increased with increasing the storage duration. The same trend was noticed in both seasons. These results agree with those obtained by Schirrra and D'hallewin (1997), Abdelaziz *et al.* (2000) and Boontawee (2005).

3.5. TSS %

The results in Table (5) show that the storage period has a significant effect on TSS% of fruits. The high values were established at 10 weeks. The highest values attained for treatments T_5 & T_6. There are no significant differences between other treatments. The same trend was noticed for the two seasons. The present results were in agreement with Abdelaziz *et al.* (2000).

3.6. Acidity %

The storage period effect on increasing the fruit acidity (Table 6) was inconsistent. The highest values reached at 10 weeks period. The differences between treatments were not significant in both seasons. This result agreed with that obtained by Abdelaziz *et al.* (2000) and Boontawee (2005).

Table (2): Influence of hot water, calcium chloride and sodium chloride on hue angel of "Mexican" lime during 2004 and 2005 cold storage periods.

Treatment*	Storage duration (weeks)							Mean
	0	2	4	6	8	10	12	
				2004				
T_1	106.74	96.93	90.89	90.79	90.68	90.50	-	94.42
T_2	106.74	98.19	94.46	91.29	90.93	90.83	-	95.41
T_3	106.74	102.30	100.83	95.95	91.33	91.13	90.29	97.05
T_4	106.74	103.09	100.98	96.71	90.78	90.56	90.37	97.03
T_5	106.74	103.32	100.48	97.26	91.51	90.44	-	98.29
T_6	106.74	104.35	101.01	97.45	92.72	91.05	-	98.89
Mean	106.74	101.36	98.11	94.91	91.33	90.75	90.33	
$LSD_{0.05}$	T = 0.50		D = 0.58		T*D = 1.12			
				2005				
T_1	107.21	98.93	92.89	91.86	90.68	90.50	-	95.35
T_2	107.21	98.19	94.46	91.29	90.93	90.83	-	95.49
T_3	107.21	102.80	99.92	96.54	92.38	90.96	90.55	97.19
T_4	107.21	103.86	100.68	97.84	93.88	91.58	90.76	97.97
T_5	107.21	102.46	99.89	97.96	93.65	91.76	-	98.82
T_6	107.21	104.53	102.55	100.21	96.76	93.55	-	100.80
Mean	107.21	101.80	98.40	95.95	93.05	91.53	90.67	
$LSD_{0.05}$	T = 0.58		D = 0.63		T *D = 1.26			

* As in Table (1)

Table (3): Influence of hot water, calcium chloride and sodium chloride on Chrom of "Mexican" lime during 2004 and 2005 cold storage periods.

Treatment*	Storage duration (weeks)							Mean
	0	2	4	6	8	10	12	
				2004				
T_1	40.68	50.69	54.07	56.26	58.29	59.54	-	53.26
T_2	40.68	48.03	52.46	55.12	56.53	58.58	-	51.90
T_3	40.68	47.90	50.18	53.25	54.29	56.40	58.75	53.78
T_4	40.68	48.48	51.46	53.88	54.70	57.49	59.03	51.64
T_5	40.68	46.32	49.81	52.79	54.88	56.47	-	50.16
T_6	40.68	45.72	48.99	50.52	52.95	54.86	-	48.95
Mean	40.68	47.86	51.16	53.64	55.27	57.22	58.89	
$LSD_{0.05}$	T = 0.32		D = 0.38		T*D = 0.76			
				2005				
T_1	39.74	50.12	53.24	55.54	57.28	60.15	-	52.68
T_2	39.74	47.43	50.76	53.18	54.96	57.98	-	50.68
T_3	39.74	46.85	49.60	50.38	53.54	57.20	60.70	51.14
T_4	39.74	45.40	48.54	52.96	53.86	56.98	60.21	51.10
T_5	39.74	45.15	47.76	49.86	52.59	54.87	-	48.33
T_6	39.74	44.04	47.02	49.12	51.54	53.06	-	47.42
Mean	39.74	46.50	49.49	51.84	53.96	56.71	60.46	
$LSD_{0.05}$	T = 0.41		D = 0.43		T *D = 0.81			

* As in Table (1)

Table (4): Influence of hot water, calcium chloride and sodium chloride on juice (%) of "Mexican" lime during 2004 and 2005 cold storage periods.

