ISSN 1110-0419

Annals Of Agric. Sc., Moshtohor,
Vol. 43(3): 1185-1201, (2005).

PHYSIOLOGICAL STUDIES ON EGYPTIAN LIME FRUITS, I- EFFECT OF WAXING AND GA_3 POSTHARVEST TREATMENTS ON KEEPING QUALITY AND STORAGE LIFE OF LIME FRUITS.

BY

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ABSTRACT

Lime fruits were harvested at maturity stage in 2003 and 2004 from a private farm at Kalubia Governorate. Lime fruits were sorted, washed, dried and waxed or dipped for 5 minutes in GA_3 solution (50 or 75 ppm) or a combination of both treatments before stored. Control fruits were sorted, washed and dried only. Then Lime fruits were stored at 13°C and 90% R.H. for 84 days. Fruits physical and chemical properties were investigated. Lime fruits treated with wax or GA_3 either 50 or 75 ppm individually or in combination with wax significantly had lower weight loss and decay % compared with control fruits. Moreover, these treatments significantly decreased the reduction of firmness and the deterioration of fruit quality parameters (Juice contents, Color, Total soluble solids, Total acidity and Vitamin C). Also from these investigation showed that, GA_3 either at 50 or 75 ppm has the same effect on keeping lime fruits quality during storage. This research proved that waxing and GA_3 either at 50 or 75 ppm as a postharvest treatment has a good effect on maintaining lime fruit quality during storage.

INTRODUCTION

Lime fruits are extensively consumed all the year around as compared to other citrus fruits. There for it's major importance to keep lime fruits green to be able to be exported to the European market, at it has a big opportunity to increase it's quantity to the these markets under the Egyptian European partnership agreement However, it has to be at green color.

Due to their chilling injury sensitivity, lemons are stored at 13°C and 90% R.H. The main factors governing storage life of lemons are water loss and susceptibility to decay (Ben-Yehoshua, *et al.*, 1987).

Limes have little or no natural cuticle to retard moisture loss, so the fruits should be waxed to prevent moisture loss and desiccating (Hardenburg, *et al.*, 1986).

Post harvest treatments with some growth regulators also had been used in order to reduce decay incidence and delay the color transmutation (Ben-Yehoshua, *et al.*, 1994). Treating Balady lime fruits by GA3 at 500 or 1000 ppm

was able to inhibit both decay and progress in rind color (Fahmy, *et al.*, 1972, Blunden, *et al.*, 1979 and El-Helaly, 2002).

The purpose of this study is to investigate the effect of postharvest treatments with waxing and low concentration of GA_3 alone or in combination on fruits quality and storability of lime.

MATERIALS AND METHODS

This study was carried out during two successive seasons (2003-2004) at Horticulture Research Institute, Fruit handling Department, Ministry of Agriculture, Egypt. Uniform 15 year old Balady lime trees grown in a private farm at Kalubaia Government were selected.

At maturity stage according to (El-Shiati, 1959) fruits were picked by clipper and directly transported to the laboratory to be washed, dried, divided and subjected to the following treatments:

No (1): dipping in distilled water for 5 minutes (control).
No (2): waxing by natural wax without any fungicide added.
No (3) and No(4): dipping in 50 or 75 ppm GA_3 solution for 5 minutes then fruits dried without waxing.
No (5) and No (6): dipping in 50 or 75 ppm GA_3 solution for 5 minutes then fruits were dried and waxed.

All treatments were packaged in normal ventilated polyethylene bags (20μ m. in thickness), each had 10 holes (5 mm. in diameter) (Grierson, 1969). Each bag had 18 fruits (20 ±5 gm). At 2 weeks intervals, samples were taken and the fruit physical and chemical characteristics were measured or calculated as follow:

- Weight loss % and decay % were calculated as the following equations:
  a- Weight loss %=fruits weight of bags at the examination date ×100/ the initial weight of bags (at the start of the experiment).
  b- Decay% =decayed fruits per bags ×100 /the initial weight of bags.
- Contents of juice were estimated by squeezing 18 fruits (as three replicates) by handy squeezer and then juice percentage was calculated (w/w).
- Fruit firmness was estimated in 18 fruits (6 from each replicate) by Lfra texture analyzer instrument using a penetrating cylinder of 1 mm. in diameter to a constant distance 2 mm. inside the skin of fruits and by a constant speed 2 mm. per sec. and the peak of resistance was recorded per gm.
- Color of the skin development was estimated by Hunter colorimeter type (Dp-9000) for the estimation of "L", "a" and "b" values and a subsequent calculation of the corresponding hue angle according to McGuire, 1992 and Voss, 1992.
- Total soluble solids were determined by abbe' rafractometer according to (A.O.A.C., 1980).
- Total acidity percentage was determined by titration and calculated as citric acid according to (A.O.A.C., 1980).
- Ascorbic acid was determined according to (Lucas, 1944).

- Chlorophyll and carotene compounds in the rind were determined according to the procedure suggested by Robblen (1957). A Carl Zeiss photoelectric colorimeter was used for determination. The optical density at 622; 644 and 440 wave length to determine chlorophyll (a), chlorophyll (b) and carotene contents according to the following equations:

  Chlorophyll (a) = 9.784×O.D. (662) - 0.99×O.D. (664) =....mg/100gm. F.W.

  Chlorophyll (b) = 21.426×O.D. (644)-4.65×O.D. (662) =...mg/100gm. F.W.

