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USING OF SOME ENVIRONMENTALLY SAFE TREATMENTS TO IMPROVE THE STORABILITY OF NAVEL ORANGE (*CITRUS SINENSIS* L.) FRUITS

[39]

Layla, I. Tabbara, N. Abdel Hameid and A. Bondok
Horticulture Dept., Fac. of Agric., Ain Shams Univ., Cairo, Egypt

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ABSTRACT

This investigation was carried out during two successive seasons 2013 and 2014 on fruits of Washington Navel orange (*Citrus sinensis* L.). The experiment was conducted to evaluate the influence of some environmentally safe matural products to improve the storability of Navel orange (*citrus sinensis*) fruits during 2013 and 2014 seasons, Jojoba oil (1,3,5)%, castor oil (0.5, 1,2)%, yeast (1,2,3)%, seaweed (1,2,3)%, hot water (45°C and commercial wax were used for proposed study, After the application of the treatments on the fruits, fruits were stored at a temperature of 5°±1 C and 90%±5 of relative humidity for 60 days, physical characteristics (weight loss%, decay% and the peel's thickness of the crust) and chemical properties (total phenols) were determined. Results indicated that, castor oil (2 and 1)% and jojoba oil 5% reduced the deterioration in weight loss%, decay%, peel thickness, and phenols content, compared to the content was obtained in control. So the results show that, coating orange fruits with castor oil (1, 2)% and jojoba oil (5)% had the most effective in improve the storability of orange fruits Navel Orange (*Citrus sinensis* L.).

INTRODUCTION

Citrus is the main fruit crop in Egypt and most varieties are available during winter. Washington Navel orange is one of the most important citrus fruits in Egypt. Under egyption condition it is common practice to store mature Washington Navel orange fruits until the suitable time for marketing **(Abdel-Wahab and Rashid, 2012)**.

Citrus is a major export products of Egypt. The total cultivated area for orange is about 133236 ha (333090 feddan), and total production is estimated at 275000 ton\year **(GAIN, 2015)**, Washington Navel orange is the most popular orange cultivar among other citrus species in Egypt **(FAO, 2010).** Washington navel orange fruits (*citrus sinensis*) are non climactric, with persistently low respiration and ethylene production rates **(Kader and Arpaia, 2002).**

Essential oils are volatile, natural, complex compounds characterized by a strong odour and are formed by aromatic plants as secondary metabolites. EOs or ethereal oils are also aromatic oily liquids obtained by steam or hydro-distillation from plant materials such as flowers, buds, seeds, leaves, twigs, bark, herbs, wood, fruits and roots **(Solgi and Ghorbanpour, 2014)**.

It is well known that in the East began the history of essential oils ; for the process of distillation the technical basis of the essential oil industry was conceived and first employed in the Orient, especially in Egypt, Persia and India. As in many other fields of human endeavor, As usual "The sun rises in the East".

MATERIALS AND METHODS

1- Plant material

This investigation was carried out during two successive seasons 2013 and 2014 on Washington Navel Orange, samples of fruits were obtained from private orchard grown in Wadi-Elnetron, the fruits were harvested at consuming maturity depending on TSS/acid indicator (≈10.5 in 20 October) fruits were used immediately after harvested.

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Fruits were used immediately after harvested, surface washed with tap water and then air dried. Fruits randomly divided into 15 equal groups; each group treated as one treatments as follows for five minutes:

Commercial Wax

- Fruit dipping in **jojopa oil 1,3,5 %** for 5 min, at room temperature
- Fruit dipping in **Castor oil 1\2,1,2 %** for 5 min, at room temperature
- Fruit dipping in **yeast 1,2,3%** for 5 min, at room temperature
- Fruit dipping in**seaweed 1,2,3%** for 5 min, at room temperature
- **hot water**at **45ºc** for 5 min
- **Control**(without any treatment)

Each treatment was represented three replicates, each of one box about (3k\box).After that all the experimental fruits were stored on 5ºC for 60 days.

