

PHYSIOLOGICAL STUDIES ON THE EFFECT OF FOUR ROOTSTOCKS ON HERNANDINA CLEMENTINE FRUITS

II- FRUIT STORABILITY

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Abstract

This study was carried out on Hernandina fruits were taken from a private farm at Wady El-Mullak region, Ismailia Governorate during two successive seasons (2005:2006 & 2006:2007) to determine the effect of four citrus rootstocks on fruit storability at two different low storage temperatures.

Hernandina trees grafted on Sour orange, Carrizo citrange, Cleopatra mandarin and Citrumelo rootstocks were selected for this study. Mature fruits of each treatment in both seasons, were picked, washed, dried, sorted to obtain uniform samples then stored at 5°C or 10°C and 90 - 95% RH up to 90 and 75 days during the first and the second season, respectively. Physical and chemical properties at 15 day intervals were determined during storage.

Weight loss percentage, decay percentage, total soluble solids and TSS/total acidity ratio increased gradually with the prolonged of storage. In the contrary, fruit gravity, fruit firmness, juice percentage, total acidity and ascorbic acid contents decreased gradually with the increasing of the storage period. Furthermore, fruit color changed directly from yellow to orange-yellow to orange to reddish-orange during storage.

Fruits were produced on Sour orange rootstock showed weight loss incidence, TSS and TSS/total acidity ratio significantly less and decay incidence, fruit gravity, fruit firmness and total acidity were significantly higher than fruits were bearing on the other rootstocks. Rootstock type had no obvious effect on changing of fruit color, fruit juice and ascorbic acid contents changes in stored fruits. However some of these differences return to pre-harvest factors.

Fruits stored at 5°C significantly had less weight loss and decay percentage than that fruits stored at 10°C. Furthermore, storage at 5°C significantly reduced the deterioration rate of fruit gravity, fruit coloration, softening, juice content and changes of TSS, total acidity, TSS/total acidity ratio and ascorbic acid in comparison with storage of fruits at 10°C.

It can be concluded that, Clementine Hernandina fruits are able to be store for 60 days at 5°C and 90-95% RH with negligible changes of fruit characteristics and quality. Moreover, rootstock types under this study nearly had a little effect on fruit storability.

INTRODUCTION

Citrus is one of the most important fruit crop in Egypt. The total planted area is estimated to be 382027 Faddan in 2006 season produced about 3211709 tons of fruits in the same year. While the exported quantity in 2005 reached 530909 tons from all citrus species. (General Horticulture Administration, MOA, 2005)

There is a good opportunity for other citrus species than orange to increase its exported quantity to Europe countries under the Egyptian-Europe Association Agreement. The production of the Egyptian local mandarin fruit during a short period and its sensitivity to post harvest and handling management obligate to search about new cultivars, especially early and late ones and has a good ability for marketing and handling processes.

There are new mandarin cultivars and hybrids that have been entered to the Egyptian citrus industry such as Marisol, Clemenules, Hernandina, Nova mandarin, Ellendale tangor and others. These cultivars have been spread in the private sector orchards. However, there is a lack of information about these new cultivars behavior under the Egyptian local conditions, concerning production maturation and post harvest management.

Post-harvest life of mandarin fruits depends on complicated interactions between the physiology of the fruit and its pathogens. Storage temperature is the prime importance. The same variety grown under different climatic conditions may need different storage temperature requirements.

D'Hallewin et al. (1994) mentioned that storage behavior of Avana mandarin was more affected by rootstock. Also, fruits from trees on Sour orange had the lowest loss from disease incidence during storage, but chilling injury was greatest in fruits produced on Sour orange rootstock. Moreover, quality parameters of fruits were affected by rootstock at harvest and these differences remained during storage and shelf life. The same trend was found by *Reynaldo (1999)* on Ruby Red grapefruit.

Farih et al. (1995) reported that Clementine cultivars Sidi Aissa, Ain Taoujdate and Cadoux fruits from trees on Cleopatra mandarin conferred greater resistance to storage rots than the other rootstocks (Sour orange, Rough lemon, Troyer citrange). The same trend was reported by *Ritenour et al. (2004)* on Navel oranges, 'Ray Ruby' grapefruit and 'Oroblanco' fruit. On contrast, *Valbuena (1996)* indicated that Persian lime fruits on trees grafted on Cleopatra mandarin rootstock had more post-harvest damage and disease incidence significantly higher than that of fruits from trees grown on Volkameriana lemon.

It has been reported that Fremont tangerine fruit on Volkameriana followed by fruits on Rangpur lime had the lowest weight loss percentage during storage while the

highest were found in fruits on Sour orange rootstocks. Also, the lowest values of juice were found in fruits on Sour orange. Fruits on Carrizo citrange had the highest TSS. Acidity percentage decreased during storage and fruits from trees on Volkameriana rootstocks had the lowest acidity percentage, while that from trees on Sour orange had the highest acidity content (Ali, 2002).

El-Hilali *et al.* (2003) reported that the highest juice content after 30-days storage was obtained from fruits harvested on C. volkameriana and 'Troyer' citrange and the lowest in fruits from Afourer on 'Sacatan' citrumelo. Fruits from 'Troyer' citrange and 'Sacatan' citrumelo had higher acid content than fruits picked from other rootstocks. In general, total soluble solids in juice were high in fruits from all combinations, except for fruits harvested from Sour orange stored at 4 degrees C.

Schirra, *et al.* (1997) on Tarocco oranges, reported that total soluble solids content of orange juice increased during storage, while fruit juice content, titratable acidity and ascorbic acid contents decreased. The same results were mentioned by Mohamed *et al.* (2002 and 2003).

The purpose of this study is to determine the effect of four rootstock types (Sour orange, Carrizo citrange, Cleopatra mandarin and Citrumelo) on Hernandina fruits quality and storability at two different low storage temperatures (5°C and 10°C).