  Carotene = 4.695×O.D. (440)-0.268(A+B) =...mg/100gm. F.W.

All data were tabulated and statistically analyzed according to Snedecor and Cochran, 1980. All mean were compared using the L.S.D. values at 5% level.

RESULTS AND DISCUSSION

1-Weight loss and Decay percentage:

Data presented in Tables (1 and 2) clearly indicated that, weight loss and decay percentage increased gradually and significantly with prolonging the storage period in both seasons under this investigation.

These results are confirmed by Ben-Yehoshua, *et al.*, 1987, Salem, *et al.*, 1988, Eaks, 1990 and El-Helaly, *et al.*, 2002, They reported that weight loss and decay percentage increased with the extension of the storage period.

Also it is clear from the same data that, postharvest treatments with either waxing or GA_3 alone or together significantly reduced both weight loss and decay percentage of Lime fruits during storage in all the seasons of this work.

These results are in line with those found by Fioravanco, *et al.*, (1995) on Tahiti lime fruits and El-Helaly (2002) on Banzahir limes. They reported that fruits waxed fruits or those treated with GA_3 showed lower weight losses and maintained good quality during storage.

2-Fruit Firmness:

Data presented in Table (3) show that, fruit firmness decreased gradually and significantly with prolonging the storage period during the two seasons in this investigation.

Also it is clear from the previous Table that waxing and GA_3 dipping postharvest treatments significantly reduced the softening rate of lime fruits during storage. Concerning the effect of the different concentration of GA_3, data also obtained that, Lime fruits treated with GA_3 at 50 ppm had the same fruit firmness as fruits treated with GA_3 at 75 ppm either it was associated with waxing or not.

The present findings are in correspondence with those reported by Ben-Yehoshua, *et al.*, (1987), who reported that lemon fruits firmness decreased gradually and significantly as storage period increased.

Table (1): Effect of waxing and GA_3 treatments on weight loss percentage of lime fruits during cold storage.

Storage period (days).	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Means
	The first season (2003).						
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	3.97	3.20	2.24	2.01	2.33	2.77	2.75
28	7.99	5.92	7.57	7.21	5.15	6.58	6.74
42	13.13	7.50	8.11	10.23	8.05	10.02	9.51
56	18.59	13.37	9.85	10.68	10.57	11.95	12.50
70	20.24	14.06	14.57	16.32	11.26	12.70	14.86
84	25.24	14.73	14.83	17.49	13.82	14.99	16.85
Means	12.74	8.40	8.17	9.13	7.31	8.43	
	The second season (2004).						
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	2.86	2.28	2.80	2.23	2.00	1.34	2.25
28	5.77	4.63	5.75	5.13	4.29	3.35	4.82
42	8.45	5.40	7.98	7.09	5.37	4.46	6.46
56	11.31	7.69	8.99	8.17	6.71	6.24	8.19
70	12.25	9.18	9.54	9.69	7.74	6.85	9.21
84	13.32	10.37	11.88	10.57	9.94	8.86	10.82
Means	7.71	5.65	6.71	6.13	5.15	4.44	
L.S.D. at 5%							
Factors		Post harvest treat.		Storage period		Interaction	
1st season		1.595		1.723		N.S.	
2nd season		1.097		1.185		2.903	

Table (2): Effect of waxing and GA_3 treatments on decay percentage of lime fruits during cold storage.

Storage period (days).	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Means
	The first season (2003).						
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42	8.08	0.00	0.00	0.00	0.00	0.00	1.35
56	16.14	0.00	0.00	0.00	0.00	0.00	2.69
70	27.07	6.75	3.82	1.59	0.00	4.67	7.32
84	43.64	14.79	8.76	13.15	0.00	6.23	14.43
Means	13.56	3.08	1.80	2.11	0.00	1.56	
	The second season (2004).						
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	3.02	0.00	0.00	0.00	0.00	0.50
42	3.98	5.33	2.62	0.00	0.00	0.00	1.99
56	12.21	6.32	5.58	7.30	5.19	4.59	6.87
70	33.84	12.60	13.20	12.62	7.48	5.84	14.26
84	58.03	34.38	43.47	40.17	31.18	26.47	38.95
Means	15.44	8.81	9.27	8.58	6.26	5.27	
L.S.D. at 5%							
Factors		Post harvest treat.		Storage period		Interaction	
1st season		3.634		3.926		N.S.	
2nd season		3.205		3.462		8.48	

Table (3): Effect of waxing and GA_3 treatments on firmness (gm./cm^2) of lime fruits during cold storage.

Storage period (days).	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Means
	The first season (2003).						
0	118.83	118.83	118.83	118.83	118.83	118.83	118.83
14	108.83	118.68	114.17	120.98	122.08	118.67	117.24
28	96.50	114.08	117.67	119.30	122.05	121.58	115.20
42	87.51	113.35	114.06	111.56	115.37	114.57	109.40
56	68.75	112.67	117.95	120.98	111.48	112.01	107.31
70	109.90	101.08	106.78	114.46	105.22	104.15	106.93
84	122.14	88.33	91.83	111.44	97.33	89.25	100.05
Means	101.78	109.57	111.61	116.79	113.19	111.29	
	The second season (2004).						
0	109.79	109.79	109.79	109.79	109.79	109.79	109.79
14	100.53	109.98	106.17	112.98	114.08	110.67	109.07
28	90.15	106.68	109.87	111.50	114.25	113.78	107.71
42	80.51	106.35	106.46	103.96	107.77	106.97	102.00
56	60.85	105.57	110.45	113.48	103.98	104.51	99.81
70	70.90	94.58	99.78	107.46	98.22	97.15	94.68
84	90.14	81.43	84.63	104.24	90.13	82.05	88.77
Means	86.12	102.05	103.88	109.06	105.46	103.56	

L.S.D. at 5%

Factors	Post harvest treat.	Storage period	Interaction
1st season	6.37	6.96	N.S.
2nd season	7.27	8.7	N.S.

