

VI- SUMMARY

This study was conducted during the two seasons of 1993 and 1994, on twenty years old Washington navel orange trees budded on sour orange rootstock grown at three locations *i.e.* Wady El-Mollak (El-Esmailia governorate); South El-Tahreer and El-Qanater (El-Qaliobia governorate).

Twenty trees, healthy and nearly similar in vigor received the common fertilization and irrigation programs used in each location, were chosen.

The present study included two parts: The first part was fruit maturity determination, while the second was fruit handling and storage treatments.

Anyhow, fruit maturity study covered the effect of orchard location (heat units) and irrigation system.

In this respect, fruit samples were collected from labeled fruits at the three locations starting from the age of 150 days from fruit set, and repeated every 10 days interval till the age of 200 days. Each fruit sample comprised 30 fruits for determining maturity indices, *i.e.* total soluble solids, acidity, and T.S.S/acid ratio. Meanwhile, available heat units at each location for different fruit ages were calculated. At each date, 25 fruits per each sample were stored under room temperature ($18\pm4^{\circ}\text{C}$) for studying the ability of harvested fruits to maintain their fine conditions without shrinkage.

Furthermore, fruit handling and storage study included the effect of orchard location, irrigation system, storage method, package

size, storage temperature, and fungicides and non-traditional treatments on fruit storage.

Mature fruits were harvested from trees grown at Wady El-Mollak location under drip irrigation for studying the effect of storage temperature and package size, while for studying the effect of location and irrigation system on fruit storage, fruits were taken from the different three locations as well as Wady El-Mollak location, respectively.

Fruits were soaked in water containing 1500 ppm SOPP at 45°C and pH 11.8 for four minutes, dried and sprayed with wax containing 4000 ppm TBZ.

The treated fruits were packed in export packages for studying the effect of storage temperatures, *i.e.* room ($18\pm4^{\circ}\text{C}$), $4\pm1^{\circ}\text{C}$ and $7\pm1^{\circ}\text{C}$ besides the effect of different locations under study and different irrigation systems at Wady El-Mollak on the shelf life of fruits.

Furthermore, for studying the effect of package size *i.e.* consumer and export package, fruits were taken from Wady El-Mollak location under drip irrigation. Meanwhile, fruits were also harvested from El-Qanater location for studying the effect of fungicides and non-traditional treatments on fruit storage. In this respect, fruits were washed with tap water, dried then treated as follows:

- 1- Control (untreated): Clean dry fruits were sprayed with wax.
- 2- 1500 ppm SOPP (Sodium orthophenyl phenate) dissolved in water at 45°C for 4 minutes. Fruits left to dry then sprayed with wax.

- 3- 2000 ppm IMZ (Imazolil): Clean dry fruits were sprayed with wax containing 2000 ppm IMZ.
- 4- 4000 ppm TBZ (Thiobendazole): Clean dry fruits were sprayed with wax containing 4000 ppm TBZ.
- 5- Hot water treatment at 47°C for 6 minutes.
- 6- 500 ppm Garlic oil: Clean dry fruits were sprayed with wax containing 150 ppm Pro-Gib plus.

All treated fruits were packed in export package and stored under both room temperature ($18\pm4^{\circ}\text{C}$) and $7\pm1^{\circ}\text{C}$. Fruit samples were taken every 20 days till the end of storage period.

Generally, in all previous experiments, fruits were subjected to the following determinations of fruit quality during storage: fruit decay, fruit weight loss and fruit analysis *i.e.* TSS, acidity, TSS: acid ratio and ascorbic acid contents.

