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PHYSIOLOGICAL STUDIES ON EGYPTIAN LIME FRUITS, II- EFFECT OF MICRO VENTILATION RATE ON LIME FRUIT QUALITY AND STORABILITY.

BY

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ABSTRACT

This investigation was carried out during two successive seasons (2003 and 2004) at the Horticulture Research Institute, Fruit handling Department. Lime fruits were picked from a private farm at Kalubia Government. Fruit were transported directly to the laboratory to be sorted, washed, waxed and packed into a non-ventilated, normal ventilated or micro-ventilated bags (2,4,6,8 micro holes per bags, 1 mm. in diameter). Fruits physical and chemical properties were analyzed at 14 days intervals. Lime fruit packaged inside non-ventilated bags had the highest decay percentage and the lowest weight loss during storage compared with the other treatments. Lime fruits packaged inside micro-ventilated bags had the lowest decay incidence compared with the other treatments.

Also lime fruits packaged inside micro-ventilated bags had weight loss incidence less than packaged lime fruits inside normal ventilated. Micro-ventilated bags significantly reduced the deterioration rate of lightness and the dehydration of pigments during storage compared with fruits packaged inside normal- ventilated bags. Micro-ventilation rate had no effect on fruit contents juice percentage, Total Soluble Solids, Total acidity and V.C. during storage. Non-ventilation rate lead to accumulate high concentration of CO_2 which appeared to cause some damage for fruits. This study confirmed that micro-ventilation rate can be used instead of normal-ventilation rate in order to decrease decay and weight loss during marketing or storage without any bad effect on fruit quality parameters.

INTRODUCTION

Limes are popular to the Egyptian consumer as beverage, for food flavoring and as a source of vitamin C. Lime fruits are extensively used all year round. Therefore, it's of major importance to increase the grower's income. Lime also had a good opportunity to increase its exported quantity (NARP, 1994). Optimal storage for Lime is 13°C to avoid chilling injury but long term storage at that temperature lead to fruit senescence and fungal decay (Cohen, and Schiffmann-Nadel, 1978). Loss of the peel green color is due to loss of the green pigments. Chlorophyll development of the yellow color in the peel due to the

formation of Caroteniod pigments (Sanson, 1986; Nakasone and Paull, 1999 from El-Bassiouny, 2003). High density polyethylene (HDPE) wraps delayed loss of firmness and peel coloration of lemons for up to 6 months with the fruit kept at 17 to 20°C (Ben-Yehoshua, *et al.*, 1983 and Sharkey, *et al.*, 1985). Packaging significantly reduced weight loss and the positive results were obtained by storing lime fruits at 10°C. Packing green lime fruits stored at 10°C had no unmarketable fruits after 12 weeks of storage (El-Helaly, *et al.*, 2002). However, waxed fruits that also seal-packaged was found to accumulate ethanol and off flavors (Albrigo and Fellers, 1983; Albrigo and Ismail, 1983 and Purvis, 1983). Storage of numerous perishable produce in modified atmosphere (M.A.) was effective in reducing the undesirable effects of ethylene, lowering their metabolic activities and extending their shelf life. This is achieved by reducing O_2 level and increasing that of CO_2 in the storage environment compared to their percentage in the air (21.3% and 0.03% respectively) Yehia, 1997 and 1998 and Kader, 2002.

The physiological needs of the stored produce define the optimum levels of each of these gases, while the produce tolerance to high CO_2 and low O_2 levels define their limits. The desirable effects of modified atmosphere (M.A.) could be achieved by placing the fruits in a bag made of special film and is referred as modified atmosphere packaging. The film should be selected to have desired gas transition, O_2, CO_2 and water vapor to maintain the desired modified environment of atmosphere O_2%, CO_2% and R.H. % to minimize the postharvest changes that lead to fruit deteriorate (Schlimme and Rooney, 1994).

However, the desirable packaging film should maintain the levels of these gases within the proper needs and tolerance limits of packaged fruits since too low O_2 level would lead to anaerobic respiration and off taste (Kader, 1986 and 2002) and too high CO_2 level would cause numerous undesirable effects (Kader, 1986 and 2002 and Watkins, 2000).

Studies on consumer packaging of citrus were dominated for some years by tests as to whether plastic bags are needed to be perforated, and if so how much ventilation was adequate. The Florida citrus commission 1960, standardized ventilation for 5 Lb. (2.27 Kg.) polyethylene bags for Florida citrus at minimum of 72 one-forth inch (6.35 mm.) holes (Grierson, 1969).

The present investigation was carried out to study the effect of some micro-ventilation rate compared with normal-ventilation rate or non-ventilation at all on lime fruits quality and storability.

MATERIALS AND METHODS

This investigation was carried out during two successive seasons (2003 and 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 Kalubia Government were selected.

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

Treat. 1: packaged in normal ventilated polyethylene bags each had 10 holes (5mm. in diameter) (Grierson, 1969).

Treat. 2: packaged in non-ventilated polyethylene bags.