Treatment*	Storage duration (weeks)							Mean
	0	2	4	6	8	10	12	
				2004				
T_1	50.02	52.98	51.87	52.74	54.98	55.72	-	53.05
T_2	50.02	53.48	52.12	52.46	54.73	56.52	-	53.22
T_3	50.02	52.70	51.28	55.15	56.04	55.11	54.41	53.53
T_4	50.02	53.67	52.55	53.96	53.31	54.81	54.95	53.32
T_5	50.02	54.55	53.43	57.42	59.79	60.28	-	55.92
T_6	50.02	53.56	54.10	57.95	59.95	60.44	-	56.00
Mean	50.02	53.49	52.57	54.95	56.47	57.15	54.68	
$LSD_{0.05}$	T = 0.71		D =0.83		T*D = 1.62			
				2005				
T_1	49.35	51.93	53.90	54.98	54.96	54.45	-	53.30
T_2	49.35	51.78	53.23	53.32	52.24	53.23	-	52.19
T_3	49.35	52.51	53.35	53.15	54.46	54.25	53.80	52.99
T_4	49.35	52.44	53.05	54.17	54.26	54.14	54.60	53.14
T_5	49.35	52.02	54.74	55.20	57.75	59.24	-	54.72
T_6	49.35	52.60	54.63	56.19	58.43	60.02	-	55.20
Mean	49.35	52.21	53.82	54.50	55.35	55.89	54.20	
$LSD_{0.05}$	T = 0.49		D = 0.57		T *D = 1.23			

* As in Table (1)

Table (5): Influence of hot water, calcium chloride and sodium chloride on TSS (%) of "Mexican" lime during 2004 and 2005 cold storage periods.

Treatment*	Storage duration (weeks)							Mean
	0	2	4	6	8	10	12	
				2004				
T_1	7.80	8.20	7.95	8.20	8.25	8.30	-	8.12
T_2	7.80	8.33	8.05	8.20	8.20	8.15	-	8.12
T_3	7.80	8.23	8.15	7.79	8.00	8.33	8.25	8.08
T_4	7.80	8.45	7.85	7.75	8.28	8.30	8.23	8.10
T_5	7.80	8.40	8.30	8.23	8.25	8.50	-	8.25
T_6	7.80	8.55	8.25	8.25	8.35	8.40	-	8.27
Mean	7.80	8.36	8.09	8.07	8.22	8.33	8.24	
$LSD_{0.05}$	T = 0.11		D = 0.13		T*D = 0.27			
				2005				
T_1	7.88	7.73	7.93	7.58	7.63	8.08	-	7.80
T_2	7.88	7.80	7.98	7.75	7.55	8.18	-	7.85
T_3	7.88	7.80	8.18	7.65	7.83	8.28	8.40	8.00
T_4	7.88	7.90	8.18	7.40	7.73	8.13	8.28	7.92
T_5	7.88	8.20	8.43	7.85	7.95	8.28	-	8.10
T_6	7.88	8.33	8.45	8.00	8.05	8.33	-	8.19
Mean	7.88	7.96	8.20	7.71	7.81	8.21	8.34	
$LSD_{0.05}$	T = 0.09		D = 0.11		T*D = 0.24			

* As in Table (1)

Table (6): Influence of hot water, calcium chloride and sodium chloride on acidity (%) of "Mexican" lime during 2004 and 2005 cold storage periods.

