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Effect of Postharvest- Cold Shock and some Safe Treatments on Carotene Development in "Nova" Tangerines.

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ABSTRACT

Increasing the carotene density in the peel of "Nova" tangerines, which have been extremely- widely spreaded for their flavor and nutritional value, is demanded by producers and consumers and the most importantly is utilizing natural and safe means to achieve it. In this study, harvested greenish yellow tangerines were exposed during the two consecutive seasons 2014 and 2015 to several treatments such as: - Control (water), cold shock (immersed for 30 minutes at 2^0C and then incubated at 5^0 C for 6 hours), EDTA, K- EDTA, K_2SO_4 (all at 0.1 % concentration) and Ethrel at 500 ppm, then all treated tangerine fruits were incubated at ambient temperature 22 ± 2^0C for three days. The results showed that postharvest- cold shock treatment resulted in lower percentage of weight loss as compared with other treatments. Moreover, this achieved lower percentage of rind electrolyte leakage relative to EDTA and Ethrel treatments. On the contrary, cold shock treated fruits have higher content of vitamin C in comparison with those treated with other applied treatments. In addition, postharvest- cold shock treatment had superior amount of carotene content of tangerine peel as compared with other postharvest treatments.

Keywords: Postharvest, carotene, chlorophyll breakdown, "Nova" tangerine, cold shock, EDTA, Ethrel.

INTRODUCTION

Citrus fruits are immensely popular worldwide for their flavor and nutrition. Citrus originated in the south east of Asia and is now grown in the tropical- subtropical belt from 40^o latitude north to 40^o latitude south in both humid and arid regions (Baldwin, 1993).

Mandarins and some mandarin hybrids or tangerines are highly demanded by consumers especially in Egypt and many Arab countries. However, they are considered as highly- perishable citrus, since they have a limited storability to maintain their quality and high marketability within the acceptable limits. They could be stored for 2- 4 weeks in cold rooms at 4^o C, since the fruit is susceptible to decay and cold injury.

In some cases, tangerines could be stored for 1- 2 weeks at zero^o C without damage but for no more duration (Wills *et al.,* 1989). Meanwhile, proper manipulation of cold treatment could benefit citrus producers, since it enhances the biosynthesis of carotenes. The color of citrus fruit is due to the presence of chlorophyll in green fruit and carotenoids in yellow to orange fruit. These pigments are located in plastids in the flavedo (peel) and in juice vesicles (in the pulp). Citrus contains one of the most complex carotenoid patterns among fruits (Gross, 1977).

The more intense (redder) peel color of tangerines and other citrus fruits such as "Sinton" citrangeqat is due to the peel pigments cryptoxanthin, β- citraurin, β- apo- 8-carotenal, violaxanthin, antheraxanthin and zeaxanthin, with β- citrauin being the main pigment contributing to the red tint of these fruits (Yokoyama and White, 1966 and Gross, 1977), while cryptoxanthin predominates in the juice pulp of tangerines (Gross, 1977).

Many treatments and conditions can influence the peel and juice color. It was reported that at color break, there was an apparent degeneration of the thylakoids in peel chloroplast accompanied by an increase in carotenoids biosynthesis (Gross, 1987). Thus, green fruit turns yellow to orange at maturity. Degreening was found to require light (Goldschmidt, 1988) and is promoted by low temperature, high sucrose level (Huff, 1984 and Takagi *et al.,* 1989) and ethylene (Eaks, 1977), while high nitrogen level inhibits this process (Takagi *et al.,* 1989) as well as the improper use of cytokinins and gibberellins (Coggins and Lewis, 1962).

Further evidence was provided by Cohen (1990), since the exposure of oranges and mandarins to temperatures higher than 25^o C was desirable for the destruction of chlorophyll, but adversely disturbed the biosynthesis of carotenoid pigments responsible for the development of orange color, which resulted in a pale yellowish color. There has been a strong trend of lesser use of agrochemicals, which either cause an undesired alteration in the taste, firmness or adversely affect their storability. The proper use of cold shock can safely stimulate the formation of more carotenoids in the peel and juice of citrus fruits.