Treat. 3, 4, 5, 6: packaged in polyethylene bags had 2, 4, 6, 8 micro holes (1 mm. in diameter) all bags had the same size (15 X 35 cm.) and 330 gm. of lime only.

Every treatment had 18 bags (10 μ m. in thickness), at 14 day intervals samples were taken and the fruit physical and chemicals properties were measured or calculated as following:

- Weight loss % and decay % were calculated as the following equals:
  - a- Weight loss % = fruits weight of bags at the examination date ×100/ the initial weight of bags (at the start of the experiment (330gm.).
  - b- Decay % =decayed fruits per bags ×100 /the initial weight of bags.
- Juice content was 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 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 abb'e 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.
- Gas measurements within the headspace atmosphere of the bags were estimated using a sampling syringe inserted through a septum. The gas samples were analyzed for CO_2 and O_2 concentrations using a DualTrak model 902D Gas analyzer (Quantek Instruments, USA).

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 percentage:

Data presented in Table (1) show that, weight loss percentage increased gradually and significantly with prolonging the storage period in the two seasons of this investigation.

These results are in accordance with those obtained by El-Shaiti, 1959; Corini and Testoni, 1988 on lemon; Hegazi, *et al.*, 1988 on lime; Eaks, 1990 on lemon; El-Helaly, 2002 and El-Helaly, *et al.*, 2002, on lime. They reported that, weight loss in lime or lemon increased gradually and significantly with the extension of the storage period.

Data also cleared that, no ventilation or micro ventilation rate significantly reduced weight loss incidence of lime fruits during storage compared with the normal ventilation rate.

Data also indicated that, weight loss percentage increased gradually but non-significantly with the increasing micro-ventilation rate. The same trend was clear in the second season.

These results agree with those obtained by Ben-Yehoshua, *et al.*, (1987) on lemon, Corini and Testoni, 1988 on lemon; and El-Helaly, *et al.*, 2002, on lime. They found that, seal packaging significantly reduced weight loss incidence during storage.

2- Decay percentage:

It is obvious from data presented in Table (2) that, decay percentage of stored lime fruits increased gradually and significantly with the extension of the storage period during the two seasons in this investigation.

These results confirm with those obtained by Salem, *et al.*, 1988 on lime; El-Helaly (2002) on lime and El-Helaly, *et al.* (2002) on lime. They suggested that, decay incidence of lime increased gradually and significantly with prolonging the storage period.

Also it is clear from the previous data that, micro-ventilation rate significantly reduced decay incidence of lime during storage compared with normal-ventilation or non-ventilation of bags. Moreover normal-ventilation rate also significantly reduced decay incidence of lime fruit during storage compared with non-ventilation of bags.

Date also showed that, all micro-ventilation rate had the same effect on reducing the incidence of decay. This trend was obvious during the two seasons in this work.

These results confirmed by Ben-Yehous, *et al.*, 1987 on lemon; Cohen, *et al.*, 1990, on lemon; El-Zayat, *et al.*, 1998 on lime and El-Helaly, *et al.*, 2002, on lime. They found that, packaging significantly reduced decay incidence during storage.

Table (1): Effect of Ventilation rate 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	3.08	0.39	0.39	0.00	0.33	0.25	0.74
28	6.93	0.50	0.77	0.60	0.71	0.85	1.73
42	8.76	0.65	1.10	1.02	0.86	0.97	2.23
56	9.79	0.84	1.21	1.56	1.23	1.08	2.62
70	13.42	1.51	1.23	1.83	2.01	1.59	3.60
84	14.76	1.55	1.43	1.97	2.12	3.49	4.22
Means	8.11	0.78	0.88	1.00	1.04	1.18	
	The second season (2004).						
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	2.66	0.34	0.49	0.74	0.89	1.22	1.06
28	4.71	0.51	0.54	1.10	1.54	1.68	1.68
42	6.69	0.88	1.27	1.43	2.02	2.31	2.43
56	9.86	0.92	1.46	1.66	2.10	2.49	3.08
70	11.01	1.29	2.14	2.24	2.49	2.68	3.64
84	12.17	1.54	2.31	2.92	3.06	3.16	4.19
Means	6.73	0.78	1.17	1.44	1.73	1.93	
L.S.D. at 5%							
Factors		Ventilation rate		Storage period		Interaction	
1st season		0.36		0.39		0.99	
2nd season		0.69		0.75		1.82	

Table (2): Effect of Ventilation rate 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	2.64	0.00	0.00	0.00	0.00	0.00	0.44
28	3.35	3.58	4.04	0.00	0.00	0.00	1.83
42	5.76	45.25	6.48	0.00	0.00	0.00	9.58
56	6.00	61.38	6.44	0.00	0.00	0.00	12.30
70	13.96	86.18	6.70	3.72	4.50	6.03	20.18
84	31.55	98.17	8.75	5.50	8.63	10.46	27.18
Means	9.04	42.08	4.63	1.32	1.88	2.36	
	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	8.92	0.00	0.00	0.00	0.00	1.49
42	3.98	23.03	2.94	2.82	0.00	0.00	5.46
56	12.21	34.92	6.49	6.87	5.82	6.22	12.09
70	19.84	59.47	8.61	12.70	9.91	11.44	20.33
84	33.84	85.47	12.76	15.18	12.09	13.34	28.78
Means	9.98	30.26	4.40	5.37	3.97	4.43	
L.S.D. at 5%							
Factors		Ventilation rate		Storage period		Interaction	
1st season		3.38		3.65		8.96	
2nd season		4.8		5.18		12.7	

