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EFFECT OF HARVESTING STAGE AND STORAGE TEMPERATURES ON THE STORABILITY OF BANZAHIR LIME FRUITS

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ABSTRACT

Limes (cv. Banzahir) at two harvesting stages (light green and yellowish green) were harvested, in 1997 and 1998 seasons, and stored at three storage temperatures 7, 13°C or RT (18-21°C and 78-85% RH). Effects of harvesting stage and storage temperature on extending storage period and fruit quality were studied Banzahir fruits at both stages stored at RT, 7 and 13°C remained 4,8 and 12 weeks, respectively.

The highest significant percentages of unmarketable fruits were found in fruits at both stages stored at RT, while the lowest ones in those stored at 13°C. Generally, the difference was not significant between unmarketable fruits percentages of limes at both stages stored at the same temperature. During the first period of storage (4 weeks), rind colour of fruits at both stages stored at 7°C was similar to those stored at 13°C, while storage at RT hasted colour development. The differences between storage at 7 and 13°C were noticed after 8 weeks of storage, storing at 7°C retarded the progress of colour change. Weight loss percentages in yellowish green fruits were significantly lower than those in light green ones, at all storage temperatures. The least significant percentages of weight loss were found in fruit stored at 13°C. As the storage period advanced, TSS percentages increased, whereas V.C content decreased. Citric acid percentages did not change significantly during the first period of storage (4 weeks), but thereafter decreased. V.C content was affected by storage temperature, generally, the highast values were found in fruits stored at 13°C. Harvesting stage clearly influenced acidity, light green fruits had higher percentages of citric acid than yellowish green ones.

Keywords: Storability, room temperature, Banzahir lime and harvesting stage.

INTRODUCTION

Egypt is a large producer of citrus fruits. In 2000 , the production was nearly 2,401,054 tons (According to statistics of Ministry of Agriculture 2001). Storage of perishable citrus fruits is very essential to adjust consumption supply and to make these commodities available all over the years. Banzahir lime is one of these fruits which could be stored during its abundance or peak supplies to spread the crop along period to help balance supply, demand and to maintain a reasonable stable price for producers as well as for marketing agencies and consumers.

As being semi-tropical fruits, almost all citrus were susceptible to low temperature injury. Lemons and limes are especially susceptible to cold storage breakdown, (Hulme, 1971). Pantastico *et al.* (1968) reported that lime fruits are subjected to pitting at temperatures of 7.5°C and below. However, Bleinroth *et al.* (1976) reported that Tahiti limes stored well for up to 2 months at 6°C but at over 7°C they lost their green colour within 4 weeks. Whereas,

Hardenburg *et al.* (1986) recommended, for storage lime fruits, temperature is 9 to 10°C. Anyway, definite the optimum temperature for storing lime fruits is very important for minimum decay and maximum quality. Storage below that temperature subjects the fruits to physiological disorders, such as bronzing pitting of the peel and the pits may coalesce and form leathry, brown, sunken areas on the rind, while storage above, causes other physiological disorders as well as increasing percent of decay.
The present study was done to investigate the effect of storage temperatures and harvesting stage on the storability of Banzahir lime fruits.

MATERIALS AND METHODS

Banzahir limes were harvested in 1997 and 1998 seasons, from a private orchard in Hosh Issa region, Behira Governorate. The soil was classified as a clay soil. The trees were twenty years old, budded on sour orange rootstocks spaced at 5x5 meters a part, and received the cultural practices commonly adopted in that area. Fruits were picked with care at two harvesting stages, light green and yellowish green.

In January, each stage was represented by 570 fruits were taken at random from the trees and were about the same size and free from obvious defects. Thirty fruits of each stage were used as an initial sample for physical and chemical analysis. The remaining fruits of each stage were washed in tap water and air dried by the aid of an electric fan. Each stage was divided into small groups, 30 fruits each (10 fruits for each replicate), and packed in mesh bags, i.e. there were 18 bags for each stage. All bags for both stages were put in 18 plastic boxes (60 x 40 x 18 cm). Each box contained two bags represented the two harvesting stages (light green and yellowish green). Boxes were divided into three lots, the first six boxes were stored at room temperature (18-21°C and 78-85% RH), the second stored at 7°C and the third stored at 13°C with relative humidity 85-90%.

Treatments were six as follows:

1. Light green fruits stored at RT.
2. Yellowish green fruits stored at RT.
3. Light green fruits stored at 7°C.
4. Yellowish green fruits stored at 7°C.
5. Light green fruits stored at 13°C.
6. Yellowish green fruits stored at 13°C.

Fruits of each treatment were evaluated at 14 days-interval. A sample of 30 fruits (10 fruits for each replicate) was taken for each treatment to study the effect of the different experimental treatments on:

1. Rind colour

Fruit rind colour was matched with the citrus colour chart of Harding *et al.* (1940), (Fig. 1)

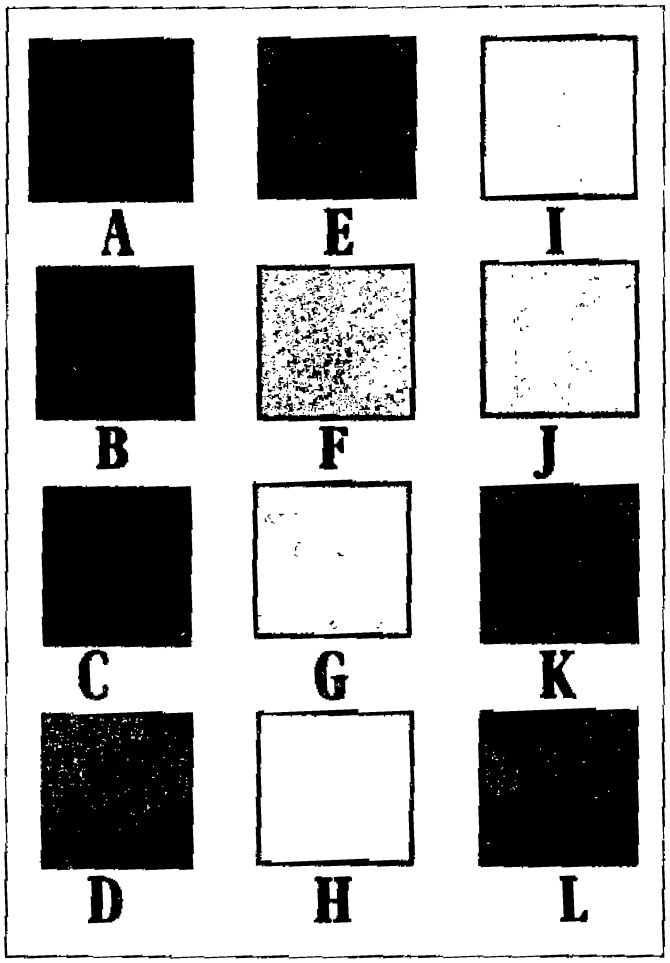

Fig.1 Colour chart used for determining the rind colour of citrus fruits, similar to that used by Harding et al.(1940).