Treatment*	Storage duration (weeks)							Mean
	0	2	4	6	8	10	12	
				2004				
T_1	6.53	6.77	6.63	6.55	6.58	6.67	-	6.62
T_2	6.53	6.73	6.54	6.81	6.36	6.39	-	6.56
T_3	6.53	6.90	6.39	6.07	6.62	6.63	6.66	6.54
T_4	6.53	7.08	6.14	6.38	7.08	6.96	6.83	6.71
T_5	6.53	6.85	6.25	6.62	6.98	6.83	-	6.66
T_6	6.53	6.38	5.86	5.96	6.71	6.85	-	6.39
Mean	6.53	6.77	6.30	6.40	6.72	6.72	6.74	
$LSD_{0.05}$	T = 0.14		D = 0.17		T*D = 0.54			
				2005				
T_1	6.77	6.59	6.76	6.64	6.43	6.27	-	6.57
T_2	6.77	6.67	6.87	6.73	6.49	6.41		6.65
T_3	6.77	6.78	6.74	6.94	6.56	6.56	6.73	6.77
T_4	6.77	6.76	6.85	6.74	6.56	6.56	7.08	6.80
T_5	6.77	6.71	6.85	6.21	6.63	6.49	-	6.61
T_6	6.77	6.81	6.88	6.85	6.83	6.38	-	6.76
Mean	6.77	6.72	6.82	6.69	6.41	6.45	6.90	
$LSD_{0.05}$	T = 0.4		D = 0.38		T *D = 0.33			

* As in Table (1)

3.7. Vitamin C

Table (7) shows that the values of vitamin C significantly decreased with increasing the storage duration. All treatments had no significant effect on the values of vitamin C. The same trend was obvious for both seasons. Abdelaziz *et al.* (2000) and Boontawee (2005) observed similar results to the present study.

3.8. Technological index (TI)

The technological index is an important variable to the citrus industry. The higher values mean better quality for juice manufacture (Kluge *et al.*, 2003). The results in Table (8) indicate that increasing the storage duration significantly increased the T_I. At ten weeks period, treatments T_5 & T_6 have a significant effect in increasing the TI. Other treatments have no-significant effect in both seasons had the same trend.

Table (7): Influence of hot water, calcium chloride and sodium chloride on vitamin C (mg/100ml juice) of "Mexican" lime during 2004 and 2005 cold storage periods.

Treatment*	Storage duration (weeks)							Mean
	0	2	4	6	8	10	12	
				2004				
T_1	26.50	24.54	22.54	20.98	18.18	16.13	-	21.48
T_2	26.50	24.49	22.73	19.72	19.25	16.85	-	21.59
T_3	26.50	24.27	23.46	20.98	21.59	16.19	16.38	21.48
T_4	26.50	24.59	24.18	20.97	18.51	16.63	15.85	21.03
T_5	26.50	24.36	22.57	20.14	17.95	16.53	-	21.34
T_6	26.50	24.70	22.53	19.84	17.88	16.57	-	21.33
Mean	26.50	24.49	23.00	20.61	18.72	16.47	16.12	
$LSD_{0.05}$	T = 0.49		D = 0.33		T*D = 0.72			
				2005				
T_1	24.73	22.39	19.95	19.77	17.38	14.96	-	19.70
T_2	24.73	20.80	18.95	20.01	18.93	16.01	-	19.74
T_3	24.73	20.27	19.14	18.19	19.22	16.75	15.92	19.17
T_4	24.73	22.06	18.43	18.43	18.38	16.05	15.28	19.05
T_5	24.73	20.53	18.84	18.89	16.85	16.31	-	19.36
T_6	24.73	21.05	18.97	18.69	17.38	15.80	-	19.43
Mean	24.73	21.12	19.05	19.00	18.02	15.98	15.60	
$LSD_{0.05}$	T = 0.56		D = 0.35		T *D = 0.77			

* As in Table (1)

Table (8): Influence of hot water, calcium chloride and sodium chloride on technological index (TI) of "Mexican" lime during 2004 and 2005 cold storage periods.