3-Fruit Firmness:

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

These results are in line with those found by Ben-Yehoshua, *et al.*, 1987 on lemon, who reported that lemon fruit firmness decreased gradually and significantly with the extension of storage period

Also we can conclude from the same date that, fruits packaged inside non-ventilated or micro-ventilated bags had higher firmness than fruits packaged into normal-ventilated bags. However, fruits packaged inside non-ventilated lost its firmness rapidly during the first stages of storage then fluctuated to be raised again until reached the maximum at the end of storage period (Table 3 and figure 1).

These results are in line with those mentioned by Ben-Yehoshua, *et al.*, 1983 on lemon; Cohen, *et al.*, 1990, on lemon; El-Zayat, *et al.*, 1998 on lime and lemon. They reported that, individual seal packaging of fruits with high density polyethylene significantly reduced the deterioration rat of fruit firmness during storage.

4-Fruit lightness:

Data shown in Table (4) obtained that, lightness decreased significantly as the storage period increased during the two seasons in this investigation.

Also data cleared that, lime fruits packed inside bags with micro-ventilation rate had the highest lightness compared with the other fruits which were stored inside non-ventilated or normal-ventilated bags.

5-colour transmission (hue angle):

Data presented in Table (5) cleared that, fruit color (as hue angle) changed gradually and significantly from green (hue angle = 180 or less) to yellow (hue angle = 90) with the extension of the storage period during the two seasons in this study.

Also data shown in Table (5) cleared that, micro-ventilation rate reduced the color transmutation rate from green to yellow compared with normal-ventilation rate. These results are in accordance with those mentioned by Bleinroth, *et al.*, 1976; Predebon and Edwards (1992); El-Helaly (2002) and El-Helaly, *et al.* (2002). They reported that, lemon or lime fruit color changed gradually and significantly from green to yellow with prolonging the storage period.

6-Juice contents:

Data illustrated in Table (6) cleared that, lime fruit juice contents increased gradually and significantly during the first stages of storage (at the 10^{th} and 6^{th} weeks during the first and the second season's respectively) then tended to decrease till the end of storage period. These results are in line with those obtained by Hegazi, *et al.* (1988) and Cohen, *et al.* (1990). They reported that juice contents of lime or lemon fruits increased with the extension of storage period. Also the last author indicated that, this increase had been reflected to begin decreasing at the last of storage period.

Table (3): Effect of Ventilation rate treatments on firmness (gm./cm2) 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	108.72	114.92	116.08	113.04	117.58	115.92	114.38
28	102.92	105.92	108.33	115.18	115.92	112.00	110.05
42	104.00	99.75	99.95	112.51	110.87	111.66	106.46
56	101.36	96.41	105.97	108.24	107.18	110.68	104.97
70	104.78	117.22	103.50	110.61	104.08	106.67	107.81
84	98.58	132.90	95.97	102.50	101.54	100.89	105.40
Means	105.60	112.28	106.95	111.56	110.86	110.95	
	The second season (2004).						
0	109.79	109.79	109.79	109.79	109.79	109.79	109.79
14	96.82	103.02	104.18	101.14	105.68	104.02	102.48
28	90.52	93.52	100.93	102.78	103.52	99.60	98.48
42	92.40	88.15	96.90	100.91	99.27	100.06	96.28
56	90.36	85.41	95.93	97.24	96.18	99.68	94.13
70	92.28	104.72	86.90	98.11	91.58	94.17	94.63
84	86.38	120.70	84.97	90.30	89.34	88.69	93.40
Means	94.08	100.76	97.09	100.04	99.34	99.43	

L.S.D. at 5%

Factors	Ventilation rate	Storage period	Interaction
1st season	5.02	5.43	13.29
2nd season	4.56	4.97	10.91

Table (4): Effect Ventilation rate 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	51.81	50.90	51.57	49.79	51.51	50.48	51.01
28	48.80	48.08	51.49	49.67	51.75	49.05	49.81
42	46.51	49.04	49.34	48.79	48.75	49.05	48.58
56	45.34	43.67	48.19	49.94	49.49	47.26	47.32
70	42.79	40.84	47.74	47.77	46.34	46.24	45.29
84	40.61	39.65	45.28	43.39	44.62	45.79	43.22
Means	46.63	46.10	49.17	48.56	49.00	48.35	
	The second season (2004).						
0	56.23	56.23	56.23	56.23	56.23	56.23	56.23
14	54.62	55.41	55.46	54.79	54.41	58.44	55.52
28	50.50	50.75	59.86	57.67	56.24	55.57	55.10
42	50.94	52.82	54.91	55.77	53.03	54.69	53.69
56	49.68	51.12	53.53	53.23	53.59	55.62	52.80
70	48.35	50.01	54.20	53.90	54.25	53.91	52.44
84	42.13	49.68	54.64	54.45	54.81	51.76	51.25
Means	50.35	52.29	55.55	55.15	54.65	55.17	