3-Fruit lightness:

Data obtained in Table (4) cleared that, fruit lightness decreased gradually and significantly with prolonging of storage period during the two seasons in this work.

Data also indicated that, both of post harvest treatments (waxing and GA_3 dipping) significantly decreased the rate of darkness (deterioration of lightness) of Lime fruits during storage in the two seasons. Also data corresponded that, the combination between waxing and GA_3 dipping was more effective of reducing deterioration rate of lightness during storage than any of them alone.

4-colour transmission:

Data shown in Table (5) showed that, Lime fruits colour transmit from green (Hue angle = 180) to yellow (Hue angle = 90) during storage in the two season in this investigation. These results are in line with Bleinroth, *et al.*, (1976), Cohen, *et al.*, (1990), Predebon and Edwards (1992), El-Helaly (2002) and El-Helaly, *et al.*, (2002). They mentioned that, Lemon or Lime fruits showed colour development from green to yellow with the progress of storage period. Also data cleared that, postharvest treatments with waxing or GA_3 significantly inhibited the transmission of colour during storage either the treatments were individual or in combination. .

Table (4): Effect of waxing and GA_3 treatments on L "lightness" of lime fruits during cold storage.

Storage period (days).	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Means
	The first season (2003).						
0	50.55	50.55	50.55	50.55	50.55	50.55	50.55
14	49.08	49.15	48.72	49.48	50.50	52.74	49.95
28	47.86	51.84	45.98	50.76	50.13	50.39	49.49
42	46.62	49.41	44.86	45.26	51.30	49.56	47.84
56	44.10	52.04	48.39	47.51	51.43	48.66	48.69
70	44.19	44.88	48.36	44.01	47.18	47.04	45.94
84	41.68	46.58	46.53	46.95	42.99	45.87	45.10
Means	46.30	49.21	47.63	47.79	49.15	49.26	
	The second season (2004).						
0	56.23	56.23	56.23	56.23	56.23	56.23	56.23
14	51.28	54.92	53.82	51.07	56.30	55.27	53.78
28	52.02	54.70	52.56	56.02	55.68	56.00	54.50
42	51.30	53.23	51.11	49.62	55.83	54.95	52.67
56	48.53	53.01	49.48	51.73	54.30	54.50	51.93
70	49.31	53.78	49.26	48.36	54.02	53.39	51.35
84	47.98	52.56	48.93	49.25	52.80	56.17	51.28
Means	50.95	54.06	51.63	51.75	55.02	55.22	

L.S.D. at 5%

Factors	Post harvest treat.	Storage period	Interaction
1st season	2.05	2.298	5.07
2nd season	2.014	2.237	4.98

Table (5): Effect of waxing and GA_3 treatments on Hue angle of Lime skin fruits during cold storage

Storage period (days).	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Means
	The first season (2003).						
0	120.85	120.85	120.85	120.85	120.85	120.85	120.85
14	114.94	115.74	114.08	112.16	116.84	114.42	114.70
28	100.92	106.03	107.80	103.84	106.87	110.29	105.96
42	97.49	101.03	102.63	102.44	105.51	107.21	102.72
56	89.07	97.32	97.07	96.38	103.52	104.67	98.01
70	81.97	90.95	95.61	94.77	101.63	103.03	94.66
84	80.53	88.78	90.21	95.61	99.11	102.05	92.72
Means	97.97	102.96	104.04	103.72	107.76	108.93	
	The second season (2004).						
0	111.76	111.76	111.76	111.76	111.76	111.76	111.76
14	109.10	109.47	110.74	111.05	110.45	111.59	110.40
28	101.41	108.43	110.48	108.39	108.36	110.26	107.89
42	100.71	103.05	107.02	108.30	107.35	108.26	105.78
56	98.28	101.95	105.95	106.59	106.07	107.88	104.45
70	96.85	97.20	104.64	106.14	104.21	105.26	102.38
84	95.42	96.90	100.51	103.83	104.39	102.61	100.61
Means	101.93	104.11	107.30	108.01	107.51	108.23	

L.S.D. at 5%

Factors	Post harvest treat.	Storage period	Interaction
1st season	3.264	3.525	8.635
2nd season	2.296	2.479	6.073

Also, data cleared that, the combination of waxing and GA3 as a postharvest treatment was more effective for reducing colour transmission than the individual treatment of waxing or GA_3. These findings are in accordance with those obtained by El-Shiati, (1959), who mentioned that, waxing decreased the Egyptian lime color transformation during storage compared with unwaxed lime fruits.

Also these results are in correspondence with those obtained by Blunden, *et al.*, (1979) on Persian limes, Motlagh and Quantic, (1988) on Brazilian limes and El-Helaly (2002) on the Egyptian Banzahir limes, as they mentioned that GA_3 at 500 ppm was effective in reducing lime color transmission during storage or degreening.