2. Weight loss

Fruits were weighed at 14 day- intervals in each sample during storage period and loss in fruit weight was recorded and calculated as a percentage from the initial weight.

3. Unmarketable fruits

The number of unmarketable fruits due to chilling injury, decay and chrinkage calculated as percentage from the total number of each sample.

4. Total soluble solids

Total soluble solids in the juice were determined by a hand refractometer.

5. Ascorbic acid (V.C)

Calculated as mg/100 ml juice according to A.O.A.C. (1985).

6. Titratable acidity

Titratable acidity of the juice was expressed as percentage of citric acid according to A.O.A.C (1985).

Statistical analysis:

Data were statistically analyzed according to Snedecor and Cochran (1971). As the light green and yellowish green fruits were included in the same experiment, one error was calculated for the whole experiment. As the error variance is independent from treatment means, LSD values were calculated from this pooled error.

RESULTS AND DISCUSSION

Storage period

The data presented in Tables (5 and 6) clearly pointed out that fruits at both harvesting stages stored at RT remained only 4 weeks of storage, while those stored at 7°C lasted 10 weeks, fruits stored at 13°C could be kept for 12 weeks. This may be explained by storage at high temperature causes an increase of fungal infection, respiration rate and ethylene production, while storage at low temperature subjects the fruits to physiological disorders such as pitting and breakdown of the peel (Rygg and Harvey, 1959). Kawada and Kitagawa (1994) reported that storage temperature is important for minimizing fruit injury and decay of citrus.

1. Rind colour

From the data demonstrated in Tables (1 and 2) and Fig I, it was noticed that fruits at each harvesting stage had the same initial colour, (Letter E) for light green and (Letter G) for yellowish green .The colour developed as the storage period advanced in both experimental seasons. These findings agreed with those obtained by Bleinroth et al. (1976) on limes and lemons and Predebon and Edwards (1992) on Eureka and Lisbon lemons.

Table (1): Effects of various treatments on rind colour of Banzahir lime fruits during storage in 1997.

Weeks in storage	Treatments					
	Light green RT	Yellowish green RT	Light green 7°C	Yellowish green 7°C	Light green 13°C	Yellowish green 13°C
0	E	G	E	G	E	G
2	G	I	E-F	G-H	F	G
4	J	J	F	H-I	F	H-I
6	-	-	F	I	G-H	I
8	-	-	F-G	I-J	H	I
10	-	-	-	-	H	I-J
12	-	-	-	-	H-I	I-J

Table (2): Effects of various treatments on rind colour of Banzahir lime fruits during storage in 1998.

Weeks in storage	Treatments					
	Light green RT	Yellowish green RT	Light green 7°C	Yellowish green 7°C	Light green 13°C	Yellowish green 13°C
0	E	G	E	G	E	G
2	H	I	E-F	G	E-F	G
4	J	J	F	H-I	F	H-I
6	-	-	F	I	G	I
8	-	-	F-G	I	G-H	I
10	-	-	-	-	H	I-J
12	-	-	-	-	H	I-J

After first period of storage (4 weeks), rind colour of fruits at both harvesting stages, stored at 7°C, was similar to that of those stored at 13°C, while storage at RT resulted to haste colour development. The differences between storage at 7 and 13°C were noticed after 8 weeks of storage, storing at 7°C retarded the progress of colour change of light green fruits, in both seasons. Storage at RT enhanced the development of fruit colour, was previously noticed by Heikal and Others (1965) on Egyptian lemons and Schiffmann-Nadel (1975) on lemons. Nam and Kweon (1989) reported that high temperature hastened colour change of satsuma mandarin.

2. Weight loss

The data presented in Tables (3 and 4) and Figs(2 and 3) indicated that the percentages of weight loss, in both years of study, significantly increased as the storage period advanced. Similarly, Rana and Kartar (1992) reported that percentage weight loss of sweet orange fruits increased with increasing storage time.

It was clearly noticed that, in both seasons, weight loss percentages in yellowish green fruits were significantly lower than those in light green ones at all storage temperatures. The significant highest weight loss percentages were found in fruits stored at RT (17.32-18.69% and 14.18-20.13% in 1997 and 1998, respectively), as an average for 4 weeks.

Table (3): Effect of various treatments on percent weight loss of Banzahir lime fruits during storage in 1997.

Weeks in storage	Treatments: Light Green RT	Yellowish Green RT	Light Green 7°C	Yellowish Green 7°C	Light Green 13°C	Yellowish Green 13°C	Average	Average of the last 4 treatments	Average of the last 2 treatments
0	-	-	-	-	-	-	-	-	-
2	12.08	11.22	6.90	4.30	5.00	3.50	7.17 B	4.93 D	4.25 F
4	25.30	23.41	11.50	7.63	8.10	7.11	13.84 A	8.59 C	7.61 E
Average	18.69 A	17.32 B	9.20 C	5.97 ED	6.55 D	5.31 E			
L.S.D		Treatments		Storage period		Interaction			
0.05		0.865		0.263		0.978			
0.01		1.212		0.369		1.371			
6	-	-	19.25	14.10	11.97	10.40		13.93 B	11.19 D
8	-	-	23.80	19.60	16.01	13.00		18.10 A	14.51 C
Average	-	-	15.36 A	11.41 B	10.27 C	8.50 D			
L.S.D		Treatments		Storage period		Interaction			
0.05		0.855		0.335		1.016			
0.01		1.244		0.454		1.431			
10	-	-	-	-	19.11	15.98			17.55 B
12	-	-	-	-	22.55	18.02			20.29 A
Average	-	-	-	-	13.79 A	11.34 B			
L.S.D		Treatments		Storage period		Interaction			
0.05		0.873		0.590		1.122			
0.01		1.448		0.805		1.795			

Average followed by the same letters are not significant different at 0.05 level.

Table (4): Effect of various treatments on percent weight loss of Banzahir lime fruits during storage in 1998.

Weeks in storage	Treatments						Average	Average of the last 4 treatments	Average of the last 2 treatments
	Light Green RT	Yellowish Green RT	Light Green 7°C	Yellowish Green 7°C	Light Green 13°C	Yellowish Green 13°C			
0	-	-	-	-	-	-	-	-	-
2	13.20	10.14	7.03	4.50	4.00	3.20	7.01 B	4.68 D	3.60 F
4	27.06	18.22	15.00	8.77	8.11	6.00	13.86 A	9.47 C	7.06 E
Average	20.13 A	14.18 B	11.02 C	6.64 D	6.06 D	4.60 E			
L.S.D		Treatments		Storage period		Interaction			
0.05		0.903		0.300		1.041			
0.01		1.265		0.420		1.460			
6	-	-	23.31	17.00	13.10	9.07		15.62 B	11.09 D
8	-	-	28.78	22.66	16.98	11.89		20.07 A	14.44 C
Average	-	-	18.53 A	13.23 B	10.55 C	7.54 D			
L.S.D		Treatments		Storage period		Interaction			
0.05		0.807		0.524		1.227			
0.01		1.174		0.710		1.728			
10	-	-	-	-	21.20	14.03			17.62 B
12	-	-	-	-	24.12	17.10			20.61 A
Average	-	-	-	-	14.59 A	10.22 B			
L.S.D		Treatments		Storage period		Interaction			
0.05		1.347		0.646		1.463			
0.01		2.233		0.881		2.340			

Average followed by the same letters are not significant different at 0.05 level.