Attempts to harvest citrus fruits early at maturity, while still greenish then exposing them to ethylene gas under costly conditions may result in pale yellow coloration. Moreover, storing fruits on the tree and delaying harvest of citrus fruits to acquire better flavor and coloration could result in partial loss of juice acidity due to the process of gluconeogenesis and disturbing the balance between the total soluble solids and acidity.

Such conclusion was supported by the finding that the necessary enzymes for postharvest use of organic acids for energy production and conversion of sugars through gluconeogenesis were found in the juice (Echeverria and Valich, 1989). Moreover, it was found that ethylene degreening treatment caused a reduction of sugar content of citrus fruit by increasing respiration and required the utilization of sugars as an energy source (Biale and Young, 1962).

Thus, the objectives of this study were to discover the possibility of utilizing the cold shock treatment after harvest to enhance carotene formation in the peel and juice of "Nova" mandarin fruits as compared with the efficacy of some chemical treatments and to reveal their influence on fruit quality.

MATERIALS AND METHODS

The current investigation was carried out during 2014 and 2015 seasons on "Nova" tangerine fruits harvested from a private orchard located at Al- Noubariya region, Behira governorate, Egypt. The soil of the orchard was sandy soil and the trees were 10 years old, uniform in vigor as possible, grafted on sour orange rootstock, spaced at 5 x 5 m and received the ordinarily applied agricultural practices in this area.

168 tangerine fruits were harvested at greenish yellow stage on 8 February for the two successive seasons and transported to the laboratory provided that fruits were uniform in shape, size and color, healthy and free of apparent defects as possible.

The collected tangerine fruits were divided into six groups (treatments), each group contained 28 fruits for four replicates (7 fruits / replicate) and each treatment consisted of four replicates. Then, these tangerine fruits were washed with running tap water, dipped for 2 minutes in sodium hypochloride solution (0.05 % v/v) for a surface sterilization, washed again in distilled water for 3 minutes and then air dried. Subsequently, each fruit group was exposed to one of the following treatments: - Control (immersed for 30 minutes in distilled water), cold shock (immersed for 30 minutes in hydrocooling water at 2^0 C and then incubated for 6 hours at 5^0 C) then moved to ambient temperature for 3 days before the assessments, EDTA at 0.1% (w/v), chelated potassium (K-EDTA) at 0.1% (w/v), K_2SO_4 at 0.1 (w/v) and finally, Ethrel at 500 ppm (v/v) as a commercial degreening agent. Tween- 20 was added to each solution with 0.05% (v/v) as a surfactant agent.

The treated tangerine fruits were left for air drying, weighted (initial weight), packed in foam dishes with 7 fruits per replicate and then left on the shelf at room temperature (22 ± 2^0C) for 3 days. Quality assessments were estimated at zero time of shelf life (initial values) by using another 28 untreated tangerine fruits. In addition, control fruits were further assessed by the end of their incubation period for 3 days as well as other treated fruits.

Quality assessments included weight loss, which was calculated as a percentage of the initial weight according to Ghoname (1992), the percentage of total soluble solids was detected by using hand refractometer, the percentage of titratable acidity was measured as gm citric acid per 100 ml juice according to the method of Spayed and Morris (1981) and their ratio (TSS / acidity) was calculated. Vitamin C also was determined as mg of ascorbic acid using the technique of Egan *et al.* (1987). Furthermore, the percentage of total sugars was assessed by using the procedure of Egan *et al.* (1987). The carotene content of tangerine fruit peel was extracted, calculated and recorded as mg / litre according to Wintermans and Mots (1965). Finally, the percentage of electrolyte leakage of tangerine fruit peel was calculated as per to the electrolyte leakage values before and after killing according to Ahrenes and Ingram (1998).

All the obtained data were laid out as split plot analysis in a completely randomized design (CRD) and analyzed by using SAS program version 1996. The least significant difference (LSD) was used to compare the means and based on 0.05 level according to the method described by Steel and Torrie (1980).