5-Juice contents:

Data presented in Table (6) show that, Juice contents of Lime fruits significantly increased with the extension of the storage period until reached the maximum values at the 5th and 3rd period during the first and the second season respectively, then decreased until the end of the storage period in the two seasons in this study. These results are in line with those reported by Eaks and Masias (1965), Hegazi, *et al.*, (1988) and Cohen, *et al.*, (1990), who reported that, juice contents of Lime fruits increased gradually and significantly during storage and the last author added that, the percent of Juice showed a steady increase in stored Lemons during the first 3 months and then began to decline.

Data also indicated that, postharvest treatments with either waxing or GA_3 alone or in combination had no effect on juice contents of lime during storage.

These findings are in accordance with those reported by Mohammed *et al* (2003a) who found that, waxing or wrapping had no effect on juice contents of Valencia orange and Marsh seedless grapefruit fruits during cold storage.

6-Total soluble solid, Total acidity and Ascorbic acid (V.C.) contents of lime fruits:

Data presented in Tables (7, 8 and 9) and Figures (1 and 2) clearly show that, total soluble solids increased while total acidity and ascorbic acid contents of Lime decreased gradually and significantly during storage in the two seasons of this investigation. These results are in accordance with those found by Hegazi, *et al.*, (1988) on Lime, Rana, *et al.*, (1992) on Sweet orange, Attia, (1995) on Balady orange and Mohamed, *et al.*, (2003 a and b) on Valencia orange and Marsh seedless grapefruit. They reported that Total soluble solids increased gradually and significantly during storage. Also these results are in line with those reported by Hegazi, *et al.*, (1988) on Lime, Artes, *et al.*, (1993), on Lemon, El-Helaly (2002), on Lime, El-Helaly, *et al.*, (2002), on Lime and Mohamed, *et al.*, (2003 a and b), on Valencia orange and Marsh seedless Grapefruit. They mentioned that total acidity contents of citrus fruits significantly decreased during storage. Moreover these results are supported by El-Shiati, (1959) on Lime, El-Helaly (2002), on Lime and Mohamed, *et al.*, (2003 a and b), on Valencia orange

and Marsh seedless Grapefruit. They suggested that V.C. contents of citrus fruits decreased gradually and significantly with advanced storage period. On contrary these findings disagree with those reported by Arets, *et al.*, 1983 on Lemon who mentioned that, total soluble solids of Lemon fruits did not change while ascorbic acid contents increased during storage. Also disagree with those reported by El-Helaly, (2002) and El-Helaly, *et al.*, (2002) on Lime as they found that, Total soluble solids in lime decreased during storage.

According to data presented in Tables (7, 8 and 9) and Figures (1 and 2) it's obvious that, postharvest waxing or GA_3 dipping significantly reduced postharvest change rate of total soluble solids, Total acidity and ascorbic acid content of Lime fruits during storage. Also data cleared that, postharvest treatments with either waxing or GA_3 dipping individually or in combination significantly reduced total soluble solids and total acidity while it increased ascorbic acid contents during storage. Also, it's clear from data illustrated in figures (1, 2 and 3) that, postharvest waxing or GA_3 dipping treatments delayed the inverse point which appeared with control fruits in total soluble solids and total acidity contents at the last periods of storage period. These results agree with those reported by El-Helaly, (2002) on Lime, El-Helaly, *et al.*, (2002) on Lime and Mohamed, *et al.*, (2003 a) They reported that, waxed or wrapped citrus fruits had significantly lower Total soluble solids and higher contents of total acidity and ascorbic acid at the end of the storage. On the contrast, El-Shaity, (1959) reported that, waxing had no effect on lime fruit contents (T.S.S., Total acidity and ascorbic acid) during storage. Also El-Helaly, *et al.*, (2002) added that, postharvest treatments with either GA_3 or I.B.A. had no effect on Lime fruit contents (T.S.S., Total acidity and ascorbic acid) during storage.

7- Pigments (Chlorophyll "a", Chlorophyll "b" and carotenes):

Data illustrated in Tables (10, 11 and 12) show that, Lime fruit peel contents of chlorophyll "a" and chlorophyll "b" gradually and significantly decreased while carotenes increased during storage in the two seasons of this work.

These results are in line with those reported by El-Helaly, (2002), and El-Helaly, *et al.*, (2002).

Data also illustrated that, postharvest treatments with either waxing or GA_3 individually or in combination significantly delayed the Lime fruits color transmutation. Data also viewed that, Lime fruit peels treated with GA_3 50 ppm or 75 ppm either alone or associated with waxing had the highest chlorophyll "a" and chlorophyll "b" contents and the lowest carotenes at the end of storage period compared with untreated or waxed only. However the peel of waxed lime fruits had chlorophyll "a" and chlorophyll "b" significantly higher than untreated fruit and had carotenes significantly less than the peel of the untreated fruits at the end of storage period.

These results are in accordance with those reported by Blunden, *et al.*, (1979) on Limes, Motlagh and Quantic, (1988), on Limes and El-Helaly, (2002), on Limes. They reported that GA_3 as 500 ppm was effective in delaying degreening of Lime fruits during storage.

Table (6): Effect of waxing and GA_3 treatments on Juice percentage of lime fruits during cold storage.