The obtained results can be summarized as follow:

Part I: Fruit Maturity:

- 1- Fruits of El-Tahrir location attained maturity when they were 170-175 days old (20 – 30 September), received heat units 14945, total soluble solids 9.3%, total acidity 1.09% and total soluble solids: acid ratio 8.52 : 1. While, fruits from El-Qanater location reached maturity when they were 160 to 180 days old (10 – 20 September) received heat units 1586.8 with total soluble solids (9.5 – 10.4%), total acidity (1.09 to 1.25%), TSS: acid ratio (8.51: 1). On the other hand, at Wady El-Mollak location fruits became mature at the age of 175-180 days (1- 10 October), heat units

(1534 – 1605), total soluble solids (9.2 – 9.5%), total acidity (0.98 – 1.26%), total soluble solids: acid ratio (7.50 – 9.39 : 1). Meanwhile, Wady El-Mollak location under drip irrigation system, fruits reached maturity when their age was 160 – 165 days (10 – 20 September), heat units (1352.5 – 1489.0) with fruit total soluble solids 10.5%, total acidity (1.15 – 1.31%), total soluble solids: acid ratio (8.10 – 9.13 : 1).

- 2- Fruits harvested before or after the above indicated ages at each of the indicated locations or irrigation systems were not best suited for long shipment as they showed shrinkage when kept under room temperature for different periods less than 25 days after harvest.
- 3- Total soluble solids percentage increased until the age of 190 days from fruit set in all locations under study.
- 4- Fruits from El-Qanater location, generally, showed higher fruit total soluble solids percentages as compared with the other two locations used.
- 5- Trees irrigated with surface irrigation at Wady El-Mollak location gave fruits with lower values of juice TSS content until 180 days from fruit set as compared with the corresponding ones under drip irrigation system.
- 6- Titratable acidity of Navel fruit juice decreased towards the age of 200 days in all locations.
- 7- No significant differences were obtained between various locations under study in fruit juice acidity.

- 8- Under the two irrigation systems at Wady El-Mollak location, titratable juice acidity decreased as fruits approached maturity. However, irrigation systems had no effect on fruit juice acidity.
- 9- TSS: acid ratio in fruit juice of Navel orange increased with the progress in fruit age in all locations under study.
- 10- Both El-Tahrir and Wady El-Mollak locations gave fruits with higher values of TSS : acid ratio as compared with El-Qanater location.
- 11- TSS : acid ratio in fruit juice increased with increasing fruit age under both irrigation systems used.
- 12- Fruits produced under drip irrigation system had higher TSS : acid ratio as compared with the corresponding ones of those of surface irrigation system.

Part 2: Post-harvest (Fruit storage):

1- Storage method:

1- Effect of orchard location and irrigation system:

- 1- Fruit decay percentages were directly proportional and coincided with the increase in storage duration under different storage methods and different orchard locations. Room temperature storage induced higher rate of fruit decay than those of cold storage. In this sphere, fruit decay percentage increased with prolonged storage period up to 120 days under cold storage, while fruits stored at room temperature became unacceptable for consumption after 60 days. Besides, El-Tahrir location showed lower fruit decay percentage followed by Wady El-Mollak as

compared with El-Qanater location. In addition, fruit decay percentage of trees under drip irrigation system gave lower values as compared with those for trees under surface irrigation.

- 2- Fruit weight loss percentage increased with prolonging the storage period in all locations and storage methods. Fruits stored under cold temperature had the lowest weight loss percentage than those stored at room temperature. Fruit weight loss percentage increased with the extension of storage period up to 120 days when fruits stored under cold storage, while fruits at room temperature became unacceptable to consumer after 60 days. Moreover, El-Tahrir location caused the lowest fruit weight loss percentage followed by El-Qanater location as compared with Wady El-Mollak location. Besides, fruit weight loss percentage from trees under drip irrigation system gave the lowest values as compared with those under surface irrigation system.
- 3- During the storage period that was extended to 90 days, fruits juice TSS increased gradually whether fruits were stored under cold or room temperature. Room temperature gave lower rate of increase in fruit TSS than those under cold storage. In addition, juice TSS% was the highest in fruits obtained from El-Qanater and Wady El-Mollak, while fruits of El-Tahrir were the lowest in juice TSS% content. Also, TSS% of fruits from trees under drip irrigation system gave higher values as compared with those fruits from trees under surface irrigation.
- 4- Fruit acidity decreased gradually by extending the period of storage whether fruits stored under room or cold storage. In this concern,

cold storage induced higher rate of drop in fruit acidity than those under room temperature storage. Fruit juice acidity varied according to orchard location. Nevertheless, fruit acidity was highest in fruits obtained from El-Qanater followed by Wady El-Mollak as compared with El-Tahrir location. At Wady El-Mollak location fruits picked from trees under drip irrigation had highest juice acidity content than those harvested from trees under surface irrigation.