L.S.D. at 5%

Factors	Ventilation rate	Storage period	Interaction
1st season	1.69	1.72	4.21
2nd season	1.93	2.08	5.11

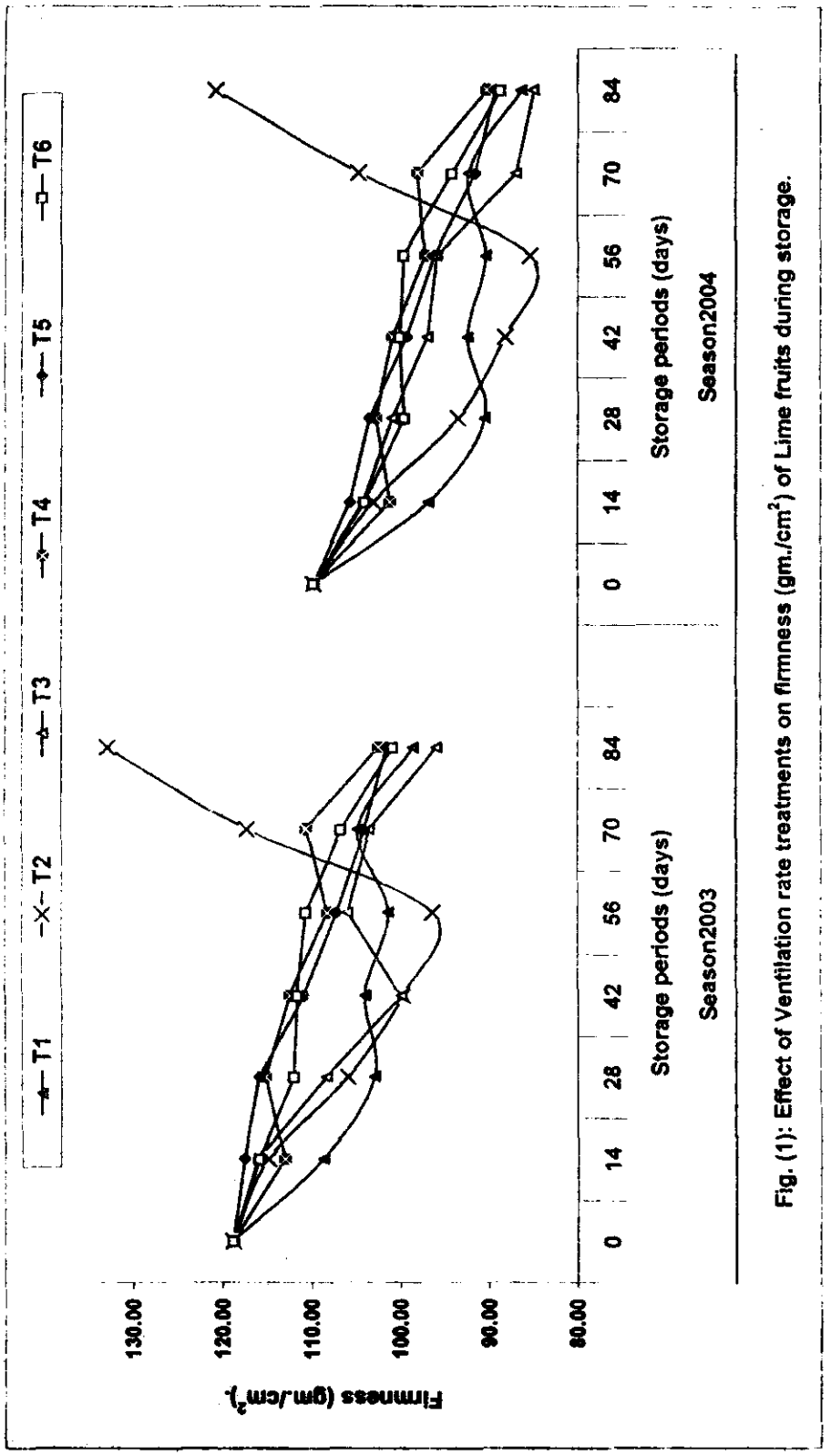

Fig. (1): Effect of Ventilation rate treatments on firmness (gm./cm^2) of Lime fruits during storage.