Storage period (days).	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Means
	The first season (2003).						
0	50.45	50.45	50.45	50.45	50.45	50.45	50.45
14	53.28	51.38	53.67	51.15	52.04	51.09	52.10
28	56.15	53.55	55.32	55.43	56.24	57.35	55.67
42	54.18	53.67	55.44	57.27	56.22	57.83	55.77
56	58.38	57.53	57.85	56.72	54.12	54.47	56.51
70	52.99	58.13	53.81	54.43	53.60	54.24	54.53
84	50.89	52.73	54.62	55.00	54.69	53.35	53.55
Means	53.76	53.92	54.45	54.35	53.91	54.11	
	The second season (2004).						
0	52.44	52.44	52.44	52.44	52.44	52.44	52.44
14	54.65	55.19	55.36	54.37	53.82	54.37	54.63
28	56.64	55.64	56.59	57.45	57.24	56.26	56.64
42	56.55	55.61	55.48	55.28	54.16	55.96	55.51
56	54.03	54.93	54.75	54.33	54.47	55.28	54.63
70	53.36	54.19	53.53	53.02	54.18	54.12	53.73
84	51.68	52.10	51.78	52.62	54.09	53.78	52.68
Means	54.19	54.30	54.28	54.22	54.34	54.60	

L.S.D. at 5%

Factors	Post harvest treat.	Storage period	Interaction
1st season	N.S.	3.87	N.S.
2nd season	N.S.	3.05	N.S.

Table (7): Effect of waxing and GA_3 treatments on Total Soluble Solids percentage of lime fruit during cold storage.

Storage period (days).	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Means
	The first season (2003).						
0	8.83	8.83	8.83	8.83	8.83	8.83	8.83
14	9.41	9.03	9.50	9.45	9.08	9.03	9.25
28	9.60	9.60	9.69	9.68	9.00	9.20	9.46
42	9.72	9.28	9.68	9.32	9.36	9.68	9.51
56	10.00	10.16	9.42	9.50	9.80	9.54	9.74
70	9.58	10.32	9.60	9.54	9.54	9.66	9.71
84	9.54	10.14	9.90	9.70	9.76	9.51	9.76
Means	9.53	9.62	9.52	9.43	9.34	9.35	
	The second season (2004).						
0	8.70	8.70	8.70	8.70	8.70	8.70	8.70
14	8.90	8.87	8.83	9.00	9.03	9.10	8.96
28	9.30	9.00	9.27	9.10	9.27	9.03	9.16
42	9.73	9.10	9.30	9.30	9.07	9.27	9.30
56	9.97	9.37	9.32	9.33	9.37	9.23	9.43
70	9.87	9.60	9.33	9.33	9.23	9.33	9.45
84	9.20	9.80	9.57	9.37	9.43	9.40	9.46
Means	9.38	9.21	9.19	9.16	9.16	9.15	

L.S.D. at 5%

Factors	Post harvest treat.	Storage period	Interaction
1st season	0.17	0.2	0.41
2nd season	0.11	0.15	0.29

Table (8): Effect of waxing and GA_3 treatments on Total acidity % of lime fruit during cold storage.

Storage period (days).	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Means
	The first season (2003).						
0	9.13	9.13	9.13	9.13	9.13	9.13	9.13
14	8.77	8.53	8.37	8.43	8.47	8.63	8.53
28	8.47	8.50	8.83	8.97	8.47	8.83	8.68
42	9.03	8.97	9.27	8.80	8.80	8.77	8.94
56	9.47	8.90	8.53	8.63	8.33	8.87	8.79
70	9.57	9.23	9.00	8.70	8.67	8.60	8.96
84	9.77	9.27	8.80	9.06	8.73	8.63	9.04
Means	9.17	8.93	8.85	8.82	8.66	8.78	
	The second season (2004).						
0	8.92	8.92	8.92	8.92	8.92	8.92	8.92
14	8.60	8.52	8.32	8.20	8.82	8.28	8.46
28	8.48	8.44	8.40	8.44	8.48	8.44	8.45
42	8.16	7.84	8.16	8.16	8.12	8.28	8.12
56	7.90	7.76	8.12	8.04	7.96	7.94	7.95
70	7.94	7.15	7.44	7.65	7.54	7.69	7.57
84	9.08	7.72	7.44	7.51	7.51	7.47	7.79
Means	8.44	8.05	8.11	8.13	8.19	8.15	

L.S.D. at 5%

Factors	Post harvest treat.	Storage period	Interaction
1st season	0.19	0.21	0.52
2nd season	0.2	0.22	0.54

Table (9): Effect of waxing and GA_3 treatments on V. C. (mg/100ml. Juice) of lime fruit during cold storage.