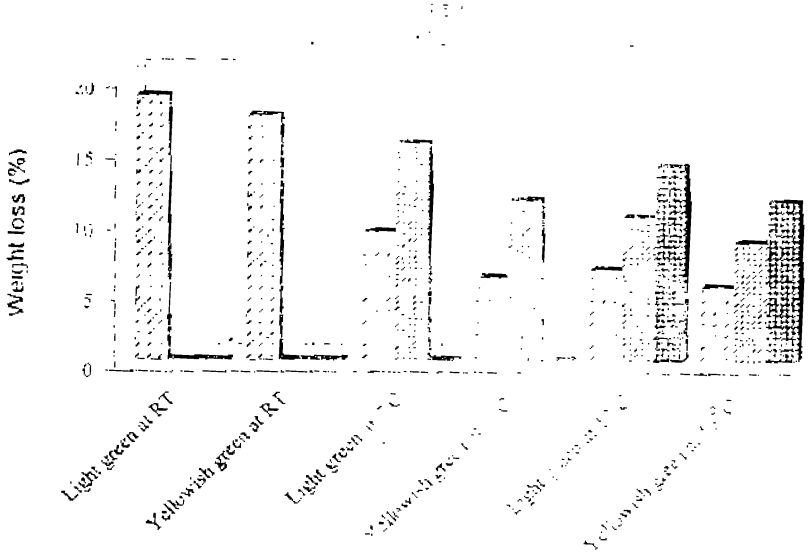

Fig. 2. Effect of various treatments on peace [illegible]

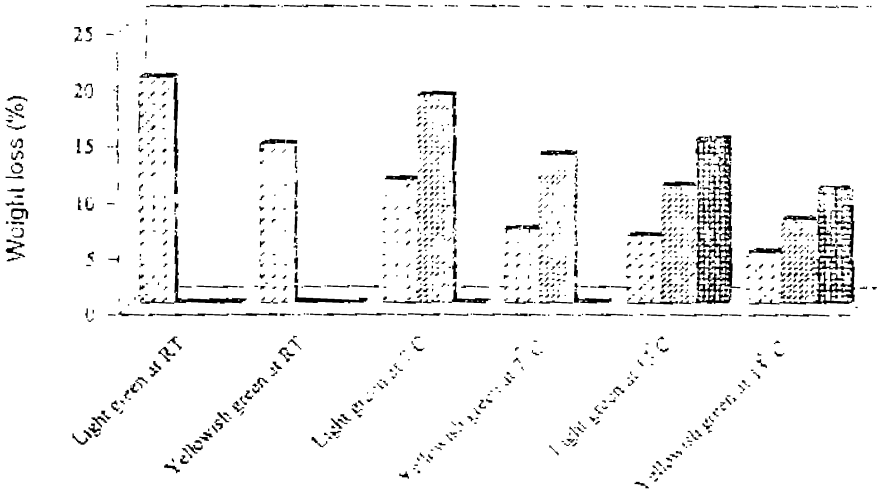

Fig. 3. Effect of various treatments on percent [illegible]

After 8 weeks of storage, the lower average percentages of weight loss were in fruits stored at 13°C (8.50-10.27% and 7.54-10.55%, respectively) compared with those in fruits stored at 7°C (11-41-15.36% and 13.23-18.53%, respectively). These findings were in agreement with those obtained by Bhullar (1983). He found that, when Kagzi lime fruits were stored at RT the physiological weight loss was 16.1%. Storage temperature directly influenced the weight loss percentages, (Isshak *et al.*, 1976). They reported that weight loss percentages of Eureka lemons were 12.36 and 15.88% after 3 months of storage at 10.0 and 15.6°C, respectively. Likewise, Hino *et al.* (1990) mentioned that weight loss of Iyo (*Citrus iyo*) fruits was greater at 20°C than at 5 or 10°C. Rate of weight loss was minimal of Encore mandarins stored at optimum temperature, (Manolopoulou- Lambrinou and Papadopoulou, 1995).

3. Unmarketable fruits

The data nominated in Tables (5 and 6) and Figs (4 and 5) declared that there was a gradual increase in the percentages of unmarketable fruits with the progress of storage period. This could be due to 1- Fruit chilling injury (for those stored at 7 or 10°C), 2- Fruit sprinkage as a results of moisture loss, 3- Fungal attack of the fruits such as green and blue molds and Alternaria rot and 4-Fruit senescence and consequently rapid deterioration of the fruits. These findings agreed with those obtained by Hulme (1971) on limes and lemons and Bertolini *et al.* (1991) on Femminello comune lemons.

The differences were not significant between unmarketable fruits percentages of limes at both stages stored at the same temperature, except those stored at 13°C in both seasons and at 7°C in first one, as an average for 8 weeks, where unmarketable fruits percentages in yellowish green fruits were significantly higher than those in light green ones. However, these findings were not in line with those obtained by Lafuente *et al.* (1997) on Fortune mandarins.

The least significant percentages of unmarketable fruits were found in fruits at both stages stored at 13°C (0.00%) compared with those stored at RT (46.67-50.00%) as an average for 4 weeks, in both seasons. The same trend was found after 8 weeks of storage, as the average unmarketable fruits percentages in fruits stored at 13°C were 2.00-4.00% and 2.00- 6.0% as compared with 32.00-34.00% and 34.00-36.00% in 1997 and 1998, respectively in those stored at 7°C. These findings were in harmony with those found by Kawada and Kitagawa (1994) on Sudachi fruits. They reported that storage temperature is important for minimizing fruit injury and decay. Besides, Manolopoulou-Lambrinou and Papadopoulou (1995) on Encore mandarins, noticed that under optimum conditions, rot development and physiological disorders were minimal.

4. Total soluble solids (TSS)

The data in Tables (7 and 8) and Figs (6 and 7) indicated that TSS percentages significantly increased as the storage period advanced, as an average for all treatments, in both years of study.