Table (5): Effect of Ventilation rate 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	107.10	110.80	112.54	109.72	113.41	115.33	111.48
28	103.60	106.45	104.21	107.22	102.09	106.47	105.01
42	98.93	104.76	103.65	103.54	101.95	103.72	102.76
56	96.98	100.15	102.60	102.26	100.28	101.94	100.70
70	95.77	99.60	101.26	99.95	98.16	100.82	99.26
84	93.22	97.35	95.41	95.00	95.42	99.12	95.92
Means	102.35	105.71	105.79	105.51	104.59	106.89	
	The second season (2004).						
0	111.76	111.76	111.76	111.76	111.76	111.76	111.76
14	105.04	104.42	103.72	107.57	105.27	106.37	105.40
28	101.05	102.37	103.43	107.38	103.57	104.36	103.69
42	96.78	101.76	103.08	103.56	100.73	101.67	101.26
56	96.13	101.41	102.16	99.40	99.23	101.22	99.93
70	94.31	98.26	102.21	97.78	98.24	97.82	98.10
84	92.42	97.95	101.37	95.68	97.17	96.90	96.92
Means	99.64	102.56	103.96	103.30	102.28	102.87	

L.S.D. at 5%

Factors	Ventilation rate	Storage period	Interaction
1st season	3.27	3.53	8.64
2nd season	2.85	3.08	7.55

Table (6): Effect of Ventilation rate 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	54.61	54.80	54.62	53.06	52.45	52.34	53.65
28	55.97	56.18	55.88	57.85	54.57	54.33	55.80
42	58.21	57.20	56.34	56.51	55.67	57.82	56.96
56	54.10	55.48	57.71	55.42	56.35	55.57	55.77
70	56.54	55.39	58.13	55.77	55.76	54.91	56.08
84	51.34	50.93	52.79	53.81	54.85	53.10	52.80
Means	54.46	54.35	55.13	54.70	54.30	54.07	
	The second season (2004).						
0	52.44	52.44	52.44	52.44	52.44	52.44	52.44
14	54.65	54.26	53.83	54.20	54.58	54.48	54.33
28	56.64	56.28	57.87	56.42	56.41	56.42	56.67
42	54.69	56.09	56.40	57.74	55.24	55.88	56.01
56	52.03	55.98	55.81	55.49	55.60	54.15	54.84
70	50.36	55.46	55.20	54.61	54.93	53.89	54.08
84	49.68	53.45	54.15	53.05	53.00	52.91	52.71
Means	52.93	54.85	55.10	54.85	54.60	54.31	

L.S.D. at 5%

Factors	Ventilation rate	Storage period	Interaction
1st season	N.S.	3.57	N.S.
2nd season	N.S.	2.78	N.S.

Also it's appear from the same data that, lime fruits packaged inside ventilated or non-ventilated polyethylene bags had the same juice contents at the end of storage.

These results are in line with those reported by Cohen, *et al.* (1990) on lemon and Mohamed, *et al.* (2003a) on Valencia orange and Marsh seedless grapefruit. They reported that, individually seal packaging had no effect on juice contents of fruits during storage.

7-Total soluble solid, Total acidity and Ascorbic acid (V.C.) contents:

According to data shown in Tables (7, 8 and 9), total soluble solids contents of lime fruits juice increased gradually and significantly while total acidity and ascorbic acid decreased gradually and significantly with prolonging the storage period.

These results are in agreement with those obtained by Hegazi, *et al* (1988) on lime, Rana, *et al.* (1992) on Sweet orange and Mohamed, *et al.* (2003a and b) on Valencia orange and Marsh seedless grapefruits. They suggested that, Total Soluble Solids increased gradually and significantly during storage. On the other side, these results are confirmed by Hegazi, *et al.* (1988) on lime, Artes, *et al.* (1993) on lemon; El-Helaly, *et al.* (2002) on lime and Mohamed, *et al.* (2003a and b) on Valencia orange and March seedless grapefruit. They found that, total acidity decreased as storage period increased. Moreover, these results are confirmed by El-Shiati, (1959) on lime, El-Helaly, *et al.* (2002) on lime and Mohamed, *et al.* (2003 a-b) on Valencia orange and March seedless grapefruit. They reported that, Ascorbic acid decreased rabidly during storage.

On contrast, these results disagree with those mentioned by Artes, *et al.* (1993) on lemon who mentioned that, total soluble solids were constant while Ascorbic acid contents increased during storage. Also these results disagree with those found by El-Helaly, (2002) on lime and El-Helaly, *et al.* (2002) on lime as they found that, total soluble solids of lime decreased gradually and significantly with prolonging the storage period.

Data also confirmed that, lime fruits either packaged in ventilated on non-ventilated polyethylene bags had the same contents of total soluble solids, total acidity and Ascorbic acid during the two seasons in this carrying out work. These results are in agreement with those obtained by Burns and Echeverria (1991) on Valencia orange; Martinez, *et al.* (1991) on Orange; Ismail and El-Menshawy, (1997) on Lemon and Grapefruit, Mohamed, *et al.* (2003a and b) on Valencia orange and March seedless grapefruit they reported that, seal packaging of lemon had no effect on their contents of total soluble solids, total acidity and Ascorbic acid.

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

Data presented in Tables (10, 11 and 12) clearly show that, the peel of Lime fruit contents of Chlorophyll (a) and (b) decreased gradually and significantly while Carotenes increased gradually and significantly with the extension of the storage period during the two seasons in this work.

