

PHYSIOLOGICAL STUDIES ON COLOR ACCELERATION OF NAVEL ORANGE FRUITS FOR EARLY EXPORTATION

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Abstract

This study was carried out during two seasons, 2003 and 2004 on Navel orange trees to study the effect of some pre and Postharvest treatments on fruit quality and color development to encourage early exportation.

Preharvest treatments were sprayed on the trees with potassium oxide and glucose at two different concentrations (0.30% or 0.15%) for each. K + G every 15 days after one month from fruit set till the beginning of color break of the peel. Postharvest treatments were exposing the fruits to ethylene gas for 24 or 48 h and the effect of the transit temperature on fruit quality was studied. Peel color, fruit weight loss percentage Juice percentage, T.S.S. / acid ratio were determined.

The results revealed that Preharvest treatments with (K + G) at the above mentioned concentrations increased juice percentage, T.S.S. / acid ratio at harvest time. This treatment was found to hasten fruit development compared with untreated fruits. The application of K + G increased red pigments parameter (a) as well as yellow pigments parameter (b) and color rate a / b ratio. The application of Preharvest treatments alone without using ethylene treatments and keeping the fruits at 10 °C as a transit period gave promising results for early exportation.

INTRODUCTION

Early in the season in different areas citrus fruits attain proper maturity except an acceptable coloration. Color is the most obvious change that occurs in many fruits and is often the major criterion used by consumers to determine the fruit quality. Many attempts were carried out to degree mature citrus fruits using ethephon (Gaona *et al* 1994) or by ethylene gas (Ladanirya and Shyam 2001). Color alternation of the fruit during ripening is affected by various factors. Kays (1991) mentioned that the proper time of harvesting may be determined the after development of the normal complete of pigments associated with that stage in many fruits. Light, temperature and oxygen concentration may also have a pronounced effect on color development. Light is not essential for the synthesis of carotenoids, and color development has been shown to be greater in the absence of light. Dass and Srivstava (1997) found that the role of potassium in citrus nutrition is earliness in harvesting, increaseing yield and fruit size and a producing attractive good color of fruit and juice and a high T.S.S. /acid ratio.

Lglesias *et al*, (2001) illustrated that during ripening, the peel of citrus fruit undergoes color break characterized by the conversion of chloroplast to chromoplast. The process involves the progressive loss of chlorophylls and the increase of carotenoid pigment, causing the change of peel color from green to orange. The rate of color break was positively correlated with sucrose content and negatively with nitrogen content in the peel.

(Tatsumi 2000) found that the peel of Hebezu fruits (citrus sp.) changed rapidly to yellow color when stored at temperatures above 10 °C.

The aim of this research is to study the effect of Preharvest treatments (spraying with potassium and glucose) and some postharvest treatments (exposure to ethylene and a transit temperature 10 °C) on early coloring of navel orange, and other fruit properties to encourage early exportation.

MATERIALS AND METHODS

This study was carried out during the two seasons 2003 and 2004 on 27 mature uniform navel orange trees grown in the Experimental Orchard of the Hort. Res. Station at El Kanater El Khayreia Kalubia Governorate and subjected to normal cultural practices recommended by the ministry of agriculture. The following treatments were carried as Preharvest treatments each on nine trees each three acting as a replicate.

The experiment included the following treatment (as a Preharvest treatment):

- 1- Control. (Water sprayed)
- 2- Spraying potassium oxide (K) 0.15 % + glucose (G) 0.15 %.
- 3- Spraying potassium oxide (K) 0.30 % + glucose (G) 0.30 %.

Trees were sprayed every 15 days after one month from fruit set till the beginning of the peel color break (1-7 November). Fruits were picked when 75% of fruits come color break on trees of any treatment and taken to the laboratory, washed with water and air dried, then divided into four groups, each group was subjected to a specified postharvest treatment.

1. The first group of fruits was held at room temperature 20 – 25 °C and 65 % RH (as a transit period).
2. The second group of fruits was held at 10 °C and 85 % RH.
3. The third group of fruits was exposed to ethylene for 24 h and then held at 10 °C and 85 % RH.
4. The fourth group of fruits exposed to ethylene for 48 h and then held at 10 °C and 85 % RH.

Calcium carbide 15 gm/ m² was used as a source of ethylene.

All fruits were packed in carton boxes (5k) in one layer. Every treatment consisted of six boxes. Two of which were used for weight losses studs

Fruits were examined weekly for physical and chemical properties until the end of the transit period (4 weeks).

Peel color, weight loss percentage, juice percentage, T.S.S. / acid ratio and total sugar, were determined. Weight loss percentage was calculated. Peel color was quantified using Hunter colorimeter (a value (-) green '(+) red, b value (-) blue '(+) yellow a / b ratio was calculated according to McGuire (1992). T.S.S., acid, sugar and carotenoids were determined according to the A. O. A. C. (1980).

The complete randomized design was used data was statistically analyzed according to Snedecor and Cochran (1980). Averages were compared using L.S.D. values at 0.05 % level. The design was randomized complete blocks with three replicates.