Table (5): **Effect of various treatments on the percentage of unmarketable Banzahir lime fruits during storage in 1997.**

Weeks in storage	Treatments								
	Light Green RT	Yellowish Green RT	Light Green 7°C	Yellowish Green 7°C	Light Green 13°C	Yellowish Green 13°C	Average	Average of the last 4treatments	Average of the last 2 treatments
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00 C	0.00 D	0.00 D
2	40.00	50.00	10.00	20.00	0.00	0.00	20.00 B	7.50 C	0.00 D
4	100.00	100.00	20.00	20.00	0.00	0.00	40.00 A	10.00 C	0.00 D
Average	46.67 A	50.00 A	10.00 B	13.33 B	0.00 C	0.00 C			
L.S.D		Treatments			Storage period			Interaction	
0.05		3.424			3.626			8.166	
0.01		4.800			4.914			11.262	
6	-	-	50.00	60.00	0.00	10.00		30.00 B	5.00 CD
8	-	-	80.00	70.00	10.00	10.00		42.50 A	10.00 C
Average	-	-	32.00 B	34.00 A	2.00 D	4.00 C			
L.S.D		Treatments			Storage period			Interaction	
0.05		1.883			5.421			10.487	
0.01		2.740			7.288			14.714	
10	-	-	-	-	20.00	20.00			20.00 B
12	-	-	-	-	30.00	40.00			35.00 A
Average	-	-	-	-	8.57	11.43			
L.S.D		*Treatments*			Storage period			Interaction	
0.05		*NS*			5.667			NS	
0.01					7.680				

Averaga followed by the same letters are not significant different at 0.05 level.
NS: Not significant

Table (6): Effect of various treatments on the percentage of unmarketable Banzahir lime fruits during storage in 1998.

Weeks in storage	Treatments								
	Light Green RT	Yellowish Green RT	Light Green 7°C	Yellowish Green 7°C	Light Green 13°C	Yellowish Green 13°C	Average	Average of the last 4 treatments	Average of the last 2 treatments
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00 C	0.00 D	0.00 D
2	40.00	50.00	20.00	20.00	0.00	0.00	21.67 B	10.00 C	0.00 D
4	100.00	100.00	20.00	30.00	0.00	0.00	41.67 A	12.50 C	0.00 D
Average	46.67 A	50.00 A	13.33 B	16.67 B	0.00 C	0.00 C			
L.S.D		Treatments		Storage period		Interaction			
0.05		4.842		3.243		8.166			
0.01		6.788		4.395		11.262			
6	-	-	60.00	50.00	0.00	20.00		32.50 B	10.00 C
8	-	-	70.0	80.00	10.00	10.00		42.50 A	10.00 C
Average	-	-	34.00 A	36.00 A	2.00 C	6.00 B			
L.S.D		Treatments		Storage period		Interaction			
0.05		2.663		4.459		8.863			
0.01		3.875		5.995		12.435			
10	-	-	-	-	30.00	20.00			25.00 B
12	-	-		-	40.00	30.00			35.00 A
Average	-	-	-	-	11.43	11.43			
L.S.D		Treatments		Storage period		Interaction			
0.05		NS		5.361		8.759			
0.01				7.265		13.987			

Average followed by the same letters are not significant different at 0.05 level.
NS: Not significant

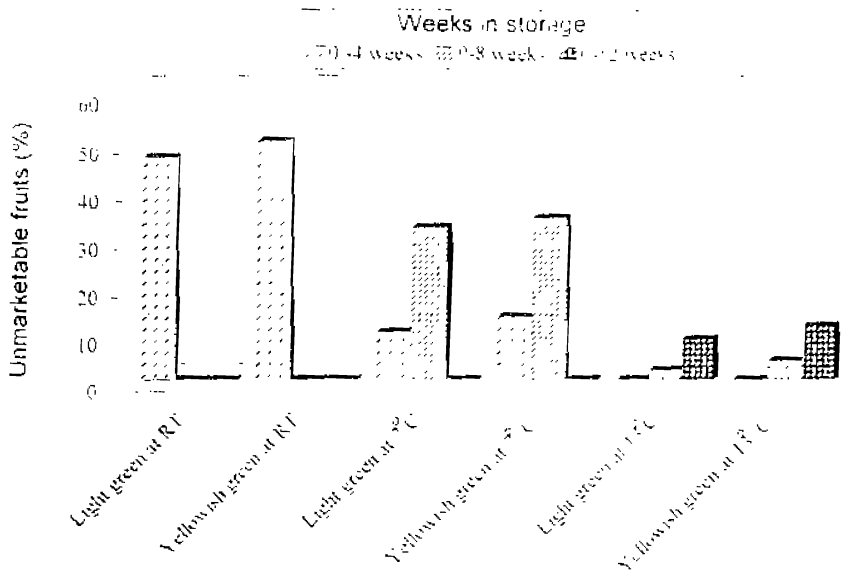

Fig. 4. Effect of various treatments on the percentage of unmarketable Banzahir lime fruits during storage in 1998.

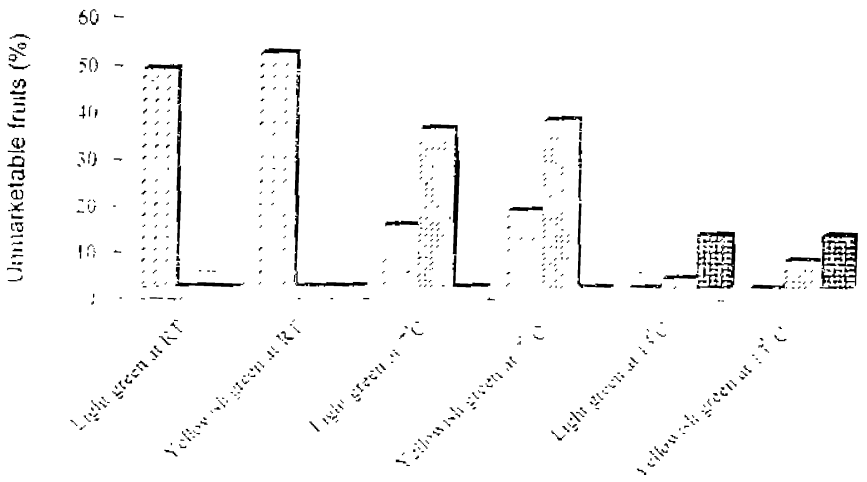

Fig. 5. Effect of various treatments on the percentage of unmarketable Banzahir lime fruits during storage in [illegible]

Table (7): Effect of various treatments on percentage total soluble solids (TSS) of Banzahir lime fruits during storage in 1997.

Weeks in storage	Treatments								
	Light Green RT	Yellowish Green RT	Light Green 7°C	Yellowish Green 7°C	Light Green 13°C	Yellowish Green 13°C	Average	Average of the last 4 treatments	Average of the last 2 treatments
0	9.00	9.33	9.00	9.33	9.00	9.33	9.17 B	9.17 C	9.17 C
2	9.53	9.20	9.00	9.53	9.20	9.33	9.30 AB	9.27 BC	9.27 C
4	9.53	10.00	9.33	9.47	9.60	9.47	9.57 A	9.47 ABC	9.53 B
Average	9.36	9.51	9.11	9.44	9.27	9.38			
L.S.D		Treatments		Storage period		Interaction			
0.05 0.01		NS		0.274 0.371		NS			
6	-	-	9.53	10.00	9.67	9.00		9.55 AB	9.33 C
8	-	-	9.47	10.00	10.00	9.47		9.73 A	9.73 A
Average	-	-	9.27 B	9.67 A	9.49A B	9.32 B			
L.S.D		Treatments		Storage period		Interaction			
0.05 0.01		0.264 0.384		0.327 0.440		NS			
10	-	-	-	-	9.53	10.00			9.77 A
12	-	-	-	-	10.00	9.53			9.77 A
Average	-	-	-	-	9.57	9.45			
L.S.D		Treatments		Storage period		Interaction			
0.05 0.01		NS		0.193 0.261		0.325 0.519			

Average followed by the same letters are not significant different at 0.05 level.
NS: Not significant

Table (8): Effect of various treatments on percentage total soluble solids (TSS) of Banzahir lime fruits during storage in 1998.