Table (7): Effect of Ventilation rate 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	8.83	9.27	8.73	8.60	9.17	9.33	8.99
28	9.50	9.80	9.40	9.20	9.67	9.63	9.53
42	9.27	9.03	9.30	9.57	9.23	9.20	9.27
56	9.30	9.20	9.03	8.97	8.87	9.47	9.14
70	9.90	8.90	9.27	8.90	8.93	9.07	9.16
84	10.07	8.97	9.60	9.20	9.70	9.43	9.50
Means	9.39	9.14	9.17	9.04	9.20	9.28	
	The second season (2004).						
0	8.70	8.70	8.70	8.70	8.70	8.70	8.70
14	8.90	9.00	8.87	9.00	9.03	9.10	8.98
28	9.00	9.07	9.20	9.10	9.13	9.17	9.11
42	9.10	9.13	9.27	9.30	9.17	9.17	9.19
56	9.17	9.25	9.33	9.37	9.23	9.27	9.27
70	9.27	9.57	9.40	9.37	9.33	9.20	9.36
84	9.30	9.67	9.50	9.58	9.48	9.36	9.48
Means	9.06	9.20	9.18	9.20	9.15	9.14	
L.S.D. at 5%							

Factors	Ventilation rate	Storage period	Interaction
1st season	N.S.	0.27	0.67
2nd season	N.S.	0.19	0.46

Table (8): Effect of Ventilation rate treatments on Total acidity 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	9.13	9.13	9.13	9.13	9.13	9.13	9.13
14	9.20	8.80	9.08	9.08	9.21	9.32	9.12
28	8.98	8.26	9.18	8.87	8.70	8.62	8.77
42	8.65	8.38	8.78	8.46	8.50	8.74	8.59
56	8.54	8.94	8.74	8.38	8.50	7.99	8.52
70	8.17	8.95	7.86	8.34	8.08	7.95	8.23
84	8.07	9.30	7.77	7.46	7.33	7.20	7.86
Means	8.68	8.82	8.65	8.53	8.49	8.42	
	The second season (2004).						
0	8.92	8.92	8.92	8.92	8.92	8.92	8.92
14	8.70	8.78	8.42	8.22	8.38	8.34	8.47
28	8.28	8.00	8.08	7.96	8.16	8.00	8.08
42	8.26	8.26	8.38	8.22	8.38	8.10	8.27
56	8.02	8.84	8.36	8.02	7.92	8.10	8.21
70	7.84	8.63	7.94	7.94	7.73	7.80	7.98
84	7.98	8.83	7.73	7.80	7.69	7.69	7.95
Means	8.29	8.61	8.26	8.15	8.17	8.14	
L.S.D. at 5%							

Factors	Ventilation rate	Storage period	Interaction
1st season	N.S.	0.4	0.98
2nd season	N.S.	0.29	0.72

Table (9): Effect of Ventilation rate 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	42.17	43.08	50.42	44.00	44.00	46.75	45.07
28	39.99	41.20	40.59	41.20	41.20	38.77	40.49
42	35.74	28.47	34.53	38.77	34.53	31.50	33.92
56	25.11	26.14	28.70	26.14	25.63	26.14	26.31
70	27.75	27.75	27.00	27.25	26.50	26.50	27.13
84	24.50	25.00	24.00	23.75	25.25	24.00	24.42
Means	35.45	34.94	36.88	36.29	35.72	35.23	
	The second season (2004).						
0	67.99	67.99	67.99	67.99	67.99	67.99	67.99
14	57.33	64.00	62.67	59.67	57.67	63.67	60.84
28	52.33	56.33	55.33	55.67	51.67	55.67	54.50
42	44.33	46.24	44.33	43.38	44.33	44.33	44.49
56	40.76	43.85	42.54	42.54	43.85	41.23	42.46
70	38.72	39.38	35.60	37.60	40.50	35.60	37.90
84	37.60	38.94	36.49	37.38	37.60	33.82	36.97
Means	48.44	50.96	49.28	49.18	49.09	48.90	
L.S.D. at 5%							
Factors	Ventilation rate		Storage period		Interaction		
1st season	N.S.		5.12		N.S.		
2nd season	N.S.		6.52		N.S.		

Table (10): Effect of Ventilation rate 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	74.82	75.15	75.32	65.37	64.01	76.92	71.93
28	56.94	67.96	50.60	62.56	60.63	63.84	60.42
42	39.12	61.17	47.02	52.04	40.73	40.73	46.80
56	26.45	55.98	39.98	29.16	29.04	28.84	34.91
70	15.92	40.39	37.80	23.36	24.02	19.82	26.89
84	5.22	24.10	20.61	17.77	8.47	13.98	15.03
Means	42.97	58.16	50.53	47.52	44.18	46.64	
	The second season (2004).						
0	94.57	94.57	94.57	94.57	94.57	94.57	94.57
14	51.01	75.61	67.34	67.22	59.85	64.21	64.21
28	39.74	65.08	55.58	50.31	54.95	59.07	54.12
42	33.97	48.99	42.74	45.08	44.06	45.49	43.39
56	31.14	40.76	42.16	41.30	36.53	43.75	39.27
70	32.99	36.40	38.99	42.86	30.40	28.75	35.07
84	21.23	36.11	28.46	27.35	25.91	32.00	28.51
Means	43.52	56.79	52.83	52.67	49.47	52.55	
L.S.D. at 5%							
Factors	Ventilation rate		Storage period		Interaction		
1st season	5.3		5.78		N.S.		
2nd season	3.69		3.99		N.S.		