MATERIALS AND METHODS

This investigation was carried out during two successive seasons (2005:2006 & 2006:2007) at Hort. Res. Institute, Fruit Handling Department, Giza, Egypt.

Trees were grown in a private farm at "Wady El-Mullak" region, Ismailia Governorate. During February 2005, 36 Hernandina trees grafted on Sour orange, Carrizo citrange, Cleopatra mandarin and "Swingle" citrumelo rootstocks were selected for this study, (9 trees for each rootstock). Trees were 7 years old, healthy, uniformed vigor growth, planted in sandy soil at 2×5 m under drip irrigation system and subjected to all agriculture practices as ministry agriculture recommendations.

Mature fruit of each treatment in both seasons (the first part of this work), were picked, washed, dried, sorted to obtain uniform samples then stored at 5°C or 10°C and 90-95% RH up to 90 and 75 days during the first and the second season, respectively. Each treatment had six carton boxes (each box had 12 fruits), representing six replicates, three replicates were used for the determination of the physical and chemical properties at 15 day intervals. The other three replicates were used to estimate the weight loss and decay percentage (either pathology or physiology) of fruits during storage.

The determination procedures were as follow:

1- **Weight loss percentage**: thirty six fruits (three boxes each had twelve fruits) were individually weighted and the differences between its weight at the beginning of the experiment and at the examination day were represented as weight loss percentage.

2- **Decay percentage** : the weight of unmarketable fruits due to pathological and physiological disorders was determined and this value was calculated.

3- **Fruit gravity** by dividing fruits size on fruit weight.

4- **Fruit firmness (g/cm^2)** was measured in 6 fruits (3 readings per each fruit) by Lfra texture analyzer instrument using a penetrating cylinder of 1 mm in diameter to a constant distance 5 mm inside the skin of fruits and by a constant speed 2 mm per sec. and the peak of resistance was recorded per gram on squire centimeter.

5- **Peel colour** changes during storage was estimated by a Hunter colorimeter type (Dp-9000) for the estimation of "L", "a" and "b" values and to evaluate colour values as Hue angle and values were calculated according to *Mc Guire (1992)*.

6- **Juice content** was estimated by squeezing 12 fruits (as three replicates) by handy squeezer and then juice percentage was calculated (w/w).

7- Percentages of **total soluble solids** (T.S.S. %), **total acidity** percentage (as citric acid) and **ascorbic acid** were estimated according to *A.O.A.C. (1985)*.

Data for all fruit parameters were analyzed as a complete randomized design with factorial treatments as described by *Snedecor and Cochran (1980)*.

RESULTS AND DISCUSSION

A- Physical properties

1- Weight loss percentage

According to data presented in Table (1) weight loss percentage of Hernandina Clementine fruits increased gradually and significantly with the increasing of storage period. Weight loss percentage of fruits stored at 10°C was significantly higher than that fruits stored at 5°C. On the other hand, fruits bearing on Sour orange rootstock had weight loss incidence significantly less than fruits produced on Carrizo and Citrumelo rootstocks. While, weight loss percentage of fruits bearing on Cleopatra rootstock was not different from that found on Sour orange.

These results agree with those mentioned by *D'Hallewin et al (1994)*, *Valbuena (1996)*, *Reynaldo (1999)* and *Ali (2002)* who reported that weight loss percentage of citrus fruit was affected by rootstock types.

2- Decay percentage

Data shown in Table (2) illustrated that decay percentage of fruits increased gradually and significantly with the increasing of storage period. Moreover, fruits

stored at 10°C significantly had decay incidence higher than that stored at 5°C regardless of rootstocks types.

Table 1. Effect of four rootstocks and cold storage on weight loss percentage during storage of "Hernandina" Clementine fruits in 2005/2006 and 2006/2007 seasons.

First season (2005)											
St. Temp.	10° C					5° C					Means
St. period (days)	Rootstock types					Rootstock types					
	1	2	3	4	Means	1	2	3	4	Means	
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	2.62	2.13	2.35	2.47	2.39	1.38	1.79	1.54	1.67	1.59	1.99
30	4.32	4.28	4.63	3.77	4.25	3.91	4.02	3.41	4.05	3.85	4.05
45	6.04	6.27	6.28	5.54	6.04	4.74	5.02	4.91	5.24	4.98	5.51
60	8.13	8.97	8.46	8.85	8.60	6.96	7.17	6.81	7.32	7.06	7.83
75	10.74	11.51	10.80	11.74	11.20	7.70	8.23	8.23	8.64	8.20	9.70
90	12.62	13.21	12.89	13.36	13.02	9.06	9.47	8.68	9.16	9.09	11.06
Means	6.35	6.62	6.49	6.53	6.50	4.82	5.10	4.79	5.15	4.97	
Second season (2006)											
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	1.9	2.5	2.0	2.3	2.2	1.2	1.3	1.2	1.6	1.3	1.7
30	3.7	4.9	3.9	4.6	4.3	2.2	2.5	2.4	3.2	2.6	3.4
45	6.9	7.9	6.7	7.9	7.4	4.6	4.7	4.6	5.6	4.9	6.1
60	9.0	10.4	8.9	10.1	9.6	6.1	7.0	5.9	7.7	6.7	8.1
75	11.1	13.0	11.6	12.3	12.0	7.7	9.3	7.3	9.8	8.5	10.2
Means	5.4	6.5	5.5	6.2	5.9	3.6	4.1	3.6	4.6	4.0	
Rootstock means					Abbreviations:						
Rootstock	1	2	3	4	1= Sour orange			2= Carrizo			
1 st season	5.6	5.9	5.6	5.8	3= Cleopatra			4= Citrumelo			
2 nd season	4.5	5.3	4.5	5.4	A= Storage Temp.			B=Rootstock types			
L.S.D. at 5%					C= Storage period in days						
Factors	A	B	C	a*b	a*c	b*c	a*b*c				
1 st season	0.16	0.18	0.24	N.S.	0.34	N.S.	N.S.				
2 nd season	0.16	0.22	0.27	0.32	0.39	0.55	N.S.				