Weeks in storage	Treatments: Light Green RT	Yellowish Green RT	Light Green 7°C	Yellowish Green 7°C	Light Green 13°C	Yellowish Green 13°C	Average	Average of the last 4 treatments	Average of the last 2 treatments
0	8.67	9.53	8.67	9.53	8.67	9.53	9.10 B	9.10 C	9.10 DE
2	9.00	10.00	9.00	10.00	8.87	10.00	9.48 A	9.47 AB	9.43 CD
4	9.60	10.00	9.60	9.60	9.00	9.00	9.47 A	9.30 BC	9.00 E
Average	9.09 B	9.84 A	9.09 B	9.71 A	8.84 B	9.51 A			
L.S.D		Treatments		Storage period		Interaction			
0.05		0.342		0.247		0.607			
0.01		0.480		0.335		0.838			
6	-	-	9.00	9.60	9.00	9.60		9.30 BC	9.30 CDE
8	-	-	10.00	9.67	9.60	9.67		9.73 A	9.63 BC
Average	-	-	9.25 B	9.68 A	9.03 B	9.56 A			
L.S.D		Treatments		Storage period		Interaction			
0.05		0.240		0.286		0.290			
0.01		0.349		0.384		0.827			
10	-	-	-	-	9.60	10.00			9.80 AB
12	-	-	-	-	10.00	10.00			10.00 A
Average	-	-	-	-	9.25 B	9.69 A			
L.S.D		Treatments		Storage period		Interaction			
0.05		0.216		0.345		0.538			
0.01		0.359		0.467		0.860			

Average followed by the same letters are not significant different at 0.05 level.

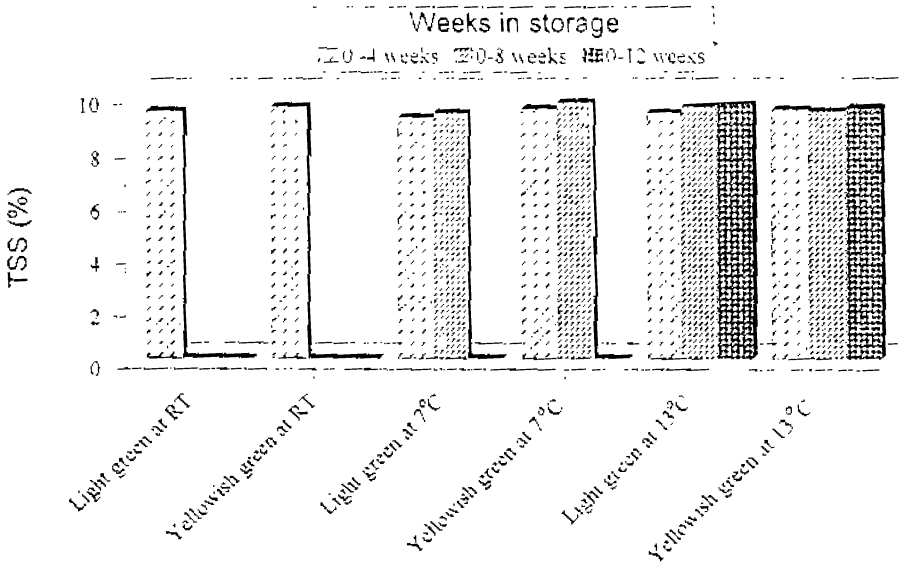

Fig. 6. Effect of various treatments on the percentage total soluble solids (TSS) of Banzahir lime fruits d storgage in 1997

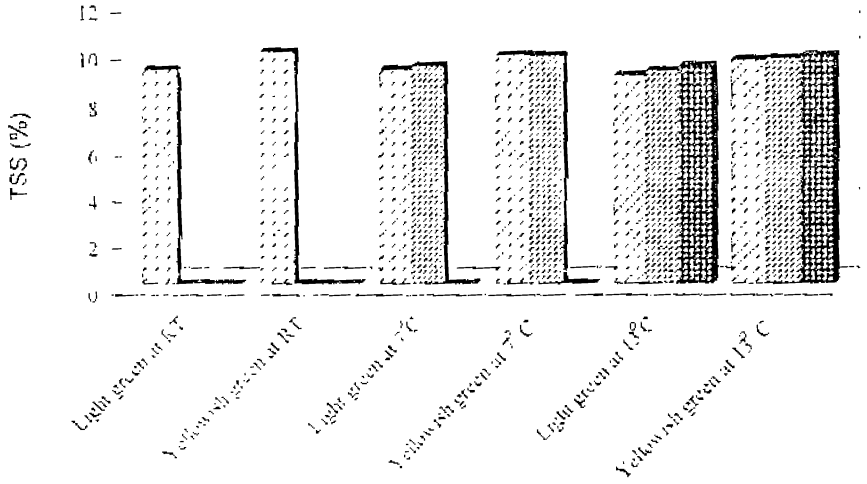

Fig. 7. Effect of various treatments on the percentage total soluble solids (TSS) of Banzahir lime fruits dur storgage in 1998

These findings were confirmed by those found by Echeverria and Ismail (1990) on fruits of Citrus limettioides cv. Palestine; Rana and Kartar (1992) and Attia (1995) on oranges They all reported that TSS increased during storage.

Regarding harvesting stage, the data showed that, in the first season, the differences were not significant between averages TSS percentage of fruits at both stages stored at the same storage temperature, except at 7°C TSS percentages of yellowish green fruits were significantly higher than those of light green ones, as an average for 8 weeks. In the second season, the averages TSS percentages were significantly higher in yellowish green fruits than in light green ones stored at the same storage temperature Likwise, Abd-El-Baki and Hassan (1963) indicated that percentages of TSS in yellow Banzahir fruits were higher compared with those in yellow green ones. The data also showed that storage temperature had no significant effect on average TSS percentages of fruits at both harvesting stages in both years of study, except in the first one, yellowish green fruits stored at 7°C had significant higher TSS percentage than those stored at 13°C as an average for 8 weeks of storage The results were in agreement with those obtained by Kanlayanarat *et al.* (1988) on Citrus hassake. They mentioned that storage temperature (2-20°C) didn't affect levels of total soluble solids.