Storage period (days).	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Means
	The first season (2003).						
0	52.92	52.92	52.92	52.92	52.92	52.92	52.92
14	50.98	43.23	46.55	55.42	42.12	46.55	47.48
28	30.67	43.33	40.00	41.33	39.33	41.33	39.33
42	36.00	36.67	40.00	40.67	39.33	42.00	39.11
56	36.00	40.67	38.67	35.33	41.33	40.67	38.78
70	21.21	32.18	31.22	30.75	30.98	33.61	29.99
84	11.60	15.02	16.92	18.11	15.97	18.83	16.08
Means	34.20	37.72	38.04	39.22	37.43	39.42	
	The second season (2004).						
0	67.99	67.99	67.99	67.99	67.99	67.99	67.99
14	57.33	56.33	58.00	58.00	57.33	66.67	58.94
28	52.33	51.33	48.33	50.33	53.33	54.00	51.61
42	44.33	49.08	48.81	50.57	52.72	52.94	49.74
56	40.76	44.33	45.28	49.82	49.10	48.38	46.28
70	38.72	42.66	42.07	43.97	46.83	43.74	43.00
84	35.10	42.05	41.39	41.61	41.61	38.99	40.13
Means	48.08	50.54	50.27	51.76	52.70	53.24	

L.S.D. at 5%

Factors	Post harvest treat.	Storage period	Interaction
1st season	11.17	12.06	29.65
2nd season	9.27	10.02	24.55

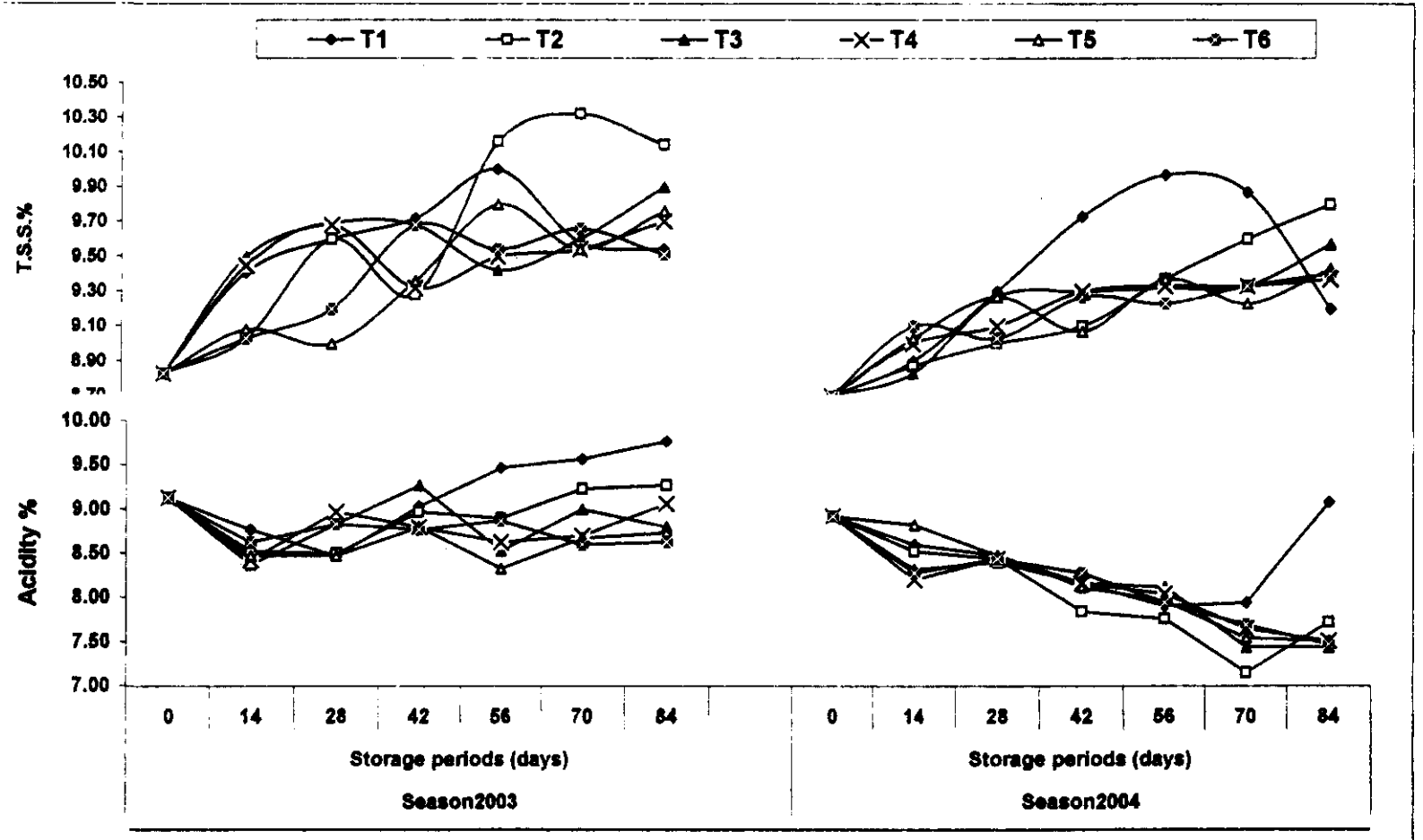

Fig. (1): Effect of Waxing and GA3 treatments on T.S.S.% andTotal acidity % of Lime fruits during storage.