On the other hand, data cleared that Hernandina fruits produced on Sour orange rootstock had significantly higher decay incidence than that fruits on other rootstocks. Furthermore, there were significant differences among fruits bearing on Carrizo, Cleopatra and Citrumelo concerning decay incidence during the two seasons in this investigation.

These results are in agreement with those obtained by *El-Zeftawi et al. (1989)*, *Valbuena (1996)* and *Ritenour et al. (2004)*. They demonstrated that decay incidence of citrus fruit was significantly different according to rootstock types.

Table 2. Effect of four rootstocks and cold storage on decay percentage during storage of "Hernandina" Clementine fruits in 2005/2006 and 2006/2007 seasons.

First season (2005)											
St. Temp.	10° C					5° C					Means
St. period (days)	Rootstock types					Rootstock types					
	1	2	3	4	Means	1	2	3	4	Means	
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	23.25	6.05	6.67	9.67	11.41	5.88	7.17	7.14	6.61	6.70	9.05
45	26.76	6.05	9.98	14.11	14.23	0.17	14.34	10.48	9.81	8.70	11.46
60	39.52	26.63	23.08	27.19	29.10	24.49	15.29	13.59	9.54	15.73	22.42
75	39.52	33.29	26.83	37.20	34.21	28.60	9.68	13.59	13.01	16.22	25.21
90	62.70	46.57	47.47	49.52	51.56	32.90	13.51	13.59	19.30	19.83	35.69
Means	27.39	16.94	16.29	19.67	20.07	13.15	8.57	8.34	8.32	9.60	
Second season (2006)											
0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.00	0.00
15	3.1	0.0	3.3	6.0	3.10	0.0	0.0	0.0	0.0	0.00	1.55
30	9.5	6.8	10.4	6.0	8.17	0.0	0.0	0.0	0.0	0.00	4.08
45	32.1	12.9	10.4	15.7	17.78	10.4	0.0	3.0	0.0	3.35	10.56
60	32.1	12.9	17.0	15.7	19.41	17.0	3.5	10.3	3.2	8.48	13.94
75	32.1	16.1	23.3	15.7	21.78	27.3	9.5	10.3	10.2	14.29	18.04
Means	18.15	8.12	10.72	9.83	11.71	9.10	2.15	3.93	2.23	4.35	
Rootstock means						Abbreviations:					
Rootstock	1	2	3	4		1= Sour orange		2= Carrizo			
1 st season	20.3	12.8	12.3	14.0		3= Cleopatra		4= Citrumelo			
2 nd season	13.6	5.1	7.3	6.0		A= Storage Temp.		B=Rootstock types			
L.S.D. at 5%						C= Storage period in days					
Factors	A		B			C		a*b	a*c	b*c	a*b*c
1 st season	3.17		4.48			5.93		N.S.	8.39	N.S.	N.S.
2 nd season	2.38		3.36			4.12		N.S.	5.82	8.24	N.S.

3- Fruit gravity (g/cm³)

Data shown in Table (3) demonstrated that fruit gravity decreased gradually and significantly with the increasing of storage period during the two seasons of this investigation. Data also indicated that storage of fruits at 5°C significantly reduced the deterioration rate of fruit gravity during storage in comparison with those stored at 10°C. On the other hand, gravity of fruits bearing on Sour orange was significantly higher in comparison with those on the other rootstocks. However, these differences return to the effect of rootstock during pre-harvest period and still appear during storage period.

Table 3. Effect of four rootstocks and cold storage on fruits gravity during storage of "Hernandina" Clementine fruits in 2005/2006 and 2006/2007 seasons.

First season (2005)											
St. Temp.	10° C					5° C					Means
St. period (days)	Rootstock types					Rootstock types					
	1	2	3	4	Means	1	2	3	4	Means	
0	0.97	0.93	0.95	0.93	0.94	0.97	0.93	0.95	0.93	0.94	0.94
15	0.94	0.90	0.92	0.92	0.92	0.96	0.92	0.94	0.92	0.93	0.93
30	0.91	0.90	0.92	0.90	0.90	0.94	0.92	0.92	0.89	0.92	0.91
45	0.87	0.87	0.75	0.87	0.84	0.91	0.90	0.89	0.89	0.90	0.87
60	0.80	0.72	0.74	0.80	0.76	0.87	0.74	0.80	0.83	0.81	0.79
75	0.78	0.73	0.72	0.75	0.75	0.85	0.73	0.79	0.82	0.80	0.77
90	0.74	0.64	0.61	0.67	0.67	0.81	0.72	0.72	0.76	0.75	0.71
Means	0.86	0.81	0.80	0.83	0.83	0.90	0.84	0.86	0.86	0.86	
Second season (2006)											
0	0.91	0.84	0.86	0.84	0.86	0.91	0.84	0.86	0.84	0.86	0.86
15	0.81	0.73	0.69	0.75	0.74	0.85	0.75	0.73	0.76	0.77	0.76
30	0.78	0.71	0.67	0.76	0.73	0.81	0.73	0.71	0.78	0.76	0.74
45	0.69	0.62	0.63	0.68	0.65	0.82	0.72	0.64	0.77	0.74	0.70
60	0.65	0.66	0.54	0.65	0.62	0.73	0.62	0.61	0.75	0.68	0.65
75	0.57	0.60	0.66	0.60	0.61	0.67	0.67	0.65	0.66	0.66	0.64
Means	0.74	0.69	0.67	0.71	0.70	0.80	0.72	0.70	0.76	0.75	
Rootstock means						Abbreviations:					
Rootstock	1	2	3	4		1= Sour orange		2= Carrizo			
1 st season	0.88	0.82	0.83	0.85	<th colspan="2">3= Cleopatra</th> <th colspan="2">4= Citrumelo</th> <th colspan="2"></th>	3= Cleopatra		4= Citrumelo			
2 nd season	0.77	0.71	0.69	0.74	<th colspan="2">A= Storage Temp.</th> <th colspan="2">B=Rootstock types</th> <th colspan="2"></th>	A= Storage Temp.		B=Rootstock types			
L.S.D. at 5%						C= Storage period in days					
Factors	A	B	C			a*b	a*c	b*c	a*b*c		
1 st season	0.017	0.024	0.031			N.S.	N.S.	0.063		N.S.	
2 nd season	0.018	0.026	0.036			N.S.	N.S.	0.072		N.S.	