The following properties were determined on at the beginning of storage and 15-days intervals throughout the storage period.

2- Physical & chemical properties

2-1. Fruits weight loss

The initial weight of fruits was recorded in each treatment and at 15 days intervals, then fruit weight loss% was calculated by weighing the same fruits at each interval and at the end of cold storage duration using the following formula:

Weight loss(%) = [(w1-w2)/w1]*100

where w_1 is initial weight of fruit samples and w_2 is weight of fruit samples after each storage periods.

2-2. **Fruits Decay%**

It was determined by counting the number of decayed fruits (with pathological disorders) and expressed as a percentage of the initial number of fruits per each sample.

2-3. Peel thickness (cm)

Rind thickness of each fruit was measured in three fruits using by caliper

2-4. Determination of Total Phenolic Content in peel (mg/g peel weight)

Total phenolic contents of the peel extracts was measured using a modified colorimetric Folin-Ciocalteu method with further slight modifications **(Singleton and Rossi, 1965)**. peel extracts (0.5 ml) were placed in a test tube. Folin-Ciocalteu reagent (previously diluted tenfold with distilled water) (2.5 ml) was added to the solution and allowed to react for 3 min. The reaction was neutralized with 2 ml of sodium carbonate (7.5 %). Absorbance at 765 nm was read after 30min. Gallic acid was used as standard and data were expressed as mg Gallic acid equivalents (GA)/ g peel weight.

Statistical analysis

This experiment was designed as completely randomize. The means were analyzed using SASS 9.1 statistical software and means were compared by Duncan's multiple range test (DMRT) at 5% level of confidence

RESULTS AND DISCUSSION

1- Fruits weight loss

Table (1) shows the effect of some environmentally safe treatments before storage on weight loss% on Navel orange, during 2013and2014 seasons.

Results showed that the weight loss percentage increased during storage period, the lowest weight loss percentage found in commercial wax with insignificant differences just compared to jojoba oil (3-5)% and castor oil (1-2)% in the first season, plus jojoba oil (1%) and castor oil (0.5%) in the second season. However, Jojoba oil (1)%, castor oil (0.5)% and seaweed (1-2-3)% in the first season and just seaweed (1-2-3)% in the second had weight loss percentage less than a control in significant differences and more than commercial wax also in significant differences, control and hot water were the worst treatments, which had the highest weight loss percentage with insignificant differences just compared to yeast (1-2-3)% inthe two season. These results indicated that the application of wax or castor oil or jojoba oil in combination with low temperature storage play an effective role in reducing the percentage weight loss of the Navel orange fruits.

Table 1. Effect of some pre-storage environmentally safe treatments on Weight loss% on Navel orange fruits, during 2013-2014 seasons