Furthermore, Nam and Kweon (1989) on satsuma mandarin noticed that levels of soluble solids were not influenced by nigh temperature (20°). The results were not in line with those found by Hino *et al.* (1990) who noticed that juice sugar content of Iyo (Citrus iyo) fruits increased with increasing temperature. However, the increase in Brix value during storage in some citrus fruits cultivars is not always directly related to changes in fruit simple sugar content, (Echeverria and Ismail, 1990).

5. Ascorbic acid (V.C)

The data presented in Tables (9 and 10) and Figs (8 and 9) declared that, as an average for all used treatments, the values of V C significantly decreased as the storage period advanced, in both experimental seasons The fall in V. C values at the last period of storage could be explained as the asoorbic acid may be easily oxidized in the presence of O_2, so when cellular disorganization occurs, as a result of senescence or rot, the enzymes which may be responsible for the oxidative destruction of the V.C (ascrobic acid oxidase, phenolase, cytochrome oxidase and peroxidase) do their oxidative activities (Hulme, 1970). The reduction of V.C. content during storage was confirmed by Heikal and Others (1965) on Egyptian lemons Bilisli *et al* (1970) reported that oxidation of V.C in the lemon fruits of 3 cvs increased with storage temperature (10-13°C).

The fruits at both harvesting stages stored at 13°C had significantly highest average values of V.C compared with those stored at 7°C or RT, in both seasons, except in first one, light green fruits stored at 13°C gave almost similar V.C. values as those stored at 7°C and lower values than those stored at RT, as an average for the first period of storage (4weeks).

Table (9): Effect of various treatments on V.C (mg/100 ml juice) of Banzahir lime fruits during storage in 1997.

Weeks in storage	Treatments								
	Light Green RT	Yellowish Green RT	Light Green 7°C	Yellowish Green 7°C	Light Green 13°C	Yellowish Green 13°C	Average	Average of the last 4 treatments	Average of the last 2 treatments
0	49.10	51.70	49.10	51.70	49.10	51.70	51.40 A	50.40 A	50.40 A
2	52.31	43.29	43.70	48.61	45.44	49.80	47.19 B	46.89 B	47.62 B
4	40.80	35.77	44.50	42.93	42.81	50.56	42.90 C	45.20 C	46.69 B
Average	47.40 B	43.59 D	45.77 C	47.75 B	45.78 C	50.69 A			
L.S.D		Treatments		Storage period		Interaction			
0.05		1.055		1.049		2.388			
0.01		1.479		1.421		3.294			
6	-	-	30.15	31.00	38.73	42.90		35.70 D	40.82 C
8	-	-	32.08	29.64	33.50	38.87		33.52 E	36.19 E
Average	-	-	39.91 C	40.78 CB	41.92 B	46.77 A			
L.S.D		Treatments		Storage period		Interaction			
0.05		1.903		1.270		3.012			
0.01		2.769		1.708		4.227			
10	-	-	-	-	36.22	39.13			37.68 ED
12	-	-	-	-	36.00	40.33			38.17 D
Average	-	-	-	-	40.26 B	44.76 A			
L.S.D		Treatments		Storage period		Interaction			
0.05		2.592		1.790		NS			
0.01		4.298		2.425					

Average followed by the same letters are not significant different at 0.05 level.
NS: Not significant

Table (10): Effect of various treatments on V.C (mg/100 ml juice) of Banzahir lime fruits during storage in 1998.

Weeks in storage	Treatments								
	Light Green RT	Yellowish Green RT	Light Green 7°C	Yellowish Green 7°C	Light Green 13°C	Yellowish Green 13°C	Average	Average of the last 4 treatments	Average of the last 2 treatments
0	47.20	49.88	47 20	49 88	47.20	49 88	48.54 A	48.54 A	48 54 A
2	46.91	41 72	48.10	45 6	50.11	47.21	46.61 B	47.76 B	48 66 A
4	44.33	37.25	36.55	40.91	49.20	46 46	42 45 C	43.28 C	47.83 A
Average	46.15 BC	42.95 D	43 95 CD	45 46 C	48.84 A	47.85 AB			
L.S.D		Treat.		Storage period		Interaction			
0.05		2.350		0 604		2.603			
0.01		3.295		0.818		3.590			
6	-	-	32.81	34 16	45.05	35.67		36 92 D	40 36 B
8	-	-	30.24	28 67	40.43	30 88		32 56 E	35.66 D
Average	-	-	38.98 C	39 84 CB	46 40 A	42.02 B			
L.S.D		Treatments		Storage period		Interaction			
0.05		2.301		0.638		2.484			
0.01		3.348		0.857		3.485			
10	-	-	-	-	37 11	34 23			35 67 D
12	-	-	-	-	38 00	35.64			36.92 C
Average	-	-	-	-	43 87 A	40.02 B			
L.S.D		Treatments		Storage period		Interaction			
0.05		2.180		0 856		2.213			
0.01		3.616		1 160		3.533			

Average followed by the same letters are not significant different at 0.05 level.

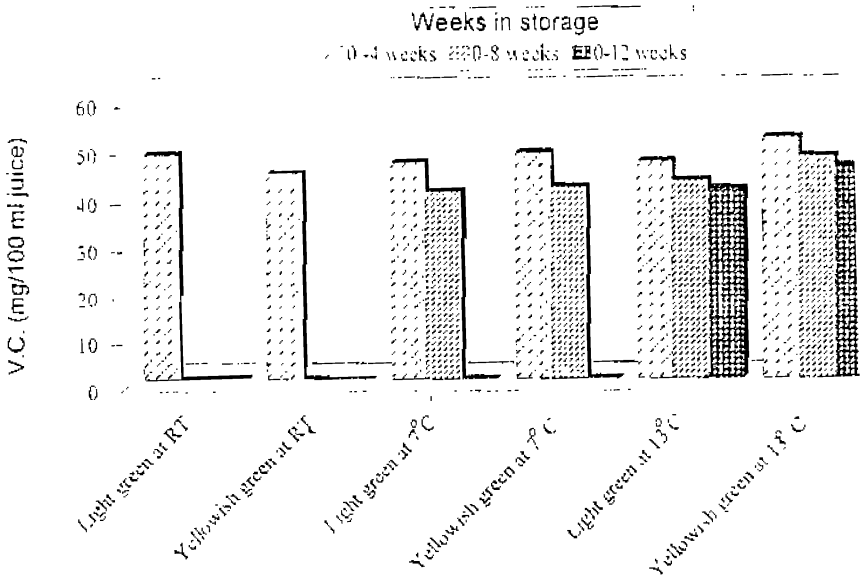

Fig. 8. Effect of various treatments on V.C. (mg/100 ml juice) of Banzahir lime fruits during storage in