4- Fruit color:

Fruit color data presented in Table (4) as Hue angle value cleared that, fruit color changed directly from Yellow (Hue angle is more than 60°) to orange-yellow to orange to reddish-orange (Hue angle is less than 45°) during storage in the two seasons of this study. Moreover, 5°C storage temperatures significantly decreased the coloration rate during storage compared with 10°C during both seasons.

Data also indicated that, rootstock type had no effect on color changes in stored fruits during the first season. While in the second one, color changes of fruits bearing on Carrizo and Citrumelo were more accelerated than those on the two other rootstocks. However, these changes were due to the pre-harvest period effect.

Table 4. Effect of four rootstocks and cold storage on fruits color, represented as hue angle values, during storage of "Hernandina" Clementine fruits in 2005/2006 and 2006/2007 seasons.

First season (2005)											
St. Temp.	10° C					5° C					Means
St. period (days)	Rootstock types					Rootstock types					
	1	2	3	4	Means	1	2	3	4	Means	
0	67.7	64.9	62.3	64.1	64.7	67.7	64.9	62.3	64.1	64.74	64.7
15	61.4	60.1	56.1	57.7	58.8	67.8	65.0	59.4	62.5	63.67	61.2
30	58.8	59.4	55.9	57.4	57.9	63.3	64.0	61.0	58.8	61.79	59.8
45	55.1	55.3	49.9	51.3	52.9	67.9	65.1	56.5	60.9	62.59	57.7
60	49.8	54.0	49.4	50.7	51.0	58.9	63.2	59.7	53.5	58.83	54.9
75	48.1	45.0	45.9	47.1	46.5	59.1	57.2	50.7	51.5	54.63	50.8
90	48.7	40.5	42.9	42.3	43.6	52.4	46.2	49.4	45.7	48.40	46.0
Means	55.7	54.2	51.8	53.0	53.6	62.5	60.78	57.0	56.7	59.2	
Second season (2006)											
0	68.6	63.0	66.1	64.7	65.6	68.6	63.0	66.1	64.7	65.6	65.6
15	53.2	51.4	48.8	53.4	51.7	54.8	48.1	59.0	54.5	54.1	52.9
30	50.2	47.0	49.8	44.6	47.9	49.9	49.2	55.6	51.4	51.5	49.7
45	46.9	42.0	51.8	35.6	44.1	45.0	50.6	52.6	49.2	49.3	46.7
60	45.6	36.8	46.9	38.6	42.0	47.1	48.8	53.5	47.5	49.2	45.6
75	44.3	30.5	43.0	42.1	40.0	49.3	46.9	54.5	45.6	49.1	44.5
Means	51.5	45.1	51.1	46.5	48.5	52.5	51.1	56.9	52.1	53.1	
Rootstock means					Abbreviations:						
Rootstock	1	2	3	4	1= Sour orange				2= Carrizo		
1 st season	59.1	57.5	54.4	54.8	3= Cleopatra				4= Citrumelo		
2 nd season	52.0	48.1	54.0	49.3	A= Storage Temp.				B=Rootstock types		
L.S.D. at 5%					C= Storage period in days						
Factors	A	B	C	a*b	a*c	b*c	a*b*c				
1 st season	1.32	N.S.	2.48	N.S.	3.5	N.S.	N.S.				
2 nd season	2.32	3.29	4.03	N.S.	N.S.	N.S.	N.S.				

These results are in harmony with those obtained by *Schirra, et al.* (1997) who demonstrated that Star Ruby grapefruit color was nearly not affected by storage period, but storage temperature resulted in increase in a/b hunter value ratio at the high storage temperature.

5- Fruit firmness : (gm/cm²)

Fruit firmness (Table 5) of Hernandina significantly decreased with the extension of storage period regardless of rootstock or storage temperature. Moreover, 5°C storage temperature significantly reduced fruit softening rate during storage regardless of rootstock types in this study.

Table 5. Effect of four rootstocks and cold storage on fruit firmness during storage of "Hernandina" Clementine fruits in 2005/2006 and 2006/2007 seasons.