Treatment*	Storage duration (weeks)							Mean
	0	2	4	6	8	10	12	
				2004				
T_1	3.90	4.34	4.12	4.32	4.54	4.62	-	4.31
T_2	3.90	4.45	4.20	4.30	4.49	4.61	-	4.32
T_3	3.90	4.31	4.18	4.30	4.48	4.59	4.49	4.33
T_4	3.90	4.54	4.13	4.18	4.98	4.55	4.52	4.32
T_5	3.90	4.58	4.43	4.73	4.93	4.99	-	4.61
T_6	3.90	4.58	4.46	4.78	5.00	5.08	-	4.63
Mean	3.90	4.47	4.25	4.43	4.64	5.76	4.51	
$LSD_{0.05}$	T = 0.27		D = 0.09		T *D = 0.14			
				2005				
T_1	3.89	4.01	4.27	4.17	4.19	4.40	-	4.16
T_2	3.89	4.04	4.25	4.13	3.94	4.35	-	4.10
T_3	3.89	4.10	4.36	4.07	4.35	4.49	4.52	4.24
T_4	3.89	4.14	4.34	4.01	4.19	4.40	4.52	4.21
T_5	3.89	4.27	4.61	4.33	4.59	4.91	-	4.43
T_6	3.89	4.22	4.62	4.36	4.59	4.94	-	4.43
Mean	3.89	4.13	4.41	4.18	4.29	4.58	4.52	
$LSD_{0.05}$	T = 0.29		D = 0.06		T *D = 0.19			

* As in Table (1)

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الملخص العربي

تأثير معاملات ما بعد الحصاد على فترة تخزين الليمون "المكسيكي" وجودته

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أجريت الدراسة خلال موسمي ٢٠٠٤ و ٢٠٠٥م على ثمار الليمون المالح " المكسيكي" لدراسة تأثير غمس الثمار في الماء الساخن ومحلول كلوريد الصوديوم وكلوريد الكالسيوم. حصدت الثمار في مرحلة النضج البستاني من أشجار بالغة بعمر٧ سنوات ومطعمة علي أصل ماكروفيلا ونامية بمزرعة محطة الأبحاث والتجارب الزراعية – ديراب . أجريت ست معاملات: غمست الثمار في ماء على درجة حرارة الغرفة ٢٠°م وماء ساخن على درجة حرارة ٥٥°م وماء ساخن يحتوي علي كلوريد الصوديوم بتركيز ١٪ و٢٪ وماء ساخن يحتوي على كلوريد الكالسيوم بتركيز ١٪ و٢٪ ٠ مدة غمس الثمار ٥ دقائق وتم تخزين الثمار في غرف التبريد على درجة حرارة ١٢°م ورطوبة نسبية ٩٠٪. أظهرت النتائج أن غمس الثمار في ماء ساخن يحتوي على كلوريد صوديوم ١٪ و٢٪ أدي إلى زيادة فترة

التخزين إلى ١٢ أسبوع مقارنة بالمعاملات الأخرى (١٠ أسابيع)٠ زادت نسبة الفاقد في الوزن مع زيادة فترة التخزين كما أن غمس الثمار في الماء الساخن خفض نسبة الفاقد في الوزن مقارنة بالغمس في ماء على درجة ٢٠°م التي أعطت أعلي قيمة من الفاقد في الوزن٠ كانت أقل قيمة للفاقد في الوزن بمعاملة الثمار بالغمس في ماء ساخن يحتوي على كلوريد الكالسيوم بتركيز ٢٪٠ اختفى اللون الأخضر للثمار بعد ٤اسابيع من التخزين بمعاملة الثمار بالغمس في ماء علي درجة ٢٠°م أوماء ساخن على درجة ٥٥°م بينما اكتسبت اللون الأصفر بعد ٨ أسابيع عند الغمس في ماء ساخن يحتوي على كلوريد صوديوم ١٪ و٢٪ أوكلوريد الكالسيوم بتركيز ١٪ و٢٪٠ أدت معاملة الثمار بالغمس في ماء ساخن يحتوي على كلوريد الكالسيوم بتركيز ١٪ و٢٪ إلي زيادة في النسبة المئوية للعصير ونسبة المواد الصلبة الذائبة ودليل التصنيع ٠ لم يكن للمعاملات تأثير معنوي على حموضة العصير وفيتامين ج ٠عموما يمكن تخزين ثمار الليمون المالح " المكسيكي" لمدة ١٠ أسابيع بمعاملة الثمار بالغمس في ماء ساخن علي درجة ٥٥°م يحتوي على كلوريد الكالسيوم بتركيز ٢٪ قبل التخزين المبرد على درجة حرارة ١٢°م ورطوبة نسبية ٩٠٪ بأقل نسبة فاقد في الوزن وصفات جودة مناسبة للثمار٠