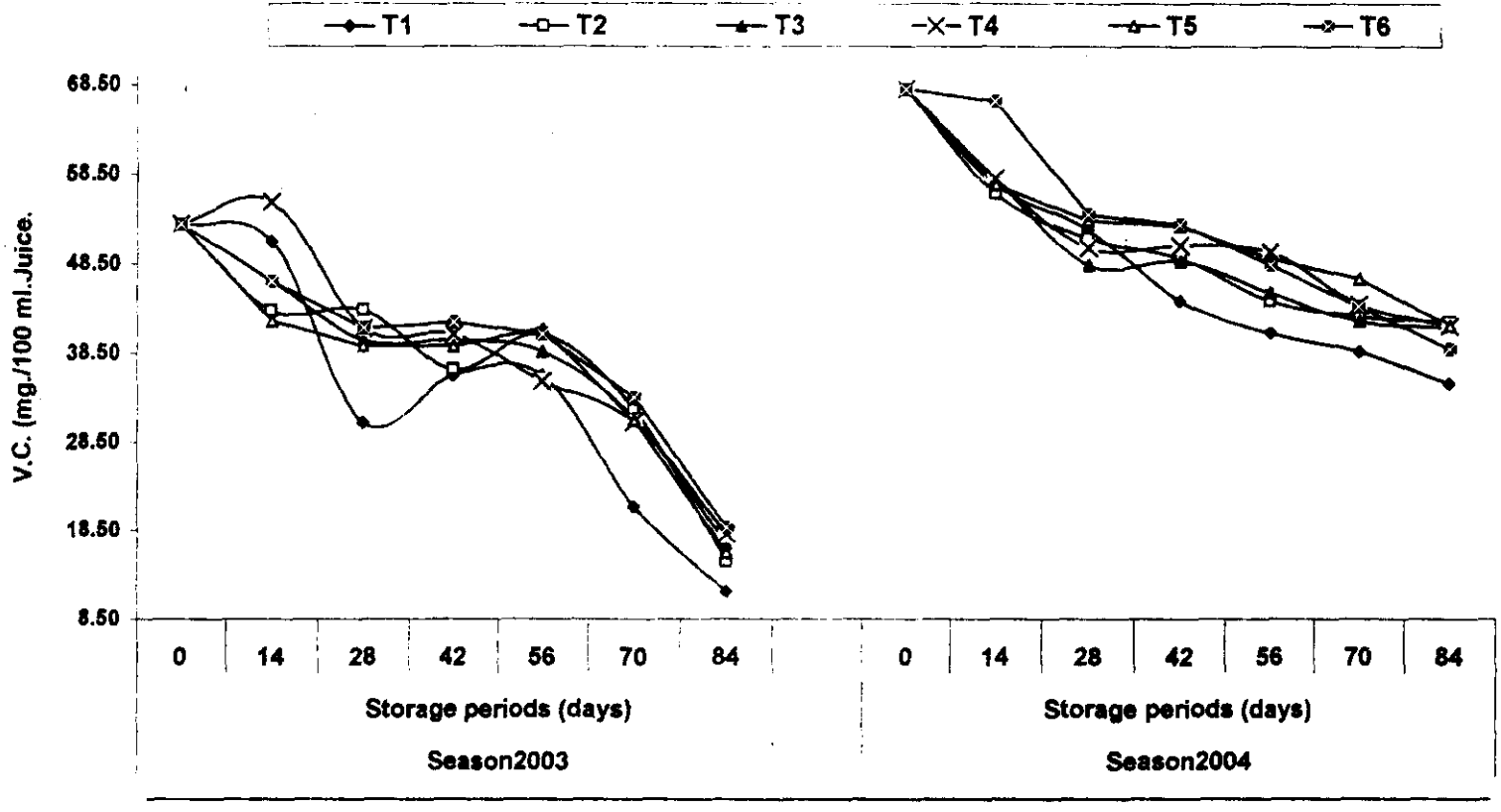

Fig. (2): Effect of Waxing and GA3 treatments on V.C. (mg./100 ml. Juice) of Lime fruits during storage.

Table (10): Effect of waxing and GA_3 treatments on Chlorophyll A content (mg/100g. Juice) of lime fruit skins during cold storage.

Storage period (days).	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Means
	The first season (2003).						
0	82.35	82.35	82.35	82.35	82.35	82.35	82.35
14	75.78	81.09	80.14	75.04	81.09	85.49	79.77
28	53.00	60.61	61.31	63.73	72.95	76.98	64.76
42	33.87	58.59	55.67	41.19	70.48	57.28	52.85
56	27.60	57.87	59.98	42.66	50.72	61.46	50.05
70	25.68	34.12	55.76	34.20	46.96	37.58	39.05
84	15.90	26.88	33.66	30.63	34.04	34.73	29.31
Means	44.88	57.36	61.27	52.83	62.66	62.27	
	The second season (2004).						
0	94.57	94.57	94.57	94.57	94.57	94.57	94.57
14	63.60	60.71	69.11	65.78	73.14	66.47	66.47
28	54.59	43.03	67.71	62.52	62.85	65.94	59.44
42	35.83	40.40	53.52	49.89	48.17	55.82	47.27
56	19.25	34.96	52.45	39.82	44.47	49.32	40.05
70	12.63	39.12	35.21	39.08	37.80	44.47	34.72
84	6.41	31.55	34.96	31.51	32.41	38.79	29.27
Means	40.98	49.19	58.22	54.74	56.20	59.34	

L.S.D. at 5%

Factors	Post harvest treat.	Storage period	Interaction
1st season	12.06	13.02	N.S.
2nd season	5.35	5.78	N.S.

Table (11): Effect of waxing and GA_3 treatments on Chlorophyll B content (mg/100g. Juice) of lime fruit skins during cold storage.