First season (2005)											
St. Temp.	10° C					5° C					Means
St. period (days)	Rootstock types					Rootstock types					
	1	2	3	4	Means	1	2	3	4	Means	
0	106.0	94.9	106.6	101.9	102.4	106.0	94.9	106.6	101.9	102.4	102.4
15	93.1	81.0	85.9	84.5	86.1	101.6	82.6	89.5	83.4	89.3	87.7
30	84.6	77.8	82.8	77.7	80.7	100.9	76.6	80.5	79.4	84.4	82.6
45	79.7	67.1	65.8	67.0	69.9	96.7	70.3	80.0	64.8	77.9	73.9
60	71.8	73.6	69.4	61.8	69.2	89.3	70.2	75.9	67.8	75.8	72.5
75	66.0	59.4	55.4	50.4	57.8	95.3	67.9	71.1	56.8	72.8	65.3
90	57.1	49.7	51.1	43.5	50.3	64.6	50.0	62.8	50.2	56.9	53.6
Means	79.8	72.0	73.8	69.6	73.8	93.5	73.2	80.9	72.0	79.9	
Second season (2006)											
0	104.5	100.9	99.1	97.5	100.5	104.5	100.9	99.1	97.5	100.5	100.5
15	100.1	89.1	77.2	92.9	89.8	104.0	90.4	84.5	80.1	89.8	89.8
30	99.8	74.0	61.8	77.0	78.7	99.9	78.1	77.4	77.3	83.2	80.7
45	75.5	59.0	66.4	71.1	68.0	89.7	75.8	70.3	74.5	77.6	72.8
60	85.7	59.7	61.9	65.8	68.3	78.5	65.0	73.8	75.3	73.2	70.7
75	57.3	34.7	66.6	38.7	49.3	62.9	49.6	53.0	50.5	54.0	51.7
Means	87.1	69.6	72.2	73.9	75.7	89.91	76.6	76.4	75.9	79.7	
Rootstock means					Abbreviations:						
Rootstock	1	2	3	4	1= Sour orange				2= Carrizo		
1 st season	86.6	72.6	77.4	70.8	3= Cleopatra				4= Citrumelo		
2 nd season	88.5	73.1	74.3	74.9	A= Storage Temp.				B=Rootstock types		
L.S.D. at 5%											
Factors	A	B	C	a*b	a*c		b*c		a*b*c		
1 st season	3.40	4.80	6.36	6.80	N.S.		N.S.		N.S.		
2 nd season	5.17	7.31	8.95	N.S.	N.S.		N.S.		N.S.		

On the other hand, firmness of fruits bearing on Sour orange were significantly higher than those on the other rootstocks during both seasons in this study, however these differences return to pre-harvest factors.

These results are in line with those demonstrated by *Alferez et al.* (2005) who mentioned that, orange fruit firmness significantly decreased with the increasing of cold storage period. Furthermore, these results are in harmony with those mentioned by *El-Hilali et al.* (2003) who mentioned that mandarin fruit firmness during storage significantly differed according to rootstock.

6- Juice percentage:

Data shown in Table (6) indicated that juice content of fruits decreased gradually and significantly with the increasing of storage period. Moreover, 5°C storage temperatures reduced the deterioration rate of juice content compared with 10°C storage temperature. Furthermore, data indicated that rootstock types had no effect on fruit content of juice during storage.

These results disagree with those obtained by *Ali (2002)* and *El-Hilali et al. (2003)* who mentioned that juice percentage of mandarin stored fruit were difference according to rootstock types. Furthermore, these results are in harmony with those illustrated by *Ramanjulu and Reddy (1989)*, *Mohamed et al. (2002)* and *Mohamed et al. (2003)* who demonstrated that juice percentage of Valencia orange and grapefruit fruit decreased with the extension of storage period.

B - Chemical properties:

1- Total soluble solids, total acidity, TSS/acid ratio and Ascorbic acid contents:

According to data shown in Tables (7, 8, 9 and 10) it is clear that, total soluble solids and TSS/acid ratio increased while total acidity and ascorbic acid contents decreased gradually and significantly with the increasing of storage period.

Data also indicated that 5°C storage temperature reduced the changes rate of TSS, total acidity, TSS/acid ratio and ascorbic acid during storage. However, this effect was not significant in TSS contents during the first season and ascorbic acid content during the two seasons of this study.

Data also cleared that fruits bearing on trees grafted on Carrizo and Citrumelo rootstocks had TSS contents higher than those on Sour orange and Cleopatra rootstocks during both seasons. On the other hand, data illustrated that fruits from trees grafted on Carrizo, Cleopatra and Citrumelo rootstocks had total acidity contents less and TSS/acid ratio higher than fruits produced on Sour orange. On contrast, in this respect, ascorbic acid content had no obvious trend during the two seasons. During the first season, fruits on Cleopatra and Sour orange rootstock had the lowest ascorbic acid content, while during the second season this trend was inverted completely. However, it appears that these effects were return to the effect of these rootstocks during pre harvest period.

Table 6. Effect of four rootstocks and cold storage on juice percentage during storage of "Hernandina" Clementine fruits in 2005/2006 and 2006/2007 seasons.

First season (2005)											
St. Temp.	10° C					5° C					Means
St. period	Rootstock types					Rootstock types					
(days)	1	2	3	4	Means	1	2	3	4	Means	
0	48.8	48.0	48.3	47.1	48.0	48.6	48.3	49.2	50.4	49.1	48.6
15	44.8	47.1	47.9	45.0	46.2	48.7	48.9	48.9	51.7	49.6	47.9
30	42.2	44.6	44.1	41.5	43.1	49.5	44.5	48.4	46.0	47.1	45.1
45	40.8	46.2	47.5	42.9	44.3	48.9	49.5	48.6	53.0	50.0	47.2
60	41.3	41.2	39.9	35.8	39.6	50.4	40.8	47.6	41.6	45.1	42.3
75	35.6	41.3	41.3	34.9	38.3	43.9	41.5	45.7	43.0	43.5	40.9
90	34.4	36.6	33.4	35.0	34.9	32.3	39.7	36.1	40.5	37.2	36.0
Means	41.1	43.6	43.2	40.3	42.1	46.0	44.7	46.4	46.6	45.9	
Second season (2006)											
0	50.2	47.1	49.6	49.2	49.0	50.2	47.1	49.6	49.2	49.0	49.0
15	49.1	49.7	45.6	48.0	48.1	45.4	42.6	47.1	44.5	44.9	46.5
30	46.0	39.9	44.1	42.7	43.2	44.7	40.9	44.4	44.9	43.7	43.4
45	42.9	30.1	42.6	37.3	38.2	44.0	39.1	41.8	42.5	41.8	40.0
60	37.2	31.4	38.9	34.0	35.4	39.0	38.0	37.8	40.0	38.7	37.0
75	31.5	32.6	35.3	30.7	32.5	34.1	34.9	33.8	34.7	34.4	33.4
Means	42.8	38.5	42.7	40.3	41.1	42.9	40.4	42.4	42.6	42.1	
Rootstock means					Abbreviations:						
Rootstock	1	2	3	4	1= Sour orange			2= Carrizo			
1 st season	43.6	44.1	44.8	43.5	3= Cleopatra			4= Citrumelo			
2 nd season	42.8	39.5	42.5	41.5	A= Storage Temp.			B=Rootstock types			
L.S.D. at 5%					C= Storage period in days						
Factors	A	B	C	a*b	a*c	b*c	a*b*c				
1 st season	1.79	N.S.	3.58	N.S.	N.S.	N.S.	N.S.	N.S.			
2 nd season	N.S.	N.S.	3.21	N.S.	N.S.	N.S.	N.S.	N.S.			