Treatment	Days in cold storage			
	2013			
	15	30	45	60
CommercialWax	**0.74d**	**1.27e**	**2.37e**	**4.36e**
jojopa oil 1%	1.14b-d	3.12a-c	4.44b-d	5.87bc
jojopa oil 3%	1.08b-d	3.18a-c	4.38b-d	4.91c-e
jojopa oil 5%	0.96cd	3.07a-c	3.95cd	4.72de
Castor oil 1/2%	1.01b-d	3.26a-c	4.51bc	5.7 b-d
Castor oil 1%	1.05b-d	2.09de	3.55d	4.83de
Castor oil 2%	0.87cd	2.01de	3.1e	4.36e
yeast 1%	1.56a	3.47ab	5.16ab	6.79ab
yeast 2%	1.53ab	2.85b-d	5.23ab	6.44ab
yeast 3%	1.44a-c	2.76b-d	4.97ab	6.45ab
seaweed 1%	1.25bc	2.45b-d	4.75a-c	5.98bc
seaweed 2%	1.18b-d	2.46b-d	4.78a-c	5.48cd
seaweed 3%	1.26b	2.36cd	4.86a-c	5.6b-d
hot water	1.82a	3.85a	5.62a	7.25a
Control	**1.89a**	**3.93a**	**5.79a**	**7.28a**
	2014			
	15	30	45	60
CommercialWax	0.85d	1.24f	2.87cd	4.77e
jojopa oil 1%	1.13b-d	2.38d	3.57cd	5.47c-e
jojopa oil 3%	1.05cd	2.26d	3.43cd	5.22c-e
jojopa oil 5%	0.92cd	2.14de	2.93cd	5.17de
Castor oil 1/2%	1.08cd	2.29d	3.35cd	5.55c-e
Castor oil 1%	0.95cd	1.88ef	3.17cd	5.27c-e
Castor oil 2%	0.84 d	1.43f	2.86d	4.97de
yeast 1%	1.37ab	3.49ab	4.64ab	6.67a-c
yeast 2%	1.36ab	3.44ab	4.75ab	6.83ab
yeast 3%	1.42ab	3.12bc	3.88bc	6.75ab
seaweed 1%	1.29bc	2.82cd	3.77b-d	5.97bc
seaweed 2%	1.27bc	2.53d	3.35cd	5.93b-d
seaweed 3%	1.25bc	2.41d	3.42cd	5.84b-d
hot water	1.69ab	3.61a	5.13a	7.28a
Control	**1.87a**	**3.73a**	**5.34a**	**7.43a**

Means having the same letter(s) in the same column are not significant at 5% level

Jojoba oil and castor oil have the same effect as commercial wax in combination with cold storage reducing the weight loss% of fruits, it may be due to the effects of oil as permeable barrier against oxygen, carbondioxide and moisture, thereby reducing respiration, water loss and oxidation reaction rates **(Kamel, 2014).** It is worth mentioning that wax, castor oil and jojoba oil are films composed of lipids exhibit good water vapor barrier properties, whereas yeast and seaweed are films made of polysaccharides or proteins usually have suitable mechanical and gas barrier properties but show poor water vapor barrier properties **(Diab et al 2001).** Also This reduction in weight loss was probably due to the effects of these coatings as permeable barrier against oxygen, carbon dioxide, moisture and solute movement, thereby reducing respiration, water loss and oxidation reaction rates **(Baldwin et al 1999),** also **(du Plooy et al 2009)** show that there is closer contact between the essential oils and fruit surfaces, allowing exposure of each fruit to similar concentrations of inhibitor over a longer period. In addition to maximum weight loss in control is due to the high rate of transpiration and respiration **(Baldwin et al 1999).**

2- Fruits Decay%

Data in **Table (2)** show that the fruits decay percentage were increased during storage period, the lowest fruits decay percentage found in commercial wax with insignificant differences just compared to jojoba oil (1-3-5)% and castor oil (0.5-1-2)% inthe two seasons, seaweed (1-2-3)% in the two seasons and yeast (1-2-3)% in the first one had fruit decay percentage less than a control in a significant differences and more than commercial wax also in significant differences, control was the most damaged treatment, which has had the highest fruits decay percentage with insignificant differences just compared to hot water in the first season, but in compared with hot water and yeast (1-2-3)% in the second season.

Some success has been achieved using essential oils as volatiles to combat decay of fruit and vegetables **(Serrano et al 2008).**This decreasing in decay percentages of coated fruit samples was probably due to the effects of these coatings and wrapping on delaying senescence, which makes the commodity more vulnerable to pathogenic infection as a result of loss of cellular or tissue integrity **(Patricia et al 2005),** or maybe also several EOs, have been studied as antimicrobial natural products against both bacteria and moulds **(Corbo et al 2009). Hassan et al (2014)** suggested that the application of edible coating will partially restrict gas exchange through the fruit peel and inhibit the action of ethylene, this inhibitory action can provide better protection against postharvest decay in fruits.