Table (11): Effect of Ventilation rat 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	79.17	80.76	68.46	83.20	72.75	68.57	75.49
28	46.06	68.83	53.84	48.27	51.90	54.55	53.91
42	41.84	66.56	41.82	43.14	46.33	46.79	47.75
56	35.09	62.32	31.82	39.96	43.22	41.32	42.29
70	30.06	44.54	28.57	33.55	24.49	24.49	30.95
84	13.36	34.95	26.74	23.53	16.02	20.48	22.51
Means	46.76	62.81	47.57	50.48	48.06	48.28	
	The second season (2004).						
0	96.07	96.07	96.07	96.07	96.07	96.07	96.07
14	72.05	102.20	76.81	81.86	89.72	89.70	85.39
28	66.09	98.27	72.18	78.49	73.68	74.67	77.23
42	66.56	92.03	71.85	78.33	66.40	65.28	73.41
56	61.32	54.65	70.72	70.09	56.43	60.67	62.31
70	45.91	53.47	42.82	34.72	54.41	56.22	47.93
84	28.43	54.94	32.04	30.47	39.51	54.27	39.94
Means	62.35	78.80	66.07	67.15	68.03	70.98	
L.S.D. at 5%							

Factors	Ventilation rate	Storage period	Interaction
1st season	5.49	6.93	N.S.
2nd season	4.78	5.17	N.S.

Table (12): Effect of Ventilation rat 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	21.20	19.10	23.19	18.51	26.70	25.30	22.33
28	28.63	28.23	25.47	21.01	27.71	23.88	25.82
42	36.52	19.43	27.89	20.52	28.85	24.57	26.30
56	45.55	37.34	30.12	35.34	29.71	31.40	34.91
70	52.93	38.68	32.19	40.04	46.13	41.83	41.97
84	76.14	39.67	51.61	54.40	52.34	50.08	54.04
Means	40.39	29.17	30.32	30.23	33.32	31.26	
	The second season (2004).						
0	17.93	17.93	17.93	17.93	17.93	17.93	17.93
14	29.90	16.63	15.09	14.48	15.88	22.29	19.05
28	34.90	20.12	16.49	15.40	15.68	17.41	20.00
42	39.94	19.36	19.17	22.66	20.14	27.94	24.87
56	49.67	21.08	20.54	33.14	18.69	32.92	29.34
70	50.70	28.33	34.26	50.83	43.00	32.49	39.94
84	82.72	41.41	45.39	58.71	49.21	46.70	54.06
Means	43.68	23.55	24.15	30.45	25.79	28.24	
L.S.D. at 5%							

Factors	Ventilation rate	Storage period	Interaction
1st season	3.38	3.65	N.S.
2nd season	2.73	2.95	N.S.

Concerning the effect of ventilation and its rate it is obvious from the same tables that, non-ventilation or micro-ventilation significantly reduced the change rate of lime fruits peel contents of pigments during storage. Also data presented that, Lime fruits packaged inside non-ventilated bags had the highest contents of Chlorophyll (a) and (b) and the lowest contents of carotenes.

9- Head space:

According to data presented in Tables (13-14) it is clear that, bags contents of O_2 significantly decreased while CO_2 increased with prolonging the storage period. These results were expected as a result of respiration incidence.

Data also indicated that, O_2 decreased while CO_2 increased rapidly inside the non-ventilated bags (Tables 13 and 14). However, O_2 contents of bags didn't reach less than 5% but CO_2 concentration raise up to more than 10 % which lead to increase fruit decay percentage (Table 2).

Table (13): Effect of Ventilation rat treatments on O2 content percentage of lime bag 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	21.00	21.00	21.00	21.00	21.00	21.00	21.00
14	21.00	13.50	19.57	18.80	19.63	20.10	18.77
28	21.00	14.67	19.23	19.47	19.23	20.30	18.98
42	21.00	12.07	19.93	20.10	20.47	20.73	19.05
56	21.00	10.47	19.70	20.17	19.87	20.17	18.56
70	21.00	6.50	17.37	20.47	20.20	20.37	17.65
84	21.00	9.63	18.97	20.90	20.33	20.63	18.58
Means	21.00	12.55	19.40	20.13	20.10	20.47	
	The second season (2004).						
0	21.00	21.00	21.00	21.00	21.00	21.00	21.00
14	21.00	12.83	19.33	19.57	19.77	20.03	18.76
28	21.00	12.67	19.93	20.30	20.47	20.40	19.13
42	21.00	10.47	19.50	20.40	20.77	20.73	18.81
56	21.00	10.47	20.60	20.97	20.53	20.17	18.96
70	21.00	6.50	18.77	20.47	20.60	20.33	17.95
84	21.00	8.63	20.43	20.90	21.00	21.03	18.83
Means	21.00	11.80	19.94	20.52	20.59	20.53	
L.S.D. at 5%							
Factors	Ventilation rate		Storage period		Interaction		
1st season	0.17		0.18		N.S.		
2nd season	0.25		0.27		N.S.		