Table 7. Effect of four rootstocks and cold storage on TSS percentage during storage of "Hernandina" Clementine fruits in 2005/2006 and 2006/2007 seasons.

First season (2005)											
St. Temp.	10° C					5° C					Means
St. period	Rootstock types					Rootstock types					
(days)	1	2	3	4	Means	1	2	3	4	Means	
0	10.17	11.10	10.93	11.17	10.84	10.17	11.10	10.93	11.17	10.84	10.84
15	10.95	11.90	10.93	11.37	11.29	10.43	11.75	10.85	12.10	11.28	11.29
30	11.12	11.58	10.92	12.18	11.45	10.77	11.33	10.67	12.23	11.25	11.35
45	11.40	12.70	10.93	12.47	11.88	10.90	12.23	11.00	11.82	11.49	11.68
60	10.73	12.40	10.90	12.53	11.64	10.70	12.33	11.33	12.93	11.83	11.73
75	10.67	12.03	11.50	12.13	11.58	10.90	12.33	10.93	12.67	11.71	11.65
90	10.77	11.50	10.13	11.97	11.09	10.80	12.67	10.67	12.40	11.63	11.36
Means	10.83	11.89	10.89	11.97	11.40	10.67	11.96	10.91	12.19	11.43	
Second season (2006)											
0	11.53	12.27	11.80	11.93	11.88	11.53	12.27	11.80	11.93	11.88	11.88
15	11.93	12.11	11.90	12.23	12.04	12.07	12.30	12.17	12.37	12.23	12.13
30	12.60	12.32	12.33	12.35	12.40	12.25	12.17	11.25	12.28	11.99	12.19
45	13.27	13.43	11.93	12.80	12.86	11.77	12.37	11.67	12.47	12.07	12.46
60	12.80	13.50	12.07	12.88	12.81	12.47	13.20	11.72	13.17	12.64	12.73
75	12.93	13.27	12.70	13.30	13.05	13.10	13.67	12.70	13.43	13.23	13.14
Means	12.51	12.82	12.12	12.58	12.51	12.20	12.66	11.88	12.61	12.34	
Rootstock means					Abbreviations:						
Rootstock	1	2	3	4	1= Sour orange			2= Carrizo			
1 st season	10.75	11.93	10.90	12.08	3= Cleopatra			4= Citrumelo			
2 nd season	12.35	12.74	12.00	12.60	A= Storage Temp.			B=Rootstock types			
L.S.D. at 5%					C= Storage period in days						
Factors	A	B	C	a*b	a*c			b*c		a*b*c	
1 st season	N.S.	0.191	0.252	N.S.	0.356			0.304		N.S.	
2 nd season	0.089	0.126	0.155	0.178	0.219			0.310		N.S.	

These results are in line with those obtained by *Ramanjulu and Reddy (1989)*, *Schirra (1992)* and *Mohamed et al. (2003)* who found that total soluble solids increased while total acidity and ascorbic acid decreased with prolonging of storage period. On contrast, these results disagree with those mentioned by *Su, et al. (1988)* who reported that total soluble solids, total acidity and ascorbic acid contents of orange remained constant during storage.

Table 8. Effect of four rootstocks and cold storage on total acidity percentage during storage of "Hernandina" Clementine fruits in 2005/2006 and 2006/2007 seasons.

First season (2005)											
St. Temp.	10° C					5° C					Means
St. period (days)	Rootstock types					Rootstock types					
	1	2	3	4	Means	1	2	3	4	Means	
0	0.83	0.70	0.72	0.65	0.73	0.83	0.70	0.72	0.65	0.73	0.73
15	0.84	0.66	0.75	0.55	0.70	0.81	0.72	0.76	0.57	0.71	0.71
30	0.79	0.65	0.69	0.52	0.67	0.78	0.68	0.72	0.56	0.68	0.67
45	0.75	0.61	0.69	0.51	0.64	0.80	0.69	0.70	0.49	0.67	0.65
60	0.72	0.61	0.66	0.49	0.62	0.75	0.65	0.68	0.46	0.63	0.63
75	0.69	0.52	0.63	0.40	0.56	0.68	0.61	0.63	0.53	0.61	0.59
90	0.67	0.53	0.59	0.37	0.54	0.69	0.57	0.61	0.51	0.60	0.57
Means	0.76	0.61	0.68	0.50	0.64	0.76	0.66	0.69	0.54	0.66	
Second season (2006)											
0	0.72	0.63	0.66	0.63	0.66	0.72	0.63	0.66	0.63	0.66	0.66
15	0.68	0.61	0.59	0.58	0.62	0.70	0.62	0.65	0.65	0.66	0.64
30	0.65	0.64	0.60	0.62	0.63	0.69	0.63	0.63	0.64	0.65	0.64
45	0.61	0.67	0.61	0.67	0.64	0.68	0.63	0.62	0.62	0.64	0.64
60	0.60	0.53	0.57	0.56	0.57	0.66	0.54	0.60	0.59	0.60	0.58
75	0.59	0.40	0.52	0.45	0.49	0.62	0.47	0.60	0.58	0.57	0.53
Means	0.64	0.58	0.59	0.59	0.60	0.68	0.59	0.63	0.62	0.63	
Rootstock means					Abbreviations:						
Rootstock	1	2	3	4							
1 st season	0.76	0.64	0.68	0.52							
2 nd season	0.66	0.58	0.61	0.60							
L.S.D. at 5%					1= Sour orange				2= Carrizo		
					3= Cleopatra				4= Citrumelo		
					A= Storage Temp.				B=Rootstock types		
					C= Storage period in days						
Factors	A	B	C		a*b	a*c	b*c	a*b*c			
1 st season	0.019	0.027	0.036		N.S.	N.S.	N.S.	N.S.			
2 nd season	0.011	0.016	0.020		N.S.	N.S.	N.S.	N.S.			