RESULTS AND DISCUSSION

1- Rind color

Effect of various Preharvest treatments on rind color of navel orange, parameter (a) and (b) as measured by Hunter lab are shown in Fig (1 '2). It is evident that the treatment with (K+G) 0.30 % gave the highest red pigments parameter (a) and yellow pigments parameters (b) followed by low concentration of K+G (0.15 %) and control. The results of parameters (a) and (b) are in line with a / b ratio Fig (3). Fig (4) illustrated that fruits treated with K+G enhanced forming the red color pigments specific between 440: 448 u.M.u., this may be responsible on pathway of carotenoid biosynthesis. These results are in line with Glesias *et al*/2001 who found that sucrose supplementation promoted sucrose accumulation and advanced color break. The results dealing with the effect of Postharvest treatments to accelerate fruit coloring, illustrates that the effect of calcium carbide was obvious on parameter (b), responsible of yellow pigments. This may be due to exogenous ethylene which markedly accelerates the senescent pigments changes of peel particularly the loss of chlorophyll than synthesis of new pigments. (Gold Schmidt *et al*/ 1993). It is evident from data that low temperature (10°C) during transit period had more effect in accelerating coloring than room temperature (20 – 25 °C). Similar results were found by Tatsumi (2000). Color rate (a/b ratio) for fruits treated with K+G improved peel color, this was clearly evident on color break and after one week during transit period at 10°C a/b ratio were 0.13 – 0.20 – 0.24 for untreated fruits, and sprayed fruits with 0.15 and 0.30 at first season, respectively. Similar results were found in the second season.

Results showed that Preharvest treatment with K+G alone (without ethylene treatment) and transit at 10 °C effectively advanced rind color. The results of Iglesias *et al*/ 2001 illustrated that color changes promoted by sucrose was not affected by ethylene. Ethylene inhibitors effectively counteracted the sucrose effects on color change.

2- Weight loss percentage

It is apparent from data of Table (1) that Preharvest and Postharvest treatments increased weight loss percentage than control fruits.

Significant increase in weight loss percentage was observed during transit period. Loss of weight was greater in fruits held at (20 °C – 25 °C) followed by fruits treated by calcium carbide and the minimum percentage was attained by fruits held at 10 °C as a transit period without exposure to ethylene. Similar results were obtained in the second season. These results are in agreement with Tatsumi (2000) who mentioned that the rate of respiration of sweet orange increased with degreening or changing to yellow color of the fruit rind at high storage temperature.

3- Juice percentage

Significant increase in juice percentage was observed at harvest time in fruits from trees sprayed with K+G at the two concentrations in comparison with untreated ones Table (2). A significant decreases were noticed in fruits treated by calcium carbide for (24 h or 48 h) as a Postharvest treatment. Concerning the effect of transit temperature, it was evident that fruits held at 10 °C had the highest juice percentage during transit period. This trend was observed in the second season only. This may be due to the increase in respiration rate from 35 to 80 Co₂ Kg – h in fruits exposed to ethylene (Ladaniya and Shyam 2001).

4- T.S.S. / acid ratio

Data illustrated in Table (3) indicates that the application of K+G (0.30%) gave the highest value of T.S.S. / acid ratio in fruits juice, followed by fruits sprayed with 0.15%. The lowest value, were observed in untreated fruits. These results are in agreement with those obtained by Dass and Srivastava (1997) who found that the role of potassium in citrus nutrition was causing earliness and a high T.S.S. / acid ratio. Concerning Postharvest treatments data shows that fruits treated by calcium carbide had higher values of the ratio than untreated fruits. This data is supported by Ladaniya and Shyam (2001) who explained that total soluble solids remained unchangeable with ethylene treatment but titratable acidity significantly declined. With

regard to the effect of temperature on T.S.S. / acid ratio it is evident that T.S.S. / acid ratio was lower in fruits held at cold temperature than those held at room temperature. The results were similar in the first and second season.

Table 1. Effect of some pre and post harvest treatments on weight loss percentage of Navel orange held at room temperature (20-25 C) and cold storage 10C during 2003-2004 .