RESULTS

The response of "Nova" tangerines to postharvest treatments with cold shock as compared with some safe chemicals and the control was reported in Table 1. The data indicated that the greatest weight loss was obtained with Ethrel treatment after 3 days of dipping. However, some other treatments such as EDTA, K-EDTTA and potassium sulphate in addition to cold shock treatment caused a great increase in weight loss relative to the control in both seasons. Moreover, cold shock treated tangerines still had less weight loss than that found with other treatments. The chelating agent EDTA resulted in similar weight loss to that obtained, when it was chelating potassium in a consistent manner in both seasons. Since treated "Nova" tangerines were followed and assessed after 3 days of incubation at 22 ± 2 ^{0} C, the data in Table1 indicated to a significant increase in weight loss in both seasons between the harvest time and after the three days of the incubation. With regard to the effect of the interaction between the treatments and the time factor, the data also in Table 1 revealed that weight loss was greater after 3 days of the incubation for fruits treated with Ethrel followed by EDTA and K- EDTA with a consistent trend in both seasons, while the cold shock treatment resulted in even less water loss than potassium sulphate.

Table 1. Effect the postharvest applied treatments, the time factor and their interaction on weight loss percentage of "Nova" tangerine fruits during the two seasons 2014 and 2015.

Season 2014				Season 2015			
Treatments	Weight loss (%) Initial	Weight loss (%) After 3 days	Mean	Treatments	Weight loss (%) Initial	Weight loss (%) After 3 days	Mean
Control	0.00f*	3.04e	1.52d	Control	0.00f	2.70e	1.35e
Cold shock	0.00f	4.71d	2.36c	Cold shock	0.00f	3.54d	1.77d
EDTA	0.00f	5.67b	2.83b	EDTA	0.00f	4.35b	2.18b
K-EDTA	0.00f	5.49b	2.75b	K-EDTA	0.00f	4.26b	2.13bc
K_2SO_4	0.00f	5.14c	2.57bc	K_2SO_4	0.00f	3.97c	1.99c
Ethrel	0.00f	6.56a	3.28a	Ethrel	0.00f	4.95a	2.47a
Mean	0.00b	5.10a	2.55	Mean	0.00b	3.96a	1.98

*** Values, within the characteristic, of similar letters were not significantly different, when compared according to the least significant difference (LSD at 0.05 level).**

With regard to the changes in total soluble solids content in response to various applied treatments, it was evident that cold shock- treated "Nova" tangerines had similar TSS to that found in the control fruits in both seasons. However, both EDTA and K-EDTA resulted in a significant increase in TSS values and were similar to each other in that characteristic in both seasons, while Ethrel treatment resulted in less TSS than the chelating agent or K-EDTA and similar to the cold shock treatment especially in the second season (Table 2). Moreover, the data shown in Table 2 referred to that after 3 days of incubation at 22±2 ^{0}C, there was a significant increase in the percentage of total soluble solids in both seasons between the harvest time and after the three days of the incubation. The interaction between postharvest applied treatment and the time factor was also reported in Table 2. TSS values with the use of cold shock after 3 days resulted in a similar TSS to that obtained with Ethrel especially in the first season, but were less than that found with EDTA or K- EDTA.

The percentage of acidity was also influenced by various postharvest applied treatments (Table 3), regardless the time factor, juice acidity was significantly reduced in response to four of the treatments, which were EDTA, K-EDTA, potassium sulphate and Ethrel relative to the control in both seasons. However, cold shock treatment resulted in a significant reduction in "Nova" juice acidity in the second season only. Ethrel treatment was able to reduce juice acidity in a significant manner as compared with cold shock treatment. In addition, the data shown in Table 3 declared that juice acidity was significantly decreased in both seasons, when comparing the initial time and after 3 days at ambient temperature, regardless of the treatments. The data in Table 3 also proclaimed that Juice acidity of "Nova" tangerines was affected by the interaction between treatments and the time of the incubation, since it tended to be greater than acidity of EDTA, K- EDTA, or even Ethrel- treated fruits.

Table 2. Effect the postharvest applied treatments, the time factor and their interaction on total soluble solids percentage of "Nova" tangerine fruits during the two seasons 2014 and 2015.