On the other side, these results agree with those obtained by D'Hallewin *et al.* (1994), Reynaldo (1999), Ali (2002) and El-Hilali *et al.* (2003) who mentioned that total soluble solids, total acidity and ascorbic acid contents were affected by rootstock types. On contrast, El-Zeftawi *et al.* (1989) mentioned that Valencia orange fruit was not influenced by rootstock types.

Table 9. Effect of four rootstocks and cold storage on TSS/TA ratio during storage of
"Hernandina" Clementine fruits in 2005/2006 and 2006/2007 seasons.

First season (2005)											
St. Temp.	10° C					5° C					Means
St. period (days)	Rootstock types					Rootstock types					
	1	2	3	4	Means	1	2	3	4	Means	
0	12.2	15.8	15.2	17.2	15.12	12.2	15.8	15.2	17.2	15.12	15.12
15	13.0	18.0	14.6	20.6	16.54	12.9	16.3	14.3	21.3	16.20	16.37
30	14.0	17.7	15.8	23.2	17.69	13.8	16.8	14.9	22.0	16.88	17.28
45	15.2	20.9	15.8	24.4	19.06	13.7	17.8	15.8	24.2	17.86	18.46
60	14.9	20.5	16.5	25.7	19.39	14.4	19.0	16.6	28.0	19.50	19.45
75	15.4	23.3	18.2	30.5	21.86	15.9	20.4	17.4	24.1	19.43	20.65
90	16.0	21.7	17.0	32.6	21.82	15.6	22.2	17.4	24.1	19.83	20.82
Means	14.39	19.69	16.16	24.89	18.78	14.07	18.32	15.94	23.00	17.83	
Second season (2006)											
0	16.0	19.6	18.0	19.1	18.16	16.0	19.6	18.0	19.1	18.16	18.16
15	17.4	19.8	20.0	21.1	19.60	17.1	20.0	18.7	18.9	18.67	19.13
30	19.4	19.3	20.5	19.8	19.74	17.7	19.5	17.7	19.3	18.55	19.15
45	21.7	20.2	19.5	19.1	20.12	17.3	19.5	18.9	20.2	18.96	19.54
60	21.2	25.4	21.3	23.0	22.73	19.0	24.3	19.6	22.3	21.29	22.01
75	21.8	33.5	24.3	29.4	27.25	21.2	28.8	21.2	23.0	23.54	25.39
Means	19.60	22.95	20.60	21.92	21.27	18.06	21.94	19.01	20.44	19.86	
Rootstock means					Abbreviations:						
Rootstock	1	2	3	4	1= Sour orange				2= Carrizo		
1 st season	14.23	19.00	16.05	23.94	3= Cleopatra				4= Citrumelo		
2 nd season	18.83	22.44	19.80	21.18	A= Storage Temp.				B=Rootstock types		
L.S.D. at 5%					C= Storage period in days						
Factors	A		B		C		a*b	a*c	b*c		a*b*c
1 st season	1.00		1.41		1.86		N.S.	N.S.	N.S.		N.S.
2 nd season	0.63		0.89		1.09		N.S.	1.54	2.18		N.S.

Table 10. Effect of rootstock types and storage temperatures on Hermadina Clementine fruits V.C contents during storage.

First season (2005)											
St. Temp.	10° C					5° C					Means
St. period (days)	Rootstock types					Rootstock types					
	1	2	3	4	Mean s	1	2	3	4	Means	
0	19.5	19.8	17.1	19.3	18.91	19.5	19.8	17.1	19.3	18.91	18.91
15	17.7	19.1	16.2	18.4	17.85	18.0	18.8	16.8	17.4	17.75	17.80
30	16.8	18.5	15.3	17.4	17.00	17.1	18.5	16.1	16.8	17.14	17.07
45	15.9	17.1	15.1	16.4	16.14	16.5	17.8	14.6	15.4	16.08	16.11
60	14.1	14.5	13.0	13.6	13.80	14.8	17.2	12.5	14.3	14.70	14.25
75	11.7	11.2	9.4	8.0	10.08	9.3	10.9	8.2	11.1	9.86	9.97
90	7.9	9.5	7.6	8.4	8.33	7.7	9.8	8.7	11.0	9.29	8.81
Means	14.81	15.66	13.39	14.49	14.59	14.71	16.10	13.43	15.04	14.82	
Second season (2006)											
0	21.6	24.0	23.3	21.7	22.64	21.6	24.0	23.3	21.7	22.64	22.64
15	19.7	21.0	18.3	17.9	19.21	20.2	21.3	19.1	18.1	19.69	19.45
30	17.7	18.3	14.0	14.1	16.03	18.9	18.7	14.9	14.5	16.74	16.39
45	16.3	15.4	13.5	12.3	14.38	16.9	16.6	13.9	12.5	14.96	14.67
60	15.3	13.5	13.0	9.2	12.75	16.4	14.0	11.5	9.2	12.76	12.76
75	11.7	10.1	8.5	7.1	9.35	13.2	11.6	10.2	8.1	10.78	10.07
Means	17.03	17.04	15.12	13.73	15.73	17.86	17.70	15.49	14.00	16.26	
Rootstock means					Abbreviations:						
Rootstock	1	2	3	4	1= Sour orange				2= Carrizo		
1 st season	14.76	15.88	13.41	14.77	3= Cleopatra				4= Citrumelo		
2 nd season	17.45	17.37	15.31	13.86	A= Storage Temp.				B=Rootstock types		
L.S.D. at 5%					C= Storage period in days						
Factors	A		B		C		a*b	a*c	b*c	a*b*c	
1 st season	0.43		N.S.		0.80		N.S.	N.S.	N.S.	N.S.	
2 nd season	0.28		0.39		0.48		N.S.	0.67	0.95	N.S.	