1 st season 2003							
Treatments	Storage period (days)	0	7	14	21	28	M
	T1	Control	0.00	1.82	3.53	5.48	8.64
(0.15)		0.00	2.09	3.78	5.55	8.80	4.04
(0.30)		0.00	2.14	3.90	6.09	9.17	4.26
M		0.00	2.02	3.74	5.71	8.87	4.07 C
T2	Control	0.00	1.76	3.21	4.98	7.70	3.53
	(0.15)	0.00	1.78	3.29	5.36	7.79	3.64
	(0.30)	0.00	1.78	3.43	5.44	7.88	3.71
	M	0.00	1.77	3.31	5.26	7.79	3.63 D
T3	Control	0.00	2.20	4.06	6.30	9.25	4.36
	(0.15)	0.00	2.39	4.48	6.41	9.31	4.52
	(0.30)	0.00	2.47	4.59	7.74	10.50	5.06
	M	0.00	2.35	4.38	6.82	9.69	4.65 B
T4	Control	0.00	2.32	4.35	6.36	9.28	4.46
	(0.15)	0.00	2.45	4.49	6.48	9.74	4.63
	(0.30)	0.00	2.61	4.59	7.32	11.62	5.35
	M	0.00	2.46	4.48	6.92	10.21	4.81 A
Average		0.00	2.15	3.98	6.18	9.14	
2 nd Season 2004							
T1	Control	0.00	2.44	3.54	5.60	8.14	3.94
	(0.15)	0.00	2.45	3.35	5.71	8.24	3.95
	(0.30)	0.00	2.50	4.43	6.62	8.86	4.48
	M	0.00	2.46	3.77	5.98	8.41	4.13C
T2	Control	0.00	2.01	3.30	5.21	7.31	3.57
	(0.15)	0.00	1.91	4.18	5.54	7.31	3.79
	(0.30)	0.00	1.97	4.22	6.36	7.99	4.11
	M	0.00	1.96	3.90	5.70	7.54	3.82 D
T3	Control	0.00	2.04	4.22	6.58	8.95	4.36
	(0.15)	0.00	1.87	3.45	5.92	9.19	4.09
	(0.30)	0.00	2.73	5.07	6.99	11.15	5.19
	M	0.00	2.21	4.25	6.50	9.76	4.54 B
T4	Control	0.00	2.11	4.88	7.54	9.80	4.87
	(0.15)	0.00	2.47	3.54	6.38	9.38	4.35
	(0.30)	0.00	2.50	5.29	9.05	13.68	6.10
	M	0.00	2.36	4.57	7.66	10.95	5.11 A
Average		0.00	2.25	4.12	6.46	9.17	
L.S.D. 5% level	A	B	C	A*B	A*C	B*C	
1 st season	0.004760	0.004122	0.005322	0.008245	0.01064	0.009218	
2 nd Season	0.005281	0.004573	0.005904	0.009146	0.01181	0.01023	

Table 2. Effect of some pre and post harvest treatments on Juice percentage of Navel range held at room temperature (20-25 C) and cold storage 10C during 2003 – 2004.

1 st season 2003							
Storage period (days)		0	7	14	21	28	M
		Treatments					
T1	Control	45.04	44.25	43.75	39.85	37.35	42.05
	(0.15)	55.70	53.74	53.30	52.54	50.21	52.43
	(0.30)	58.90	57.28	43.31	43.18	41.25	48.78
	M	53.21	51.76	46.79	45.19	42.94	47.75 B
T2	Control	51.37	50.29	44.60	42.48	40.31	45.81
	(0.15)	55.70	53.74	53.30	52.54	50.21	53.10
	(0.30)	58.93	56.41	54.68	50.03	48.36	53.68
	M	55.33	53.48	50.86	48.35	46.29	50.86 A
T3	Control	44.20	41.52	40.24	38.67	35.90	40.11
	(0.15)	55.48	52.36	49.48	48.36	45.52	50.24
	(0.30)	57.85	51.03	50.34	46.32	44.98	50.10
	M	52.51	48.30	46.69	44.45	42.13	46.82 C
T4	Control	44.00	41.28	39.58	38.32	37.44	40.12
	(0.15)	55.06	50.68	46.83	43.90	42.00	47.69
	(0.30)	55.89	54.00	49.64	48.62	46.39	50.91
	M	51.65	48.65	45.35	43.61	41.94	46.24 D
Average		53.18	50.27	47.42	45.40	43.33	
2 nd Season 2004							
T1	Control	46.21	45.84	44.67	42.97	38.25	43.59
	(0.15)	52.87	50.33	50.25	48.30	44.90	49.33
	(0.30)	56.00	55.20	51.07	50.47	47.34	52.02
	M	51.69	50.46	48.66	47.25	43.50	48.31 B
T2	Control	46.34	44.07	42.87	41.36	40.68	43.06
	(0.15)	53.24	52.65	50.40	49.74	44.98	50.20
	(0.30)	57.98	54.61	51.20	50.65	47.20	52.33
	M	52.52	50.44	48.16	47.25	44.29	48.53 A
T3	Control	46.35	44.87	42.00	40.99	39.35	42.71
	(0.15)	52.87	51.52	48.99	44.82	44.10	48.46
	(0.30)	53.21	55.20	51.07	50.47	45.34	51.06
	M	50.81	50.53	47.35	45.43	42.93	47.41 C
T4	Control	48.00	46.21	43.22	41.58	39.90	43.78
	(0.15)	51.90	51.72	50.67	48.34	40.87	48.70
	(0.30)	52.46	49.54	45.37	44.70	42.46	46.91
	M	50.79	49.16	46.42	44.87	41.08	46.46 D
Average		51.45	50.15	47.65	46.20	42.95	

L.S.D. 5% level	A	B	C	A*B	A*C	B*C
1 st season	0.3105	0.2689	0.3471	0.5377	0.6942	0.6012
2 nd Season	0.01867	0.01617	0.02087	0.03234	0.04175	0.03615

Table 3. Effect of some pre and post harvest treatments on T.S.S / Acidity of Navel orange held at room temperature (20-25 C) and cold storage 10C during 2003-2004 .