- 5- During storage period that extended up to 90 days TSS:acid ratio increased gradually whether fruits were stored under cold or room temperature. TSS:acid ratio in fruit juice at maturity varied according to orchard location. However, fruits of El-Tahrir location had the highest value of TSS:acid ratio, while both El-Qanater and Wady El-Mollak locations had nearly similar values. At Wady El-Mollak location no significant difference was obtained between fruits picked from trees under drip irrigation and those under surface irrigation.
- 6- Ascorbic acid content in fruit juice decreased by the advance in storage period. The drop in ascorbic acid content during storage was at a higher rate in fruits under room storage than those under cold storage. At picking time, ascorbic acid content was higher in fruits obtained from El-Qanater followed by those from Wady El-Mollak and El-Tahrir locations. Fruits harvested from trees under drip irrigation had higher juice ascorbic acid content than those picked from trees under surface irrigation.

II-Package size:

- 1- Decay percentage is directly proportional and coincided with the increase in storage duration in all different packages used *i.e.* export package and consumer package. Moreover, consumer package, reduced fruit decay percentage in relation to export package.
- 2- Fruit weight loss percentage of export and consumer packages increased with increasing storage period. Consumer package reduced weight loss percentage as compared with export size package.
- 3- Data clearly indicate that fruit juice TSS increased gradually during the storage period. Moreover, packages size had no significant effect on fruit total soluble solids.
- 4- Fruit juice acidity decreased gradually with prolonging storage period. No significant difference was obtained between export and consumer packages in this respect.
- 5- TSS : acid ratio in fruit juice increased with increasing storage period for either export or consumer packages used. No significant difference was noticed between export and consumer packages.
- 6- Fruit ascorbic acid content decreased with prolonged storage. No significant difference was evident between the two package sizes used.

III- Storage temperature:

- 1- Fruit decay percentage increased with prolonging storage period.
Decay percentage of fruits stored under room temperature

($18\pm 4^{\circ}\text{C}$) had the highest percentage followed by fruits stored at $7\pm 1^{\circ}\text{C}$ and $4\pm 1^{\circ}\text{C}$ in a descending order.

- 2- Fruit weight loss is directly proportional and coincided with the increase in storage duration in all storage temperatures used. Fruits stored at $4\pm 1^{\circ}\text{C}$ had significantly the lowest weight loss followed by fruits stored at $7\pm 1^{\circ}\text{C}$ as compared with fruits stored under room temperature. In the same time, fruit weight loss percentage increased with the progress in storage period up to 90 days when fruits stored at $4\pm 1^{\circ}\text{C}$ and $7\pm 1^{\circ}\text{C}$. Fruit weight loss percentage was much higher under room temperature and became unacceptable to consumers after 60 days.
- 3- Fruit juice TSS content increased with advancing storage period. The lowest temperature $4\pm 1^{\circ}\text{C}$ induced the highest increase in fruit TSS percentage during storage as compared with the other two temperatures used. No significance was detected between $4\pm 1^{\circ}\text{C}$ and $7\pm 1^{\circ}\text{C}$ in this respect.
- 4- Data indicate that in all storage temperatures used the percentage of fruit juice acidity decreased with the increase in the storage period. No significant differences were obtained between juice acidity of fruits stored at $7\pm 1^{\circ}\text{C}$ and $4\pm 1^{\circ}\text{C}$ but, was significant between fruits stored at room temperature and fruits stored at $4\pm 1^{\circ}\text{C}$.
- 5- TSS: acid ratio increased by increasing storage period in all storage temperatures. Fruits stored at $4\pm 1^{\circ}\text{C}$ produced the highest ratio of TSS : acid followed by fruits stored at 7 ± 1 as compared with fruits stored under room temperature in a descending order.