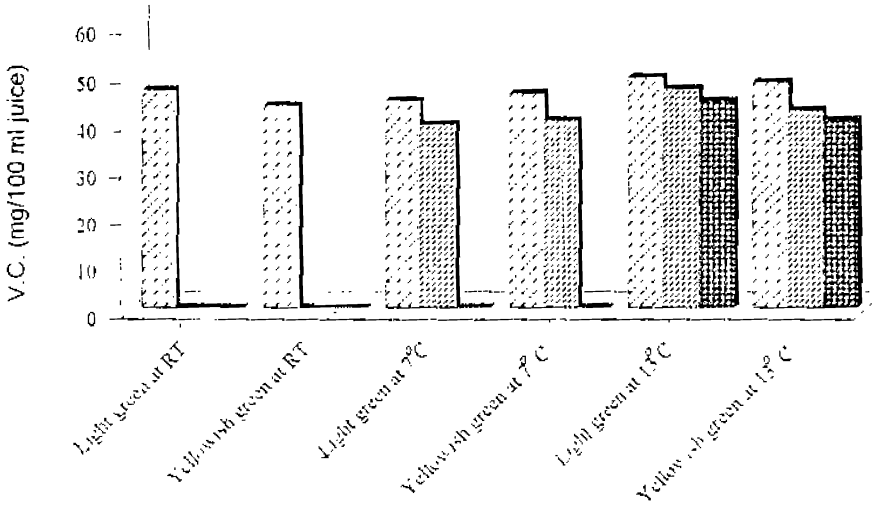

Fig. 9. Effect of various treatments on V.C. (mg/100 ml juice) of Banzahir lime fruits during storage in

Also in the second season, the differences were so slight to be significant between V.C. values of yellowish green fruits stored at 13°C and those stored at 7°C, as an average for 8 weeks. The results were agreed with those found by Eaks (1961). He found that lemons stored at 12.8°C for 3 months lost little ascorbic acid but, at 24°C significant loss occurred. However, Brune and Others (1968) found that during storage for 46 days at 21°C, vitamin C of Baia orange fruits increased slightly, but at 7.5°C there was a slight reduction.

Concerning, harvesting stage, V.C. percentages of fruits stored at RT, were significantly higher at light green stage than at yellowish green one, in both seasons, as an average for 4 weeks. Whereas, the average values of V.C in those stored at 7 or 13°C were higher in yellowish green fruits than in light green ones, in the first season. The differences were significant in all cases, except those stored at 7°C, as an average for 8 weeks. In the second season, the results were somewhat different. The insignificant effect of harvesting stage on V.C content was found in fruits stored at 7°C (as an average for 4 or 8 weeks) and at 13°C (as an average for 4 weeks). Whereas, yellowish green fruits had significantly lower values of V.C compared with light green ones stored at 13°C, as an average for 8 or 12 weeks of storage. These findings were in harmony with Khalifah and Kuykendall (1965). They reported that the time of harvest of Valencia oranges, seems to influence the effect of storage temperature on the loss of V.C. Brune and Others (1968) noticed that in 3 out of 4 trees of Eugenia uniflora the ripe fruit contained considerable less V.C than the green fruit, but in the 4 th, with the highest values throughout, the ripe fruit contained much the highest percentage.

6. Titratable acidity

The data obtained from Tables (11 and 12) and Figs (10 and 11) showed that in both seasons, citric acid percentage, as an average for all applied treatments didn't significantly change during the first period of storage (4 weeks) thereafter, the percentages of citric acid decreased with the progress of storage period, as an average of the 4 remained treatments. The constancy of acidity during the first period of storage was previously reported by Zhang *et al.* (1994) on Natsudaidai fruits. They found that titratable acidity showed no marked change occurred before 79 days of storage. The decreasing in citric acid values at the end of storage was also pointed out by Singh *et al.* (1988) on Kinnow mandarins.

In general, storage temperature had no significant effect on average percentages of citric acid in fruits at both harvesting stages, except, as an average of 4 weeks yellowish green fruits stored at RT had significantly higher citric acid percentages than those stored at 7 or 13°C in the first season. Besides, citric acid percentages of light green ones were significantly higher at RT than at 7°C, in the second season. These findings agreed with those found by Nam and Kweon (1989) on satsuma mandarins, but not in line with those noticed by Murata and Yamawaki (1992).

Table (11): Effect of various treatments on percent citric acid of Banzahir lime fruits during storage in 1997.

Weeks in storage	Treatments								
	Light Green RT	Yellowish Green RT	Light Green 7°C	Yellowish Green 7°C	Light Green 13°C	Yellowish Green 13°C	Average	Average of the last 4 treatments	Average of the last [illegible] treatments
0	12.00	9.00	12.00	9.00	12.00	9.00	10.50	10.50 A	10.50 A
2	11.91	10.20	11.70	8.58	11.66	9.00	10.51	10.24 A	10.33 AB
4	11.83	10.52	10.50	8.72	10.71	8.48	10.13	9.60 B	9.60 ABC
Average	11.91 A	9.91 B	11.40 A	8.77C	11.46 A	8.83 C			
L.S.D		Treatments		Storage period		Interaction			
0.05		1.000		NS		1.293			
0.01		1.402				1.783			
6	-	-	9.83	8.80	10.32	8.83		9.45B	[illegible] BC
8		-	8.56	8.10	10.00	8.00		8.67 C	[illegible] CD
Average	-	-	10.52 A	8.64 B	10.94 A	8.66 B			
L.S.D		Treatments		Storage period		Interaction			
0.05		1.164		0.614		NS			
0.01		1.694		0.825					
10	-		-	-	9.05	7.93			[illegible] D
12	-		-		9.00	7.56			8.28 C
Average				-	10.39A	8.40B			
L.S.D		Treatments		Storage period		Interaction			
0.05		1.323		0.914		NS			
0.01		2.194		1.239					

Average followed by the same letters are not significant different at 0.05 level.
NS: Not significant

Table (12): Effect of various treatments on percent citric acid of Banzahir lime fruits during storage in 1998.

Weeks in storage	Treatments								
	Light Green RT	Yellowish Green RT	Light Green 7°C	Yellowish Green 7°C	Light Green 13°C	Yellowish Green 13°C	Average	Average of the last 4 treatments	Average of the last 2 treatments
0	11.66	8.57	11.66	8.57	11.66	8.57	10.12	10.12 A	10.12 A
2	11 50	9.62	10.12	8.60	10.12	9 00	9.83	9.46 B	9.56 AB
4	11.40	10.48	8 92	9.04	9.71	8.70	9.71	9.09C B	9.21 BC
Average	11.52 A	9.56B C	10.23 B	8.74 C	10.50 AB	8.76 C			
L.S.D		Treatments		Storage period		Interaction			
0.05		1.147		NS		1.485			
0.01		1.609				2 048			
6	-	-	9.05	8.71	8.78	8.12		8 67CD	8.45 D
8	-	-	8.00	8.20	9.34	8.30		8.46D	8.82 CD
Average	-	-	9.55 AB	8.62 B	9.92 A	8.54 B			
L.S.D		Treatments		Storage period		Interaction			
0.05		1.153		0.559		1.522			
0.01		1.678		0 752		2.135			
10	-	-	-	-	9 00	8.07			8.54 CD
12	-	-	-	-	9.00	7.91			8.46 D
Average	-	-	-	-	9.66 A	8.38 B			
L.S.D		Treatments		Storage period		Interaction			
0.05		0.971		0.684		1.292			
0.01		1.610		0.927		2.062			