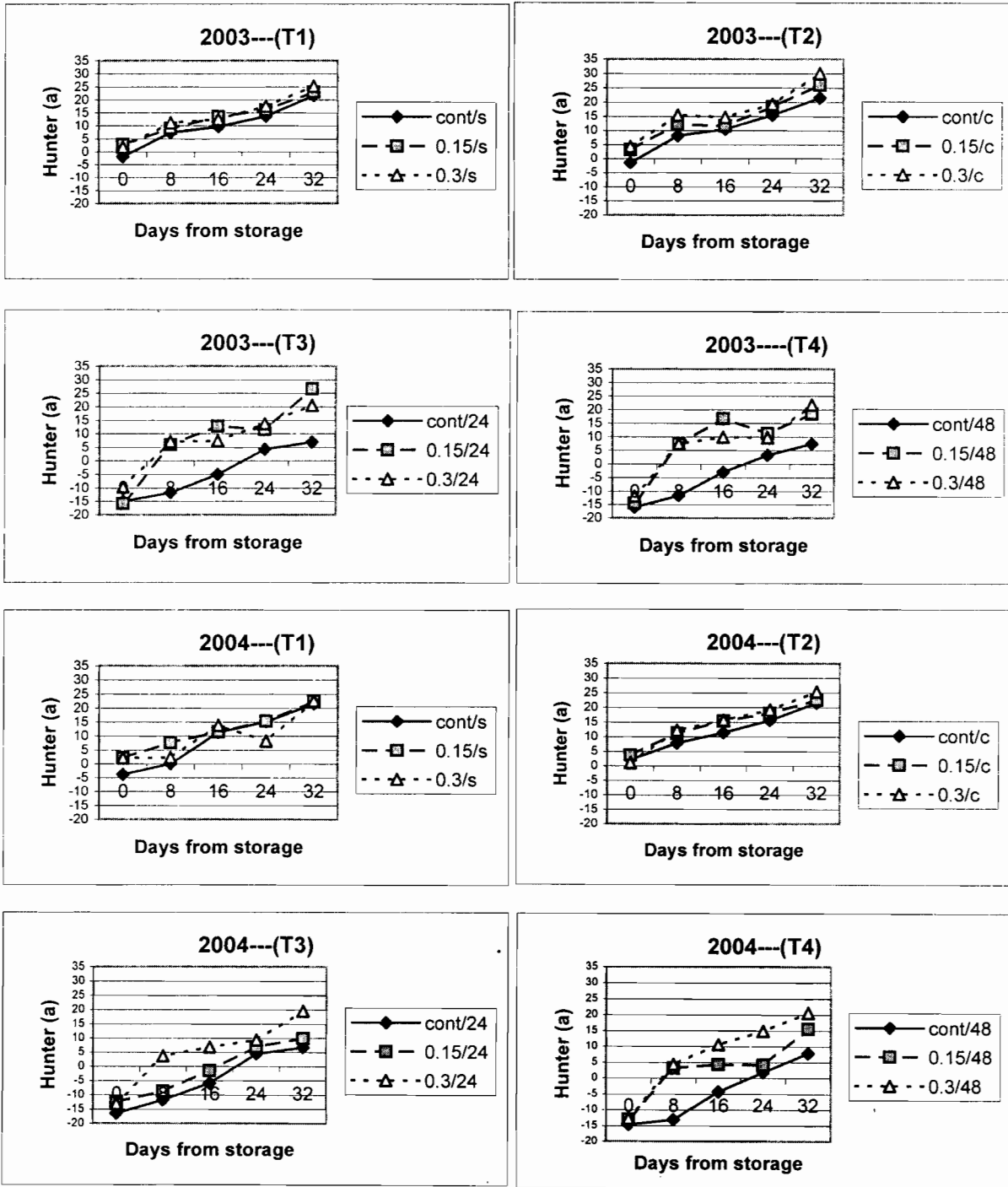
1 st season 2003							
Storage period (days)		0	7	14	21	28	M
Treatments							
T1	Control	9.59	10.98	11.70	13.41	15.42	12.22
	(0.15)	10.33	11.90	12.77	13.25	17.58	13.17
	(0.30)	12.65	12.94	14.42	19.65	24.20	16.77
	M	10.86	11.94	12.96	15.44	19.07	14.05 B
T2	Control	9.89	12.00	13.07	14.44	15.07	12.89
	(0.15)	10.55	13.11	13.83	16.36	17.03	14.18
	(0.30)	12.31	13.07	13.60	16.40	21.50	15.38
	M	10.92	12.73	13.50	15.73	17.87	14.15 A
T3	Control	9.13	9.80	10.40	11.33	11.77	10.49
	(0.15)	10.93	11.62	12.23	14.72	15.57	13.01
	(0.30)	10.98	12.31	12.62	13.50	18.03	13.49
	M	10.35	11.24	11.75	13.18	15.12	12.33 D
T4	Control	9.79	11.22	13.16	13.63	14.26	12.41
	(0.15)	10.55	11.86	12.53	16.36	16.76	13.61
	(0.30)	10.52	13.46	13.60	16.61	18.36	14.51
	M	10.29	12.18	13.10	15.53	16.46	13.51 C
Average		10.60	12.02	12.83	14.97	17.13	
2 nd Season 2004							
T1	Control	9.02	9.79	10.86	11.72	11.97	10.67
	(0.15)	10.33	12.04	12.75	13.71	14.40	12.65
	(0.30)	12.50	13.15	14.38	15.21	17.05	14.46
	M	10.62	11.66	12.66	13.55	14.47	12.59 A
T2	Control	8.76	10.10	11.22	11.70	11.97	10.75
	(0.15)	10.21	10.64	11.08	11.44	11.77	11.03
	(0.30)	12.50	12.62	13.37	13.81	15.33	13.53
	M	10.49	11.12	11.89	12.32	13.02	11.77 C
T3	Control	8.86	10.20	10.97	11.47	12.02	10.70
	(0.15)	9.31	10.41	11.44	12.56	13.12	11.37
	(0.30)	11.33	11.70	12.65	13.41	14.60	12.74
	M	9.83	10.77	11.69	12.48	13.25	11.60 D
T4	Control	8.77	10.43	11.36	12.04	12.75	11.07
	(0.15)	10.00	11.22	11.72	12.75	14.58	12.05
	(0.30)	11.33	12.28	12.87	13.75	14.93	13.03
	M	10.03	11.31	11.98	12.85	14.09	12.05B
Average		10.24	11.22	12.06	12.80	13.71	