Table (14): Effect of Ventilation rat treatments on CO_2 content percentage of lime bag during cold storage

Storage period (days).	Treatments						Means
	T_1	T_2	T_3	T_4	T_5	T_6	
	The first season (2003).						
0	0.10	0.10	0.10	0.10	0.10	0.10	0.10
14	0.10	3.43	1.00	0.63	0.20	0.30	0.94
28	0.10	7.20	0.67	0.70	0.27	0.20	1.52
42	0.10	7.53	0.93	0.40	0.20	1.17	1.72
56	0.10	9.83	1.37	0.53	0.67	0.83	2.22
70	0.10	10.37	2.00	1.17	0.43	0.70	2.46
84	0.10	11.53	2.33	1.53	0.97	0.33	2.80
Means	0.10	7.14	1.20	0.72	0.41	0.52	
	The second season (2004).						
0	0.10	0.10	0.10	0.10	0.10	0.10	0.10
14	0.10	4.43	0.77	0.27	0.20	0.27	1.01
28	0.10	5.93	0.83	0.53	0.23	0.33	1.33
42	0.10	5.87	1.33	0.37	0.27	0.23	1.36
56	0.10	7.83	1.17	0.33	0.37	0.70	1.75
70	0.10	10.37	2.33	1.17	0.87	1.50	2.72
84	0.10	10.87	2.23	1.53	1.00	0.77	2.75
Means	0.10	6.49	1.25	0.61	0.43	0.56	

L.S.D. at 5%			
Factors	Ventilation rate	Storage period	Interaction
1st season	0.43	0.46	N.S.
2nd season	0.61	0.66	N.S.

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دراسات فسيولوجية على ثمار الليمون البلدى
٢- تأثير معدل التثقيب الدقيق على الجودة والقدرة التخزينية لثمار الليمون.

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*مركز البحوث الزراعية – معهد بحوث البساتين – قسم بحوث تداول الفاكهة.
**مركز البحوث الزراعية – معهد بحوث البساتين – قسم بحوث تداول الخضر.

اجرى هذا البحث خلال موسمى ٢٠٠٣، ٢٠٠٤ بقسم بحوث تداول الفاكهة – معهد بحوث البساتين. ثمار الليمون البلدى المالح تم جمعها من مزرعة خاصة بمحافظة القليوبية عند الوصول الى مرحلة اكتمال النمو ونقلت مباشرة إلى المعمل حيث تم فرز و غسيل و تجفيف الثمار وتشميعها، ثم تم تعبئتها داخل أكياس من البولى إيثيلين غير المثقب أو المثقب بالمعدل العادى أو تم تثقيبها بمعدل ٢، ٤، ٦، ٨ ثقب دقيق (١ مل فى القطر). تم دراسة الخواص الطبيعية والكيميائية للثمار أثناء التخزين كل ١٤ يوما.

نسبة الفساد كانت الأعلى فى ثمار الليمون المعبأة داخل أكياس غير مثقبة بينما نسبة الفقد فى الوزن كانت الأدنى مقارنة بالثمار المعبأة فى المعاملات الأخرى وذلك أثناء التخزين. ثمار الليمون المعبأة داخل أكياس من البولى إيثيلين والمثقبة بالثقوب الدقيقة كانت تحتوى على أقل نسبة للفساد بالمقارنة بالثمار الأخرى. أيضا ثمار الليمون المعبأة داخل أكياس البولى إثيلين ذات التثقيب الدقيق كانت تتميز بنسبة فقد فى الوزن أقل من تلك الثمار المعبأة داخل أكياس من البولى إثيلين ذات المعدل العادى من التثقيب. تعبئة الثمار فى أكياس من البولى إثيلين ذات معدل التثقيب الدقيق قللت من معدل التدهور فى اللمعان وكذلك من معدل التغير فى محتوى القشرة من الصبغات وذلك بالمقارنة بالثمار فى أكياس البولى إثيلين ذات التثقيب العادى. إستخدام أكياس البولى إثيلين ذات معدل تثقيب دقيق لم يكن له تأثير على كل من محتوى الثمار من العصير ونسبة المواد الصلبة الذائبة ونسبة الحموضة وكذلك محتوى الثمار من فيتامين ج أثناء التخزين. أدى تعبئة الثمار فى أكياس غير مثقبة إلى زيادة تراكم ثانى اكسيد الكربون حول الثمار مما كان له أثر واضح فى زيادة نسبة الفساد فى ثمار هذه المعاملة.

تؤكد هذه الدراسة على إمكانية إحلال معدل التثقيب الدقيق بدلاً من المعدل العادى فى تعبئة ثمار الليمون وذلك بهدف تقليل حدوث كل من الفساد والفقد فى الوزن وذلك أثناء التسويق أو التخزين وذلك بدون أدنى تأثير ضار على خواص الثمار الطبيعية والكيميائية.