Season 2014				Season 2015			
Treatments	TSS (%)		Mean	Treatments	TSS (%)		Mean
	Initial	After 3 days			Initial	After 3 days	
Control	11.20d*	11.40d	11.30c	Control	10.25c	11.40b	10.83b
Cold shock	11.20d	11.40d	11.30c	Cold shock	10.25c	11.60b	10.93b
EDTA	11.20d	14.00a	12.60a	EDTA	10.25c	13.40a	11.83a
K-EDTA	11.20d	13.60b	12.40a	K-EDTA	10.25c	13.80a	12.03a
K_2SO_4	11.20d	11.40d	11.30c	K_2SO_4	10.25c	11.65b	10.95b
Ethrel	11.20d	12.40c	11.80b	Ethrel	10.25c	12.00b	11.13b
Mean	11.20b	12.37a	11.78	Mean	10.25b	12.31a	11.28

*** Values, within the characteristic, of similar letters were not significantly different, when compared according to the least significant difference (LSD at 0.05 level).**

Table 3. Effect the postharvest applied treatments, the time factor and their interaction on acidity percentage of "Nova" tangerine fruits during the two seasons 2014 and 2015.

Season 2014				Season 2015			
Treatments	Acidity (%)		Mean	Treatments	Acidity (%)		Mean
	Initial	After 3 days			Initial	After 3 days	
Control	1.05a*	1.01ab	1.03a	Control	0.99a	0.91b	0.95a
Cold shock	1.05a	1.00b	1.02a	Cold shock	0.99a	0.71c	0.85b
EDTA	1.05a	0.75c	0.90b	EDTA	0.99a	0.57e	0.78c
K-EDTA	1.05a	0.67d	0.86c	K-EDTA	0.99a	0.56e	0.77c
K_2SO_4	1.05a	0.78c	0.91b	K_2SO_4	0.99a	0.66d	0.82b
Ethrel	1.05a	0.60e	0.82d	Ethrel	0.99a	0.56e	0.77c
Mean	1.05a	0.80b	0.92	Mean	0.99a	0.66b	0.82

*** Values, within the characteristic, of similar letters were not significantly different, when compared according to the least significant difference (LSD at 0.05 level).**

Furthermore, TSS/acidity ratio was also affected by postharvest treatments of "Nova" tangerines as shown in Table 4. The data revealed that there was a consistent increase in the TSS to acidity caused by K-EDTA followed by Ethrel treatment in both seasons, when compared with the control. However, cold shock- treated fruits had considerably less TSS to acidity in the juice, when compared with Ethrel or K-EDTA. Meanwhile, the TSS to the acidity ratio of the "Nova" tangerine juice was increased at the end of the three days as compared with the harvest time (Table 4). Moreover, the data illustrated in Table 4 indicated that the TSS to acidity ratio was, in general, smaller than other applied treatments especially in the second season.

Table 4. Effect the postharvest applied treatments, the time factor and their interaction on the ratio between total soluble solids to acidity of "Nova" tangerine fruits during the two seasons 2014 and 2015.

Season 2014				Season 2015			
Treatments	TSS/Acidity (ratio)		Mean	Treatments	TSS/Acidity (ratio)		Mean
	Initial	After 3 days			Initial	After 3 days	
Control	0.00f*	3.04e	1.52d	Control	0.00f	2.70e	1.35e
Cold shock	0.00f	4.71d	2.36c	Cold shock	0.00f	3.54d	1.77d
EDTA	0.00f	5.67b	2.83b	EDTA	0.00f	4.35b	2.18b
K-EDTA	0.00f	5.49b	2.75b	K-EDTA	0.00f	4.26b	2.13bc
K_2SO_4	0.00f	5.14c	2.57bc	K_2SO_4	0.00f	3.97c	1.99c
Ethrel	0.00f	6.56a	3.28a	Ethrel	0.00f	4.95a	2.47a
Mean	0.00b	5.10a	2.55	Mean	0.00b	3.96a	1.98

*** Values, within the characteristic, of similar letters were not significantly different, when compared according to the least significant difference (LSD at 0.05 level).**