L.S.D. 5% level	A	B	C	A*B	A*C	B*C
1 st season	0.004573	0.003961	0.005113	0.007921	0.01023	0.008856
2 nd Season	0.005443	0.004714	0.006086	0.009428	0.01217	0.01054

Table 4. Effect of some pre and post harvest treatments on Total sugars of Navel orange held at room temperature (20-25 C) and cold storage 10C during 2003-2004 .

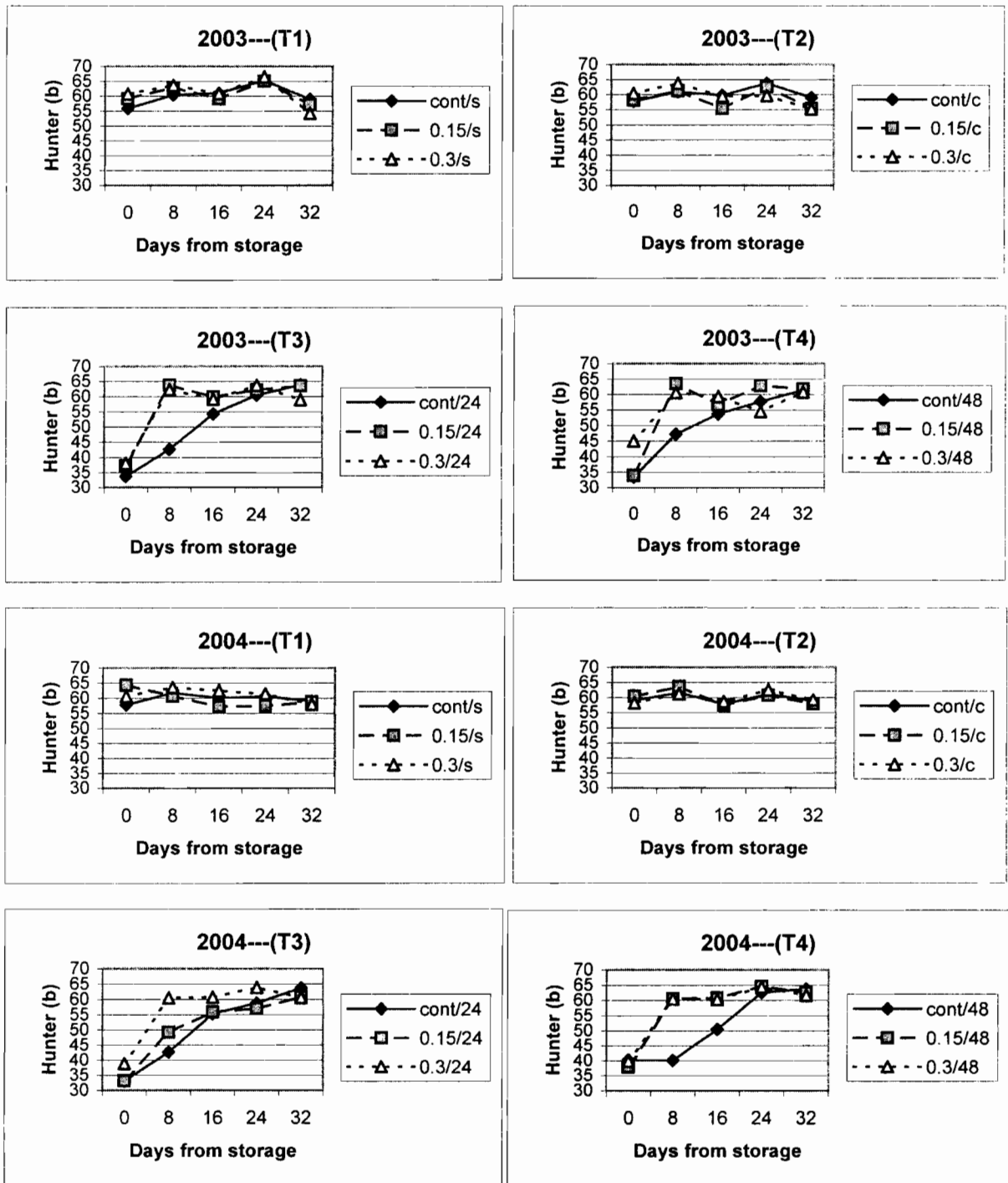
Storage period (days)		1 st season 2003					
		0	7	14	21	28	M
T1	Control	9.90	9.61	9.20	9.20	8.24	9.23
	(0.15)	10.20	10.00	9.67	9.61	8.30	9.56
	(0.30)	10.70	10.70	10.00	9.54	8.33	9.85
	M	10.27	10.10	9.62	9.45	8.29	9.55 C
T2	Control	9.85	9.70	9.07	9.03	7.35	9.00
	(0.15)	10.40	10.00	9.90	9.80	9.40	9.90
	(0.30)	10.60	9.88	9.54	9.54	9.07	9.73
	M	10.28	9.86	9.50	9.46	8.61	9.54 D
T3	Control	9.60	9.50	9.47	9.40	8.99	9.39
	(0.15)	10.13	10.10	10.10	10.00	9.81	10.03
	(0.30)	10.60	10.10	9.67	9.35	8.54	9.65
	M	10.11	9.90	9.75	9.58	9.11	9.69 A
T4	Control	9.80	9.72	9.50	9.00	8.69	9.34
	(0.15)	10.20	10.00	9.78	9.24	8.30	9.50
	(0.30)	10.60	10.50	10.00	9.64	8.97	9.94
	M	10.20	10.07	9.76	9.29	8.65	9.60 B
Average		10.22	9.98	9.66	9.45	8.67	