- 6- Fruit juice ascorbic acid content decreased gradually as storage period increased in all storage temperatures used. Storage under low temperature ($4\pm 1^{\circ}\text{C}$) reduced the loss in fruit juice ascorbic acid content.

IV- Fungicides and the non-traditional treatments:

- 1- Fruit decay percentage increased with the extension of fruit storage period for all different temperatures of storage. Fruits kept at room temperature became unacceptable to consumers after 80 days for the control treatment, while the decay percentages for other treatments ranged between 15 and 39% after the same period. All fruits kept at room temperature decayed after 100 days for all treatments. Fruits stored at $7\pm 1^{\circ}\text{C}$ didn't show any decay up to 80 days of cold storage when treated with Garlic oil. Pro-Gib, IMZ, and TBZ treatments succeeded in maintaining all fruits without decay for 40 days, while hot water and SOPP treatments had 3.0% fruit decay and control fruits had 36% fruit decay after the same period of cold storage. Garlic oil as a non-traditional treatment succeeded in reducing fruit decay under cold storage up to 12% for 160 days storage and between 18 to 39% for other fungicides and non-traditional treatments. Untreated fruits (control) were completely unacceptable to consumers after 100 days of cold storage. Anyhow, treating fruits with Garlic oil then storage at $7\pm 1^{\circ}\text{C}$ gave the least percentage of fruit decay even after 160 days of cold storage. SOPP fungicide was the second best, while hot

water and Pro-Gib-plus treatments had the highest percentages of fruit decay. The TBZ and IMZ fungicide treatments were in between.

- 2- Prolonging the storage period resulted in increased fruit weight loss. After 80 days storage at room temperature, fruits treated with fungicides ranged between 15.9% for IMZ treatment to 17.9% for SOPP treatment. Fruits received non-traditional treatments lost between 21.0% for Garlic oil treatment and 24.9% for hot water treatment for their weight after the same period of room temperature storage. After 80 days of room temperature storage all fruits became unacceptable to consumers, while fruits stored at $7\pm 1^{\circ}\text{C}$ and 85% RH remained acceptable to consumers for more than 120 days. Weight loss for control fruits after 120 days of cold storage was only 10.5%, for fungicide treatments ranged between 7.0 for IMZ and 7.7% for SOPP and for the non-traditional treatments ranged between 7.1% for Garlic oil and 9.2% for hot water treatments. Fruits treated with Garlic oil or with IMZ remained acceptable to consumers up to 160 days of cold storage with fruit weight loss of 9.4% for Garlic oil and 12.1% for IMZ treatments.
- 3- TSS percentage, of all treatments used, increased with prolonging period of fruit storage. Fruits of the control became unacceptable to the consumers after 60 days of storage under room temperature and 80 days under cold storage. Fruits treated with Garlic oil or chemical fungicides were acceptable to the consumers up to the

end of cold storage, while Pro-Gib plus, and hot water as non-traditional treatments failed in realizing such success.

- 4- Fruit juice acidity under different treatments decreased with storage either under room or cold temperatures under the same storage method. The difference between either fungicide treatments or non-traditional treatments was not clearly noticed.
- 5- TSS : acid ratio in fruit juice increased with increasing storage period. Fruits treated with Garlic oil had lowest values of TSS : acid ratio in comparison with fungicide treatments *i.e.* SOPP, IMZ and TBZ which had nearly similar values at 160 days storage.
- 6- Juice ascorbic acid content of different treatments decreased with increasing the period of storage. At 100 days of cold storage, fruits treated with hot water were inferior in ascorbic acid content as compared with other treatments. At the end of cold storage (160 days), fruits treated with Garlic oil surpassed fungicides in fruit ascorbic acid content.