Average followed by the same letters are not significant different at 0.05 level.
NS: Not significant

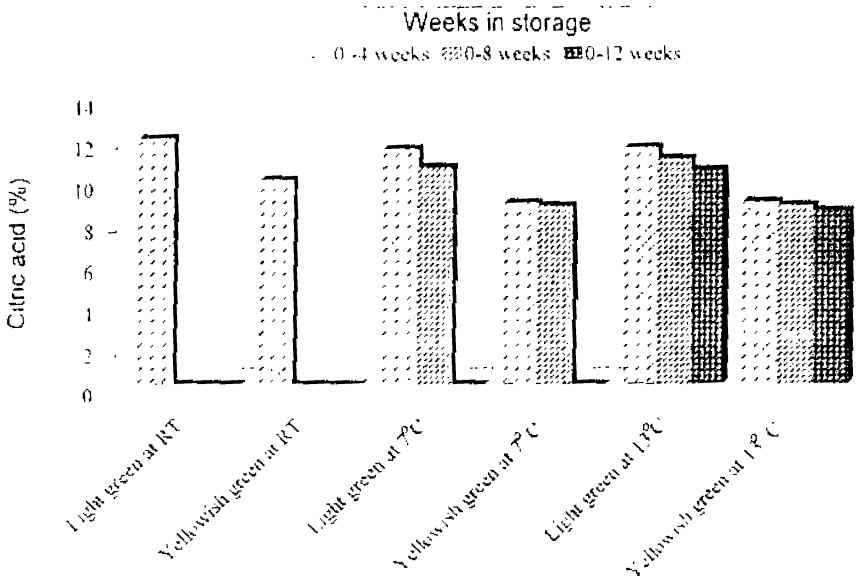

Fig. 10. Effect of various treatments on percent citric acid of Banzahir lime fruits during storage in 1997

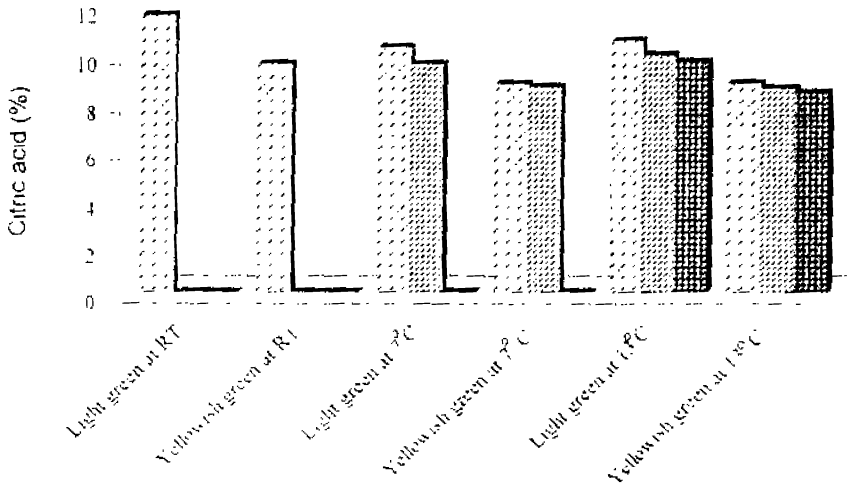

Fig. 11. Effect of various treatments on percent citric acid of Banzahir lime fruits during storage in 1998

Concerning harvesting stage, the data clearly showed that average percentages of citric acid in light green fruits, stored at all atorage temperatures (7, 13°C or RT) were significantly higher than those of yellowish green ones, except those stored at 7°C in the second season, as the differences were not significant, as an average for 8 weeks. These findings were in accordance with those obtained by Naim *et al.* (1995). They noticed that acids were less in Cadoux and Nour clementine fruits harvested at ripe stage.

CONCLUSION

Banzahir lime fruits either at light green or at yellowish green stage, stored at RT, 7 or 13°C remained 4, 8 and 12weeks of storage, respectively The highest significant percentages of unmarketable fruits were in ones at both harvesting stages stored at RT The stage of harvesting had insignificant effect on the percentages of unmarketable fruits, on the contrary it significantly influenced weight loss and acidity. Storage temperature affecied rind colour, weight loss and V C content.

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تأثير مرحلة الجمع، درجات التخزين على المقدرة التخزينية لثمار الليمون البنزهير

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أجريت هذه الدراسة عامى ١٩٩٧، ١٩٩٨ لدراسة تأثير مرحلة الجمع و درجات حرارة التخزين على المقدرة التخزينية لثمار الليمون البنزهير. جمعت الثمار فى يناير عند مرحلتى الأخضر الفاتح، الأصفر المخضر و خزنت على درجات حرارة ١٣،٧ م او درجة الغرفة (١٨-٢١م ، ٧٨-٨٥% رطوبة نسبية) و قد أوضحت النتائج ما يلى:

١- أستمرت الثمار المخزنة على درجة ١٣م لمدة ١٢ أسبوع بينما أستمرت الثمار المخزنة على درجة ٧م لمدة ٨ أسابيع فى حين لم تستمر الثمار المخزنة على درجة حرارة الغرفة أكثر من ٤ أسابيع.

٢- أعلى نسبة معنوية للثمار الغير قابلة للتسويق وجدت فى الثمار المخزنة على درجة حرارة الغرفة و أقل نسب فى المخزنة على ١٣م . عموما لاتوجد اختلافات معنوية فى النسب المئوية للثمار الغير قابلة للتسويق. بين الثمار عند مرحلتى الجمع و المخزنة على نفس الدرجة.

٣- كان تأثير التخزين على درجة حرارة ٧م مماثل للدرجة ١٣م بالنسبة للون قشرة الثمار أثناء الفترة الأولى من التخزين بينما أسرع التخزين على درجة حرارة الغرفة من تطور اللون.

٤- النسب المئوية للفقد فى الوزن كانت اقل معنويا فى الثمار الصفراء المخضرة عن ذات اللون الأخضر الفاتح و أقل فقد فى الوزن وجد فى الثمار المخزنة على ١٣م.

٥- بتقديم فترة التخزين زادت النسبة المئوية للمواد الصلبة الذائبة بينما انخفضت قيم فيتامين C فى حين لم تتغير معنويا النسبة المئوية للحموضة اثناء الفترة الأولى من التخزين (٤ أسابيع) و انخفضت بعد ذلك.

٦- تأثرت قيم فيتامين C بدرجة حرارة التخزين و عموما كانت أعلى القيم فى الثمار المختزنة على ١٣م.

٧- مرحلة الجمع كان لها تأثير واضح على الحموضة، حيث احتوت الثمار ذات اللون الأخضر الفاتح على نسب من حامض الستريك أعلى معنويا من الموجودة فى الثمار ذات اللون الأصفر المخضر.