Storage period (days)		2 nd Season 2004					
		0	7	14	21	28	M
T1	Control	9.80	9.71	9.20	9.00	8.20	9.18
	(0.15)	10.24	10.00	9.05	9.67	8.50	9.49
	(0.30)	10.55	10.20	10.11	9.64	8.63	9.83
	M	10.20	9.97	9.45	9.44	8.44	9.50C
T2	Control	9.40	10.00	10.20	9.80	9.48	9.78
	(0.15)	10.30	10.20	9.50	9.00	9.69	9.74
	(0.30)	10.44	10.15	9.78	9.67	8.94	9.81
	M	10.05	10.12	9.83	9.52	9.37	9.78 A
T3	Control	9.05	9.00	9.00	8.90	8.23	8.84
	(0.15)	10.10	10.00	9.88	9.15	8.40	9.51
	(0.30)	10.40	10.18	9.94	9.56	9.07	9.83
	M	9.85	9.73	9.61	9.20	8.57	9.39 D
T4	Control	9.10	9.40	9.70	9.40	8.99	9.32
	(0.15)	10.17	10.20	10.20	10.00	9.41	10.00
	(0.30)	10.40	10.20	10.00	9.60	8.87	9.81
	M	9.89	9.93	9.97	9.67	9.09	9.71 B
Average		10.00	9.94	9.71	9.46	8.87	
L.S.D. 5% level	A	B	C	A*B	A*C	B*C	
1 st season	0.004175	0.003615	0.004668	0.007231	0.009335	0.008084	
2 nd Season	0.005113	0.004428	0.005717	0.008856	0.01143	0.009901	

Fig 1. Effect of some pre and post harvest treatments on Colour (parameter a)of Navel orange held at room temperature (20-25 C) and cold storage 10C during 2003-2004