With regard to the effect of postharvest treatments on some quality attributes of "Nova" tangerines, the results in Table 5 proved that vitamin C in the juice was reduced by either EDTA, K-EDTA, potassium sulphate or Ethrel relative to the control in both seasons. Eventhough there was a reduction in vitamin C by cold shock treatment but was ranging only by 1.0 to 1.5 mg/100 ml, when compared with the control in both seasons. Thus, the magnitude of vitamin C reduction by cold shock was markedly less than other used chemical treatments in a consistent manner. Furthermore, the data introduced in Table 5 revealed that there was a significant reduction in vitamin C between harvest time and after 3 days at ambient temperature in a consistent manner in both seasons. Moreover, the data in Table 5 showed the response of "Nova" tangerines to the interaction of the treatments and the time factor on some chemical characteristics, it was clear that cold shock- treated tangerines had greater vitamin C content in the juice than those treated either with EDTA, K- EDTA or even Ethrel. However, potassium sulphate resulted in a similar vitamin C after 3 days on the shelf at ambient temperature to that found by cold shock treatment.

The results in Table 6 indicated that cold shock treatment resulted in greater total sugars relative to the control. The highest increase in total sugars was obtained with the application of either K-EDTA or Ethrel, followed by EDTA treatment. Thus, all used treatments after harvest resulted in a significant increase in total sugars relative to the control. Total sugars of the tangerine juice tented to increase as the days of incubation period increased in both seasons and this pattern of results coincided with the total soluble solids contents in the juice (Table 6). The interaction between other applied postharvest treatments and the time factor of incubation at 22 ± 2 ^{0} C was also shown in Table 6, where K-EDTA or Ethrel treatments resulted in the greatest values of total sugars as compared with other treatments. Meanwhile, EDTA and k_2SO_4 treatments also achieved higher values of total sugars than the control and these treatments were similar in the first season. On the contrary, when comparing untreated tangerine fruits with other treated ones, it could be found that the untreated fruits had the least values of total sugars, which did not significantly vary between the initial and after 3 days later, in a consistent manner in the two seasons.

Table 5. Effect the postharvest applied treatments, the time factor and their interaction on vitamin C content of "Nova" tangerine fruits during the two seasons 2014 and 2015.

Season 2014				Season 2015			
Treatments	Vitamin C(mg/100ml)		Mean	Treatments	Vitamin C(mg/100ml)		Mean
	Initial	After 3 days			Initial	After 3 days	
Control	33.39a*	30.00b	31.70a	Control	31.14a	28.05b	29.59a
Cold shock	33.39a	27.00c	30.20b	Cold shock	31.14a	26.70c	28.92b
EDTA	33.39a	25.04de	29.22cd	EDTA	31.14a	23.24e	27.19d
K-EDTA	33.39a	23.99ef	28.69de	K-EDTA	31.14a	22.95e	27.04d
K_2SO_4	33.39a	25.95cd	29.67bc	K_2SO_4	31.14a	24.90d	28.02c
Ethrel	33.39a	23.25f	28.32e	Ethrel	31.14a	22.95e	27.04d
Mean	33.39a	25.87b	29.63	Mean	31.14a	24.80b	27.97

*** Values, within the characteristic, of similar letters were not significantly different, when compared according to the least significant difference (LSD at 0.05 level).**

Table 6. Effect the postharvest applied treatments, the time factor and their interaction on total sugars percentage of "Nova" tangerine fruits during the two seasons 2014 and 2015.

Season 2014				Season 2015			
Treatments	Total sugars (%)		Mean	Treatments	Total sugars (%)		Mean
	Initial	After 3 days			Initial	After 3 days	
Control	8.09d*	8.46d	8.28e	Control	8.00e	8.30e	8.15e
Cold shock	8.09d	9.35c	8.72d	Cold shock	8.00e	9.11d	8.56d
EDTA	8.09d	11.11b	9.60b	EDTA	8.00e	10.69b	9.35b
K-EDTA	8.09d	12.14a	10.11a	K-EDTA	8.00e	11.69a	9.85a
K_2SO_4	8.09d	10.60b	9.35c	K_2SO_4	8.00e	10.23c	9.12c
Ethrel	8.09d	12.24a	10.17a	Ethrel	8.00e	11.76a	9.88a
Mean	8.09b	10.65a	9.37	Mean	8.00b	10.30a	9.15