This decreasing in decay percentages of treated samples was probably due to increase defense by essential oils on surface of fruits and its effects of on delaying pathogenic infection where the main components in essential oils (terpenes, terpenoids) play a major role in the antimicrobialbiological effect of essential oils **(Bakkali et al 2008).** The reduction of the severity in vivo, as well as the inhibition of mycelial growth in vitro was due to ricinoleic acid. Also, the application of **jojoba**-based waxes significantly reduced internal O_2 levels and increased internal CO_2 **(Erkan et al 2005).**

Table 2. Effect of some pre-storage environmentally safe treatments on decay% on Navel orange fruits, during 2013-2014 seasons

Treatment	Days in cold storage			
	2013			
	15	30	45	60
CommercialWax	0.0a	0.0d	3.34 d	6.68d
jojopa oil 1%	0.0a	1.67cd	8.35 cd	11.69cd
jojopa oil 3%	0.0a	1.67cd	8.35 cd	10.02cd
jojopa oil 5%	0.0a	0.0d	3.34 d	6.68d
Castor oil 1/2%	0.0a	1.67cd	5.01 cd	8.35d
Castor oil 1%	0.0a	0.0d	3.34 d	8.35d
Castor oil 2%	0.0a	0.0d	3.34 d	6.68d
yeast 1%	0.0a	6.68bc	13.36 bc	23.38b
yeast 2%	0.0a	6.68bc	11.69 c	21.71b
yeast 3%	0.0a	8.35bc	11.69 c	21.71b
seaweed 1%	0.0a	5.01cd	10.02 cd	20.04bc
seaweed 2%	0.0a	3.34cd	10.02 cd	20.04bc
seaweed 3%	0.0a	3.34cd	8.35 cd	18.37bc
hot water	0.0a	13.36ab	20.04 ab	28.39ab
Control	**0.0a**	**20.04a**	**26.72 a**	**33.4a**
	2014			
	15	30	45	60
CommercialWax	0.0a	0.0c	1.67d	6.68d
jojopa oil 1%	0.0a	3.34c	8.35bc	13.36cd
jojopa oil 3%	0.0a	3.34c	8.35bc	11.69cd
jojopa oil 5%	0.0a	1.67c	6.68cd	8.35d
Castor oil 1/2%	0.0a	3.34c	8.35bc	11.69cd
Castor oil 1%	0.0a	1.67c	6.68cd	8.35d
Castor oil 2%	0.0a	0.0c	1.67d	6.68d
yeast 1%	0.0a	8.35b	13.36b	23.38ab
yeast 2%	0.0a	8.35b	13.36b	25.05ab
yeast 3%	0.0a	6.68bc	11.69bc	23.38ab
seaweed 1%	0.0a	6.68bc	10.02bc	21.71bc
seaweed 2%	0.0a	5.01bc	8.35bc	20.04bc
seaweed 3%	0.0a	5.01bc	8.35bc	20.04bc
hot water	0.0a	13.36ab	25.05a	30.06ab
Control	**0.0a**	**20.04a**	**28.39a**	**33.4a**

Means having the same letter(s) in the same column are not significant at 5% level

Also, the active component of essential oils contain more phenol compounds had a great antifungal activity **(Abdolahi et al 2010)** and phenol compounds could affect the enzymes responsible for spore germination of fungi **(Nychas, 1995)** and have also been recognized as bioactive components **(Tabassum et al 2013)**, this leading to improve storability and extend market life of orange fruit.

3- Peel thickness / cm

Data in **Table (3)** show the results that the peel thickness was decreased during storage period, the highest value of peel thickness found in commercial wax with insignificant differences compared to jojoba oil (1-3-5)% and castor oil (0.5-1-2)% in the two seasons, control was the worst treatments, which had the lowest value of peel thickness with insignificant differences just compared to hot water, yeast (1-2-3)% and seaweed (1-2-3)% in the two seasons.