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دراسات فسيولوجية على تأثير أربعة من أصول الموالح على ثمار الكليمنتين صنف إرناندينا

٢- القدرة التخزينية للثمار

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٢- قسم البساتين - كلية الزراعة - جامعة قناة السويس - الإسماعيلية

تعتبر الموالح من المحاصيل التصديرية الهامة بالنسبة للدخل القومي المصري . وقد بلغت مساحة الموالح في مصر حوالي ٣٨٢٠٢٧ تننتج حوالي ٣٢١١٢٠٩ طن. كما وان هناك فرصة كبيرة لزيادة المصدر من الموالح غير التقليدية إلى السوق الأوروبي.

أجريت هذه الدراسة بمعهد بحوث البساتين - قسم بحوث تداول الفاكهة خلال موسمي ٢٠٠٥ و ٢٠٠٦. بهدف تحديد تأثير نوع الأصل على القدرة التخزينية لثمار اليوسفي كليمنتين (صنف إرناندينا) تحت ظروف التخزين المبرد عند كل من ٥ و ١٠ درجة مئوية و ٩٠ - ٩٥ % رطوبة نسبية.

جمعت الثمار من أشجار عمر ٧ سنوات منزرعة بمزرعة خاصة بمنطقة وادي الملوك منزرعة في ارض رملية ومطعومة على أربعة أصول هي النارنج - اليوسفي كليوباترا - الكاريزو سترانج - السوينجل ستروميلو عند وصول الثمار إلى مرحلة اكتمال النمو (الدراسة الأولى من البحث) ونقلت إلى المعمل حيث تم غسيل وتجفيف الثمار ثم تخزينها على درجة ٥ و ١٠ درجة مئوية لمدة ١٢ و ١٠ أسابيع في الموسم الأول والثاني على الترتيب. ثم فحص الثمار دوريا كل خمسة عشر يوما لدراسة التغيرات في الخواص الطبيعية والكيميائية للثمار أثناء التخزين.

وقد تبين من الدراسة ما يلي :-

زادت نسبة التالف والفقد في الوزن في الثمار المخزنة مع تقدم الثمار في التخزين وبغض النظر عن درجة حرارة التخزين. كذلك زادت نسبة المواد الصلبة الذائبة وكذلك نسبة المواد الصلبة الذائبة إلى نسبة الحموضة الكلية بينما انخفض محتوى الثمار من العصير وكذلك صلابة الثمار و الأحماض الكلية وفيتامين ج والكثافة النوعية للثمار بزيادة الفترة التخزينية. وكذلك تغير لون الثمار من الأصفر إلى الأصفر البرتقالي ثم إلى البرتقالي ثم إلى البرتقالي المحمر مع تقدم الثمار في التخزين.

كانت نسبة الفقد في الوزن وكذلك نسبة المواد الصلبة الذائبة و نسبة المواد الصلبة الذائبة إلى نسبة الحموضة الكلية في ثمار اليوسفي كليمنتين المحمولة على أصل النارج اقل منها مقارنة بالمحمولة على الأصول الأخرى. وعلى العكس كانت نسبة التالف في الثمار المحمولة على أصل النارج وكذلك الكثافة النوعية و الصلابة و نسبة الحموضة الكلية أعلى منها بالمقارنة بالثمار المحمولة على الأصول الأخرى. ومن ناحية أخرى لم يكن لنوع الأصل تأثير واضح على التغيرات المصاحبة للتخزين في كل من لون الثمار و كذلك محتوى الثمار من كل من العصير و فيتامين ج. ومع هذا فإن الكثير من هذه الاختلافات يرجع إلى تأثير نوع الأصل بمرحلة ما قبل الحصاد وليس أثناء التخزين.

أدى التخزين على درجة ١٠ مئوية إلى زيادة نسبة التالف والفقد في الوزن وكذلك الإسراع من عملية التلون وزيادة نسبة المواد الصلبة الذائبة ونسبة المواد الصلبة الذائبة إلى الحموضة الكلية ونقص محتوى الثمار من العصير والحموضة الكلية وفيتامين ج وزيادة النقص في الكثافة النوعية للثمار وذلك بالمقارنة بتلك المخزنة على درجة ٥ مئوية كذلك لم يلاحظ حدوث أضرار للبرودة في تلك المخزنة على درجة ٥ مئوية كما لم يؤدي إلى زيادة نسبة التالف في الثمار المخزنة.

وعليه يمكن القول أن ثمار اليوسفي كليمنتين صنف إرناندينا يمكن تخزينها على درجة ٥ مئوية و ٩٠ - ٩٥% رطوبة نسبية ولمدة ٦٠ يوما مع تغير طفيف في خواص الثمار بما لا يؤثر على خصائص الجودة في الثمار. بينما كان تأثير نوع الأصل (الأصول تحت الدراسة) على القدرة التخزينية للثمار محدودا.