*** Values, within the characteristic, of similar letters were not significantly different, when compared according to the least significant difference (LSD at 0.05 level).**

The alteration in carotene content in the rind of "Nova" tangerines in response to cold shock treatment after harvest was also reported in Table 7 and Fig. 1 along with the responses to other chemicals treatments. The data indicated that cold shock resulted in the greatest increase in carotene content followed by EDTA. The influence of cold shock was even greater than that found with Ethrel treatment after harvest of "Nova" tangerines. Moreover, all chemical treatments were able to enhance the formation of more carotenes in the peel, when compared with the control. In addition, the data introduced in Table 7 indicated that the carotene content in the peel remarkably increased after 3 days of the incubation at 22 ± 2 ^{0} C, regardless of the treatments. The changes in carotenes of the peel in response to various treatments and their interaction with the time factor (Table 7) showed that the greatest response of carotenes after 3 days at ambient temperature was obtained with cold shock- treated tangerines followed by EDTA treatment. However, carotene in the control peels was still lower than that of potassium sulphate or Ethrel. Meanwhile, the magnitude of carotenes by EDTA was superior to that obtained by K- EDTA in a consistent manner.

Table 7. Effect the postharvest applied treatments, the time factor and their interaction on peel carotene content of "Nova" tangerine fruits during the two seasons 2014 and 2015.

Season 2014				Season 2015			
Treatments	Carotene content (mg/L)		Mean	Treatments	Carotene content (mg/L)		Mean
	Initial	After 3 days			Initial	After 3 days	
Control	5.26f*	5.45f	5.36f	Control	5.00f	5.14f	5.07f
Cold shock	5.26f	14.51a	9.88a	Cold shock	5.00f	14.33a	9.67a
EDTA	5.26f	11.19b	8.23b	EDTA	5.00f	12.37b	8.68b
K-EDTA	5.26f	9.52c	7.39c	K-EDTA	5.00f	9.00c	7.00c
K_2SO_4	5.26f	6.70e	5.98e	K_2SO_4	5.00f	6.08e	5.54e
Ethrel	5.26f	8.05d	6.66d	Ethrel	5.00f	7.15d	6.08d
Mean	5.26b	9.24a	7.25	Mean	5.00b	9.01a	7.01

*** Values, within the characteristic, of similar letters were not significantly different, when compared according to the least significant difference (LSD at 0.05 level).**

From presented data in Table 8, it could be noticed that electrolyte leakage of the peel as influenced by various treatments was reduced by cold shock treatment in both seasons as compared with the control. Meanwhile, EDTA caused a significant increase in the leakage of electrolytes and even more than that obtained with K-EDTA. However, more electrolytes were leaked from the peel of Ethrel-treated fruits as compared with the control or cold shock treated ones. In addition, chelated potassium with EDTA resulted in a similar electrolyte leakage to that obtained with potassium sulphate. Regardless of the treatments factor, it was found that there was a significant increase in electrolyte leakage of "Nova" rind after the three days of incubation as compared with the initial values at the harvest time. With regard to the interaction between treatments and the incubation time at 22 ± 2 ^{0} C in relation to electrolyte leakage of the peel (Table 8), the results proved that both K-EDTA and potassium sulphate had similar electrolyte leakage to that found in cold shock- treated peels. The greatest values of electrolyte leakage were recorded in the peel of EDTA followed by Ethrel- treated fruits, while the lowest percentage of electrolyte leakage of the "Nova" peel was reported in the control after three days at ambient temperature.