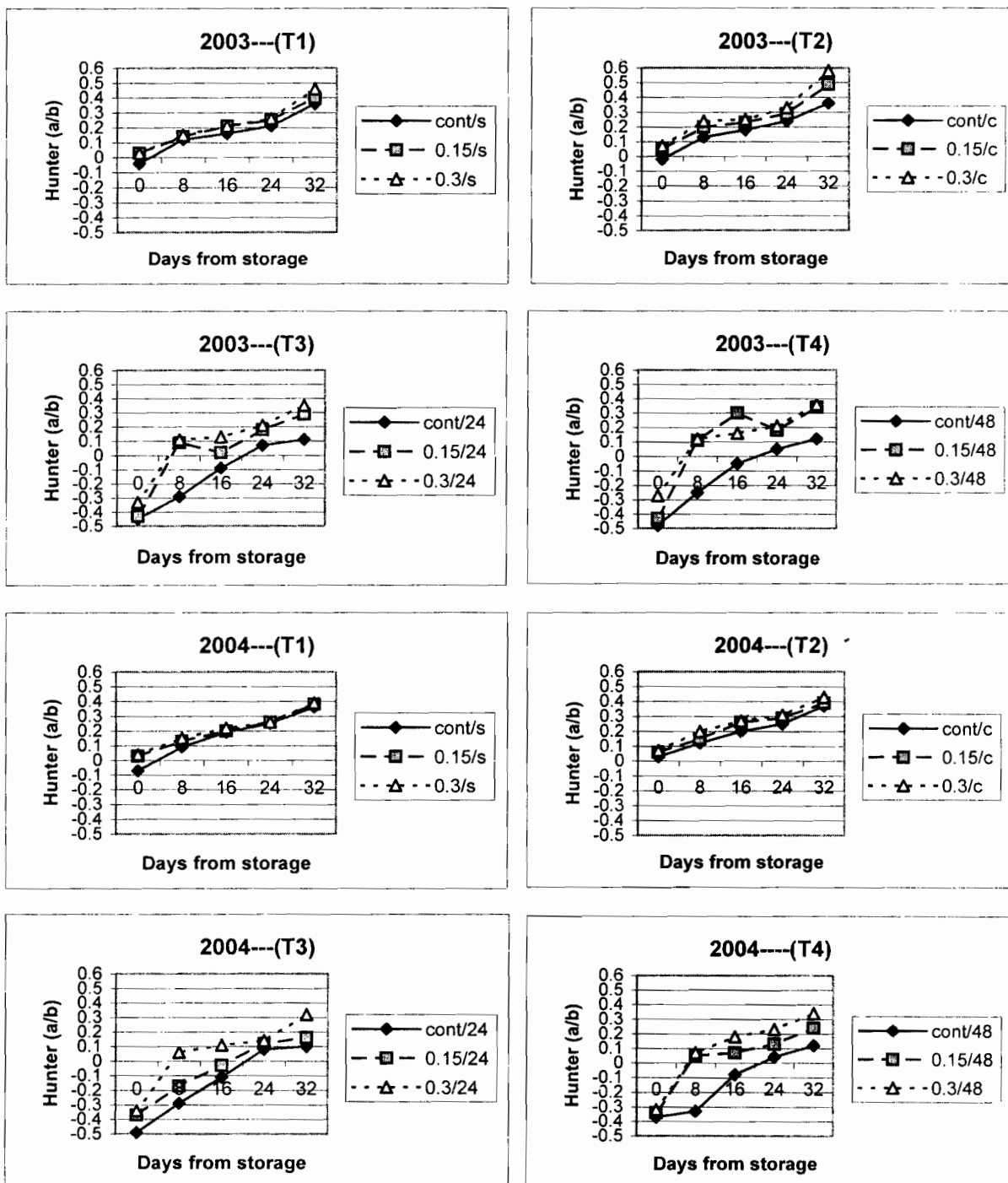
T1 (held at room temperature 20-25 C and 65% RH) **T2** (held at 10 C and 85% RH)
T3 or T4 (exposed to ethylene for 24h or 48h and then held at 10 c and 85% RH)

Fig. 2. Effect of some pre and post harvest treatments on Colour (parameter b)of Navel orange held at room temperature (20-25 C) and cold storage 10C during 2003-2004



T1 (held at room temperature 20-25 C and 65% RH) **T2** (held at 10 C and 85% RH)
T3 or T4 (exposed to ethylene for 24h or 48h and then held at 10 c and 85% RH)