Table 3. Effect of some pre-storage environmentally safe treatments on peel thickness (cm) on Navel orange fruits, during 2013-2014 seasons

Treatment	Days in cold storage			
	2013			
	15	30	45	60
CommercialWax	0.37a	0.34a	0.32a	0.31a
jojopa oil 1%	0.40a	0.32ab	0.29a-c	0.26a-c
jojopa oil 3%	0.40a	0.33ab	0.30ab	0.26a-c
jojopa oil 5%	0.39a	0.33ab	0.31ab	0.30a
Castor oil 1/2%	0.38a	0.34ab	0.30ab	0.27ab
Castor oil 1%	0.39a	0.35ab	0.30ab	0.28ab
Castor oil 2%	0.38a	0.34ab	0.31ab	0.30a
yeast 1%	0.36a	0.30b	0.29a-c	0.23b-d
yeast 2%	0.37a	0.30b	0.28a-c	0.23b-d
yeast 3%	0.35a	0.29b	0.26bc	0.22cd
seaweed 1%	0.36a	0.30b	0.26bc	0.24b-d
seaweed 2%	0.41a	0.30b	0.27a-c	0.23b-d
seaweed 3%	0.40a	0.30b	0.27a-c	0.24b-d
hot water	0.37a	0.30b	0.25b	0.21cd
Control	**0.39a**	**0.29b**	**0.25b**	**0.20d**
	2014			
	15	30	45	60
CommercialWax	0.39a	0.36a	0.32a	0.30a
jojopa oil 1%	0.40a	0.32a-c	0.29ab	0.26a
jojopa oil 3%	0.38a	0.31bc	0.30ab	0.27a
jojopa oil 5%	0.39a	0.34ab	0.31ab	0.30a
Castor oil 1/2%	0.40a	0.32a-c	0.30ab	0.27a
Castor oil 1%	0.36a	0.32a-c	0.30ab	0.29a
Castor oil 2%	0.40a	0.35ab	0.32a	0.31a
yeast 1%	0.37a	0.27cd	0.26bc	0.23bc
yeast 2%	0.36a	0.26d	0.25bc	0.23bc
yeast 3%	0.37a	0.27cd	0.27a-c	0.24bc
seaweed 1%	0.38a	0.28cd	0.25bc	0.24bc
seaweed 2%	0.37a	0.28cd	0.27a-c	0.23bc
seaweed 3%	0.40a	2.29cd	0.26bc	0.24bc
hot water	0.39a	0.26d	0.23c	0.22c
Control	**0.38a**	**0.27cd**	**0.23c**	**0.21c**

Means having the same letter(s) in the same column are not significant at 5% level.

The decrease in peel thickness may be attributed to moisture loss from fruit peel as storage period progressed **Tarabih and El-Metwally, (2014).** The incorporation of essential oils into fruit coatings, primarily applied to retain moisture, is gaining popularity **(du Plooy et al 2009).** The advantage of using coatings amended with essential oils, rather than vapor, is that there is closer contact between the essential oils and fruit surfaces, allowing exposure of each fruit to similar concentrations of inhibitor over a longer period. Permeability for citrus coatings should be high for O_2, CO_2, and C_2H_4 and low for water vapor to reduce transpiration as much as possible and not overly restrict respiration **(Ladaniya, 2011).** Surface coatings and vegetable oils were reported to maintain water status of fruits **(McDonald et al 1993)**, and thus itreduces moisture loss. Also the modification of cell wall of peel may affect firmness loss and ultimately vanishing of void spaced and hence reduction in peel thickness **(Parker and Maalekuu, 2013).**

4- The total phenols in peel (mg/g peel weight)

Data in **Table (4)** show the results that the total phenols (mg / g fresh weight) were increased during storage period, the lowest total phenols was found in commercial wax with insignificant differences compared to jojoba oil (1-3-5)% and castor oil (0.5-1-2)% in the two seasons, seaweed (1-2-3)% in the first season and yeast (1-2-3)% and seaweed (1-2-3)% in the second one significantly have had less total phenols than a control and more than commercial wax also in significant differences, control had the highest total phenols with insignificant differences compared to hot water and yeast (1-2-3)% in the first season and just compared to hot water in the second one.