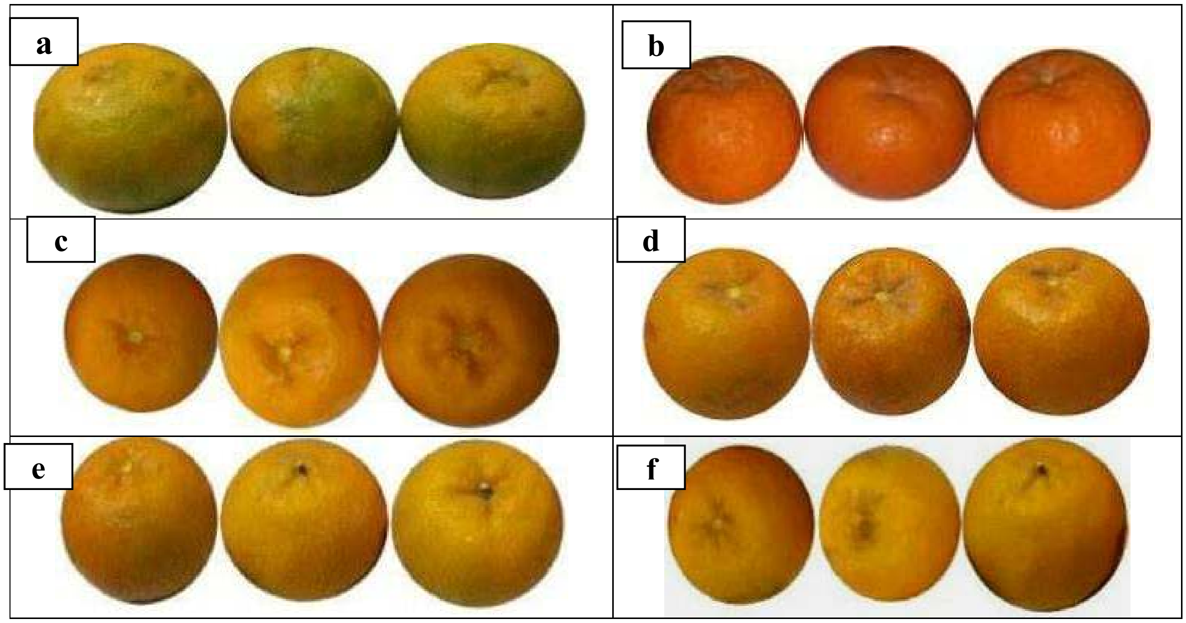

Fig. 1. Illustration of carotene development by the end of the incubation period of "Nova" tangerines as influenced by various postharvest treatments that included: a (control), b (cold shock), c (EDTA), d (K-EDTA), e (K_2SO_4) and f (Ethrel).

Table 8. Effect the postharvest applied treatments, the time factor and their interaction on electrolyte leakage percentage of "Nova" tangerine fruits during the two seasons 2014 and 2015.

Season 2014				Season 2015			
Treatments	Electrolyte leakage (%)		Mean	Treatments	Electrolyte leakage (%)		Mean
	Initial	After 3 days			Initial	After 3 days	
Control	14.81e*	19.61d	17.21d	Control	11.63e	17.44d	14.54d
Cold shock	14.81e	21.74c	18.28c	Cold shock	11.63e	20.00c	15.82c
EDTA	14.81e	47.50a	31.16a	EDTA	11.63e	45.45a	28.54a
K-EDTA	14.81e	22.73c	18.77c	K-EDTA	11.63e	20.00c	15.82c
K_2SO_4	14.81e	21.74c	18.27c	K_2SO_4	11.63e	20.03c	15.83c
Ethrel	14.81e	34.09b	24.45b	Ethrel	11.63e	26.32b	18.97b
Mean	14.81b	27.90a	21.36	Mean	11.63b	24.87a	18.25

*** Values, within the characteristic, of similar letters were not significantly different, when compared according to the least significant difference (LSD at 0.05 level).**

DISCUSSION

Low- temperature cold shock has been recently utilized as a mean to induce and improve color development of citrus fruits after harvest. For instance, Barry and Van Wyk (2006), treated "Nules Clementine" mandarin fruits by hydrocooling to about 2^0 C for 30 min. and then transferred fruits to a cold room set at 4^0 C for 6 h to complete the cold shock treatment.Thereafter, fruits were incubated at 20^0 C for about 72 h. They found that in the 2002 season, low temperature treatment or "cold shock" of "Nules Clementine" mandarin improved rind color to a level comparable with that of commercial ethylene degreening. Carotenoid concentration of cold-shock fruits was similar to that of degreened fruits and nearly doubled that of untreated fruits. Chlorophyll concentration of cold- shock and degreened fruit was nine times lower than of untreated fruit. In subsequent experiment, however, where pre- harvest growing conditions were more conductive to natural rind color development, this response could not be repeated. This indicated that the significance of field conditions before harvest on the need of cold shock treatment after harvest.