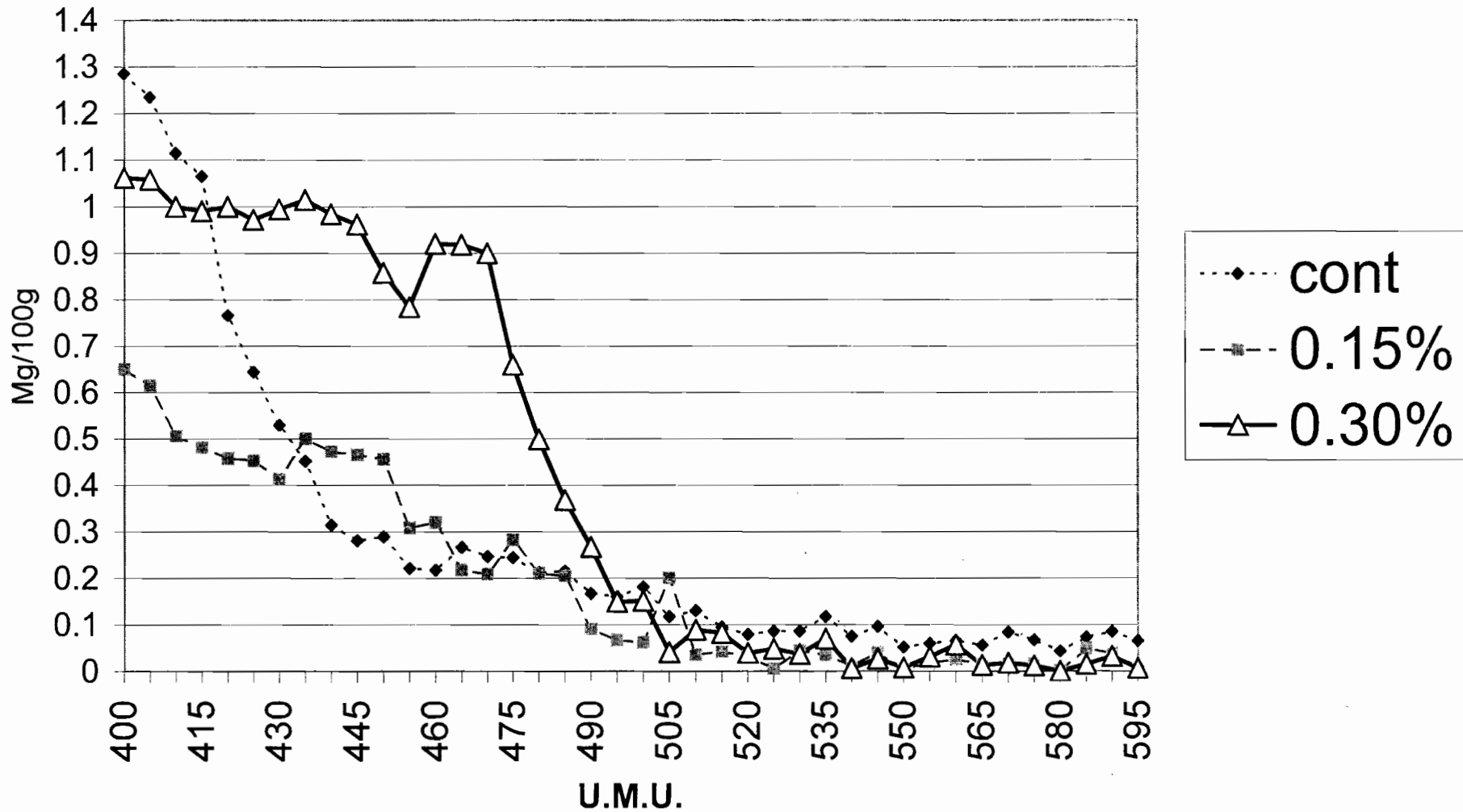
Fig. 3. Effect of some pre and post harvest treatments on Colour (parameter a/b) of Navel orange held at room temperature (20-25 C) and cold storage 10C during 2003-2004



T1 (held at room temperature 20-25 C and 65% RH) T2 (held at 10 C and 85% RH)
 T3 or T4h (exposed to ethylene for 24h or 48h and then held at 10 c and 85% RH)

Fig 4.

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5- Total sugar

Data presented in Table (4) showed significant increase in total sugar, in the juice of fruits treated with K+G at both concentrations at harvest time in comparison with untreated fruits. Concerning the effect of Postharvest treatments, no obvious difference was noticed due to ethylene treatments or transit temperatures on total sugars. These results were similar in the two seasons and are in agreement with Ladaniya and Shyam (2001).

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دراسات فسيولوجية على الإسراع فى تلوين البرتقال أبوسره بغرض التصدير المبكر

ساميه العربى ، أشرف مشرقى

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أجريت هذه الدراسه خلال عامى ٢٠٠٣ ، ٢٠٠٤ على ثمار برتقال بسره لدراسة تأثير بعض معاملات ما قبل ومابعد الحصاد على جودة ثمار البرتقال وتطور اللون بغرض تشجيع التصدير المبكر فى بداية موسم الإثمار .

إشتملت معاملات ما قبل الحصاد على الرش بأكسيد البوتاسيوم مع الجلوكوز بتركيزين مختلفين لكل منهما ١٥% ، ٣٠% بدأ الرش بالبوتاسيوم والجلوكوز بعد شهر من بداية عقد الثمار كل ١٥ يوم حتى بداية تكشف لون الثمار .

إشتملت معاملات ما بعد الحصاد على تعريض الثمار لمدة ٢٤ ساعة ، ٤٨ ساعة للإيثيلين كما تم دراسة تأثير درجة حرارة الإنتظار المؤقت (الترانزيت) على تطور الثمار .
تم تقدير كل من لون القشره - الفقد فى الوزن - النسبه المئويه للعصير - نسبة المواد الصلبه الذائبه / الحموضه والسكريات والكاروتينات .

أوضحت النتائج أن معاملة الثمار قبل الحصاد بالبوتاسيوم والجلوكوز بكل من التركيزين أدى إلى زيادة النسبه المئويه للعصير ونسبة المواد الصلبه الذائبه / الحموضه عند وقت الحصاد كما أدت هذه المعامله إلى تطور اللون بمقارنتها بالثمار الغير معامله .

أدت هذه المعامله إلى زيادة اللون الأحمر و المسئولة عنها القراءة (a) والصبغات الصفراء المسئولة عنها القراءة (b) وكذلك معدل تلوين الثمار (a/b) وأن هذه المعامله قبل الحصاد بدون الحاجه إلى تعريض الثمار إلى معاملة الإيثيلين مع الترانزيت على درجة ١٠ ° م أعطت أحسن النتائج بالنسبة للتصدير المبكر .