Cell membrane is the primary cell structure affected by chilling injury CI **(Rui et al 2010),** Cell membrane phase transition from a flexible liquid crystalline to a solid-gel structure that occurs at chilling temperature increments the risk of loss of controlled cell membrane semi-permeability **(Lyons, 1973).** If the fruit is exposed to chilling temperatures for too long, cell membranes rupture takes place, causing leakage of intracellular water, ions and metabolites, which can be monitored by determination of electrolyte leakage **(Sharom et al 1994).** Electrolyte leakage is an effective parameter to assess membrane permeability and therefore is used as an indicator of membrane integrity **(Marangoni et al 1996).**Fruits of many citrus cultivars may develop CI when exposed to low non-freezing temperatures **(Henriod et al 2005)**. oranges less-sensitive species compared to other species CI may be manifested as bronze non-depressed extended areas or superficial scald in the flavedo **(Alférez et al 2005).**

Table 4. Effect of some pre-storage environmentally safe treatments total phenols (mg/ g peel weight) in Navel orange fruits, during 2013-2014 seasons

Treatment	Days in cold storage		
	2013		
	0	30	60
Commer-	0.231a	0.288d	0.386c
jojopa oil	0.239a	0.305d	0.408c
jojopa oil	0.241a	0.300d	0.398c
jojopa oil	0.235a	0.292d	0.390c
Castor oil	0.237a	0.303d	0.402c
Castor oil	0.234a	0.298d	0.389c
Castor oil	0.236a	0.287d	0.387c
yeast 1%	0.239a	0.381bc	0.574ab
yeast 2%	0.240a	0.385bc	0.571ab
yeast 3%	0.239a	0.380bc	0.565ab
seaweed	0.237a	0.372b	0.543b
seaweed	0.232a	0.368c	0.545b
seaweed	0.239a	0.362c	0.539b
hot water	0.237a	0.400a	0.579ab
Control	**0.240a**	**0.425a**	**0.598a**
	2014		
	0	30	60
Commercial	0.241a	0.282c	0.392c
jojopa oil	0.239a	0.310c	0.410c
jojopa oil	0.232a	0.300c	0.400c
jojopa oil	0.234a	0.298c	0.399c
Castor oil	0.237a	0.306c	0.405c
Castor oil	0.234a	0.293c	0.400c
Castor oil	0.235a	0.278c	0.385c
yeast 1%	0.237a	0.381ab	0.480b
yeast 2%	0.240a	0.387ab	0.485b
yeast 3%	0.239a	0.379ab	0.497b
seaweed	0.241a	0.352b	0.467b
seaweed	0.237a	0.357b	0.470b
seaweed	0.232a	0.362ab	0.462b
hot water	0.233a	0.388ab	0.581a
Control	**0.235a**	**0.410a**	**0.592a**

Means having the same letter(s) in the same column are not significant at 5% level

Plant phenolics may be divided in two classes: (1) preformed phenolics that are synthesized during the normal development of plant tissues and (2) induced phenolics that are synthesized by plants in response to physical injury, infection or when stressed by suitable elicitors such as heavy metal-salts, UV-irradiation, temperature, etc. (phytoalexins) **(Hammerschmidt, 2003**), many phenolics, especially phenolic acids, are directly involved in the response of plants to different types of stress and accumulates in plant tissues of infected or in nearby areas are also observed in the affected areas caused by mechanical factors, **(Benhammou, 2012)**.

Conclusion and recommendations

It could be concluded that Castrol oil (1,2)% and jojoba oil 5% proved to be best treatment that were very effective in improving the overall quality of citrus fruits. Our conclusion about castrol oil and jojoba oil should be further tested by conducting systematic research studies for increasing the shelf life for other Varieties of citrus.

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