Storage period (days).	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Means
	The first season (2003).						
0	81.74	81.74	81.74	81.74	81.74	81.74	81.74
14	66.01	73.11	84.91	73.34	81.85	82.39	76.94
28	38.91	61.57	62.00	54.37	64.00	78.32	59.86
42	37.40	47.28	62.86	49.36	51.29	77.58	54.30
56	30.36	31.84	38.44	38.79	42.36	54.65	39.41
70	29.87	28.02	30.14	31.34	31.03	31.72	30.35
84	13.11	28.68	27.31	21.65	34.05	30.10	25.82
Means	42.49	50.32	55.34	50.08	55.19	62.36	
	The second season (2004).						
0	96.07	96.07	96.07	96.07	96.07	96.07	96.07
14	64.25	79.70	89.72	75.36	72.10	76.99	76.35
28	52.14	62.14	67.00	69.95	68.21	71.13	65.10
42	45.08	59.30	65.51	65.96	63.78	63.67	60.55
56	34.65	44.36	62.14	44.13	48.05	56.25	48.26
70	35.41	31.63	58.94	34.00	44.20	39.32	40.58
84	22.87	31.43	43.79	41.05	47.62	48.98	39.29
Means	50.07	57.80	69.02	60.93	62.86	64.63	

L.S.D. at 5%

Factors	Post harvest treat.	Storage period	Interaction
1st season	13.79	14.9	N.S.
2nd season	7.86	8.49	N.S.

Table (12): Effect of waxing and GA_3 treatments on Carotens content (mg/100g. Juice) of lime fruit skins during cold storage

Storage period (days).	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Means
	The first season (2003).						
0	21.77	21.77	21.77	21.77	21.77	21.77	21.77
14	35.88	27.22	23.73	34.89	26.97	20.32	28.17
28	40.25	28.99	30.53	35.09	23.82	23.55	30.37
42	60.38	39.44	33.70	52.96	28.53	29.10	40.69
56	63.94	42.68	32.32	55.36	31.40	32.49	43.03
70	73.93	43.51	33.76	57.11	31.75	31.30	45.23
84	71.01	47.19	40.66	65.66	39.31	33.98	49.64
Means	52.45	35.83	30.92	46.12	29.08	27.50	
	The second season (2004).						
0	17.93	17.93	17.93	17.93	17.93	17.93	17.93
14	22.22	18.37	15.14	18.17	15.63	16.61	17.69
28	22.68	21.71	20.69	19.96	14.57	16.83	19.41
42	23.35	20.12	14.89	14.78	15.06	14.84	17.17
56	29.39	22.07	17.47	18.89	16.76	16.32	20.15
70	32.37	23.58	16.26	14.53	19.55	17.01	20.55
84	39.08	28.35	16.62	15.86	19.72	18.75	23.06
Means	26.72	21.73	17.00	17.16	17.03	16.90	

L.S.D. at 5%			
Factors	Post harvest treat.	Storage period	Interaction
1st season	5.76	6.22	N.S.
2nd season	3.12	3.38	N.S.

Also these results are in line with those reported by El-Shiati, (1959) who reported that, waxing decreased lime colour transmission compared with unwaxed fruits during storage.

ACKNOWLEDGMENTS

This research was supported by the National Program for Promoting the productivity and exportability of some horticultural crops. The authors are grateful to Dr. Hesham Gawad (Fresno, California) for his great assistance during this work.

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دراسات فسيولوجية على ثمار الليمون البلدى
١- تأثير المعاملة بالتشميع والجبريليك أسيد بعد الحصاد على الجودة والقدرة التخزينية لثمار الليمون.

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اجرى هذا البحث على ثمار ليمون من مزرعة خاصة بمحافظة القليوبية حيث حصدت ثمار الليمون خلال الموسم ٢٠٠٣، ٢٠٠٤ عند الوصول الى مرحلة اكتمال النمو. عندئذ تم فرز و غسيل و تجفيف الثمار وتشميعها او غمسها فى محلول من الجبريلين بتركيز ٥٠ او ٧٥ جزء فى المليون لمدة خمسة دقائق او عوملت بالمعاملتين معا (تشميع + معاملة بالجبريلين بأى من التركيزين). ثمار الكنترول تم فرزها و غسلها و تجفيفها فقط لاغير. تم تخزين الثمار لمدة ٨٤ يوم على درجة ١٣ °م و ٩٠ ٪ رطوبة نسبية. تم أثناء التخزين دراسة الخواص الطبيعية والكيميائية للثمار.

أدت معاملة الثمار بالتشميع أو الجبريلين ٥٠ أو ٧٥ جزء فى المليون سواء منفردين أو بالتلازم مع التشميع إلى تقليل الفقد فى الوزن والتلف فى ثمار الليمون أثناء التخزين مقارنة بالثمار غير المعاملة. كذلك، قللت هذه المعاملات بدرجة ملحوظه التناقص فى صلابة الثمار والتدهور فى خصائص جودتها (نسبة العصير واللون ونسبة المواد الصلبة الذائبة ونسبة الحموضة ومحتوى العصير من فيتامين ج).

بالإضافة إلى ذلك فإن المعاملة بالجبريلين بتركيز ٥٠ جزء فى المليون نفس كفاءة التركيز الأعلى (٧٥ جزء فى المليون) فى المحافظة على جودة الثمار أثناء التخزين. كذلك يؤكد هذا البحث على أهمية اجراء عمليه التشميع والمعاملة بالجبريلين بأى من التركيزين المستخدمين (٥٠ أو٧٥ جزء فى المليون) للمحافظة على جودة ثمار الليمون أثناء التخزين.