In arid agriculture, as the situation in many fields especially with the expansion of the desert culture in Egypt, preharvest conditions hinder the development of carotenes, since there is a low difference between day and night temperatures. Furthermore, due to the fruit load, many citrus fruits tend to oriented towards the relatively warm soil surface, which reflect on poor development of rind carotenoids as the case for many citrus cultivars, such as "Nova" tangerines, "Washington" navel oranges and "Navalena" navel oranges. Many citrus producers tend to harvest mature fruits early, then expose them to ethylene gas in special- large chambers in order to accelerate their degreening consequently, market them at higher prices. However, they fail to induce the favorite orange color of rinds and usually market citrus fruit with pale color.

The idea of cold shock treatment with cold water is economic, feasible, effective, safe and agrees with the organic agriculture concept. The carotenoids content is not only important for the appearance of citrus fruits and for attracting consumers but also for their nutritional value as an important antioxidant. They also act as a vitamin A precursor in animal organisms (Beuernfeind, 1981). It was also reported that the primary medical use of carotenoids is the prevention or correction of vitamin A deficiency in man (Britton, 1982). Furthermore, two important photo functions have been clearly established for carotenoids: (1) their roles as accessory pigments in photosynthesis and (2) as protective agents of the photosynthetic apparatus against the potential damage of visible light (Mathews *et al.,* 1981). Several factors and conditions have been reported to affect the biosynthesis of carotenoids in fruits such as ethylene, light, oxygen, minerals such as potassium and temperature (Gross, 1987).

Color improvement in postharvest treated fruits was dependent on temperature due to the temperature sensitivity of β- citraurin synthesis (Stewart and Wheaton, 1971). The trend of carotene content, in this study, was further supported by the above references.

In conclusion, cold shock- treated fruits had superior carotene content in the peel due to the postharvest treatment, while their juice quality was still greater than the control fruits. This important finding would have a great implication in terms of the consumers and producers ability to have an added advantage with just a simple and feasible treatment.

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تأثير صدمة البرودة وبعض المعاملات الآمنة بعد القطف على تطور تكوين الكاروتين في ثمار التنجارين "نوفا".

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من المرغوب زيادة كثافة الكاروتين في قشرة ثمار التنجارين "نوفا" (الذي يعتبر واسع الانتشار جدًا لنكهته وقيمته الغذائية) من قبل كلا من المنتجين والمستهلكين والأهم من ذلك استخدام وسائل طبيعية وآمنة لتحقيق ذلك. في هذه الدراسة تعرضت ثمار التنجارين ذات اللون الأصفر المخضر خلال موسمين متعاقبين 2014 و 2015 لعدة معاملات مثل:- الكنترول (ماء) – صدمة البرودة (غمر في الماء المثلج لمدة 30 دقيقة على 2° م ثم التحضين على 5° م لمدة 6 ساعات) – إثيلين داي أمين تترا حامض الخليك (EDTA) – بوتاسيوم مخلوب بواسطة الـ EDTA – كبريتات البوتاسيوم (تركيز 1% وزن / حجم لكل المحاليل) والإثيريل بتركيز 500 جزء في المليون ثم حفظت جميع ثمار التنجارين المعاملة على درجة الحرارة العادية 22 ± 2° م. أوضحت النتائج أن معاملة صدمة البرودة بعد القطف نتج عنها أقل فقد وزن مقارنة بالمعاملات الأخرى. علاوة على ذلك، حققت نفس المعاملة أقل نسبة تسرب إليكتروليتي للقشرة بالمقارنة بمعاملتي الـ EDTA والإثيريل. على العكس من ذلك، احتوت الثمار المعاملة بصدمة البرودة على أعلى فيتامين سي مقارنة بالثمار المعاملة بباقي المعاملات الأخرى. بالإضافة لذلك، فإن معاملة صدمة البرودة بعد القطف كان لها أعلى تأثير على محتوى الكاروتين في قشرة التنجارين مقارنة بمعاملات ما بعد القطف الأخرى.