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EFFECTS OF A PREPARED WAX-EMULSION ON FRUIT WEIGHT LOSS OF SWEET LIME IN STORAGE

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ABSTRACT

A wax containing fungicide was applied to sweet lime (*Citrus limetta* Swing.) fruits as a postharvest treatment in 1989 and 1990. The fruits were waxed with aqueous emulsions of 25, 50 and 75% of prepared wax-emulsion and stored for a 5-month period at 10°C as well as in ambient storage. All wax concentrations containig 1% Sodium orthophenyl phenate (SOPP) or 0.4% Thiabendazole (TBZ) were effective in reduction of fruit weight loss in both storage conditions. The maximum reduction in weight loss (45%) without affecting fruit flavor, was achieved in fruits which were treated with 75% wax-emulsion and stored in ambient storage, in 1989. The weight loss of coated fruits decreased as concentration of wax-emulsion was increased. The weight loss was proportionally higher in peel than in pulp.

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اثرات امولسیون واکس تهیه شده روی کاهش وزن لیموشیرین در انبار

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چکیده

بعنوان تیمار پس از برداشت یک واکس که حاوی قارچکش بود در سال ۱۳۶۸ و ۱۳۶۹ بروی میوه‌های لیموشیرین (*Citrus limetta* Swing.) بکار برده شد. میوه‌ها با محلول امولسیونهای ۲۵، ۵۰ و ۷۵% از واکس تهیه شده، واکس‌زنی گردیدند و برای مدت ۵ ماه در انبار ۱۰°C و همچنین انبار معمولی نگهداری شدند. تمام غلظت‌های واکس که حاوی ۱% Sodium orthophenyl phenate (SOPP) و یا ۰/٤% Thiabendazole (TBZ) بودند در کم کردن کاهش وزن میوه‌ها در هر دو نوع انبار مؤثر بودند. بیشترین مقدار کم شدن کاهش وزن (٤۵%) بدون تاثیر گذاشتن روی طعم میوه در میوه‌هایی که با امولسیون واکس ۷۵% تیمار شده و در انبار معمولی سال ۱۳٦۸ نگهداری شده بودند بدست آمد. کاهش وزن میوه‌های واکس زده با افزایش غلظت امولسیون واکس رابطه معکوس داشت. کاهش وزن در پوست بیشتر از گوشت آن بود.

INTRODUCTION

Sweet lime is one of the main commercial citrus fruits in Iran. Fruits are mostly stored and then sent to internal and external markets for consumption during spring and summer. Marketing losses of sweet lime due to senescence and decay are excessive, thus reducing saleable weight and marketability. Ben-Yehoshua (2) indicated that a major requirement for

extending the postharvest life of citrus fruit is to slow its transpiration. A number of researchers have reported the composition and efficiency of different types of wax emulsions (7, 8, 10, 13). Waxes may serve as a carrier of fungicides, and the effectiveness of Thiabendazole (TBZ) or Sodium orthophenyl phenate (SOPP) in wax in controlling penicillium rots of citrus has been reported (9, 12). So far there is no information available on sweet lime storage in Iran. The main purpose of this study was to formulate a wax emulsion with material suitable for use as skin coating and to investigate the effect of various concentrations of a formulated wax on fruit weight loss and storage life of sweet lime in refrigerated and non-refrigerated storage.

MATERIALS AND METHODS

The composition of the prepared emulsion was that reported by Bennett (1), except that bees wax was substituted for carnauba wax. The prepared wax had the following formulation (parts by weight): paraffin wax, 165; bees wax, 55; stearic acid, 42; NaOH, 6; triethanolamine, 20; shellac, 100 and water, 2000. The emulsion was diluted with cold water to obtain 25, 50 and 75% wax emulsion. The fruits were harvested at optimum maturity on Jan. 8, 1989 and transferred to the laboratory. On the next day the fruits were washed and disinfected with a 0.5% aqueous solution of Sodium orthophenyl phenate (SOPP). After rinsing with tap water, lots of 200 uniform fruits were subjected to different treatments of wax coating. The dipping solution contain 0.1% non-ionic detergent as a wetting agent. A completely randomized design with four replications was used. The treatments were wetting agent only, 1% SOPP; 25, 50 and 75% wax-emulsions plus 1% SOPP. Each lot of fruits was dipped in its

corresponding treatment solution for one min, drained and dried in warm air.

Treated lots were divided into random samples of 5 fruits and kept in perforated polyethylene bags each with 24 holes of 5 mm diameter and stored at ambient (temperature 7-21°C; RH 40-70%) or refrigerated (temperature 10°C; RH 85-90%), for a period of 5 months. Samples of treated fruits from both storage conditions were evaluated at monthly intervals. To determine the effects of treatments on the fruit weight loss, the samples were weighed at the beginning and at regular intervals and expressed as percentage of weight loss. Water loss of peel and segments of fruits were determined by drying peel and segments of one fruit from each treatment and replication at 80°C and expressed as percentage of peel and pulp water.

For the pulp/peel ratio determination, one fruit from each treatment and replication was peeled and the pulp and peel obtained. The pulp/peel ratio was then calculated as a quotient of the pulp and peel weight.

The same experiment was repeated on Dec. 15, 1990, except that 0.4% Thiabendazole (TBZ) was substituted for SOPP and a commercial wax ("Technimul" Dussek Campbell Pty of Australia Ltd) (1:2) plus 0.4% TBZ also was used to compare the effect of prepared wax with that of commercial wax.

RESULTS

Weight Losses

The results of wax coating on weight loss of sweet lime in each year are shown in Tables 1 and 2. The percentage of weight loss in each month and at the end of the experiment was greater in ambient storage than in cold storage (10°C).

Table 1. Effect of wax coatings on cumulative weight loss(%) of sweet lime stored at 10°C and ambient temperature in 1989.

Treatment	1st month		2nd month		3rd month		4th month		5th month		Mean	
	10°C	Ambient storage	10°C	Ambient storage	10°C	Ambient storage	10°C	Ambient storage	10°C	Ambient storage	10°C	Ambient storage
Control	1.54 a†	1.41 ab	1.35 bc	4.44 a	2.45a	7.97 a	3.80 a	12.09 a	5.36 a	31.95 a	2.90 a	11.57 a
1% SOPP§	0.84 b	1.69 a	1.70 a	3.92 a	2.18 a	6.58 ab	3.39 a	11.96 a	4.66 ab	32.12 a	2.62 ab	11.28 a
25% wax + 1% SOPP	0.92 b	1.01 bc	1.43 b	3.09 a	1.53 b	6.24 ab	3.05 a	10.76 ab	3.85 ab	22.04 c	2.15 c	8.63 b
50% wax + 1% SOPP	0.76 b	1.01 bc	1.27 c	2.72 a	2.41 a	5.89 ab	3.56 a	9.18 ab	3.67 ab	19.55 c	2.31 bc	7.80 b
75% wax + 1% SOPP	0.71 b	0.65 c	1.02 d	2.49 a	1.90 a	4.99 b	3.74 a	8.62 b	3.27 b	13.75 b	1.94 c	6.16 c

† Means followed by the same letter within each column are not significantly different at 5% level by Duncan's multiple range test.

§ SOPP = Sodium orthophenyl phenate.

Table 2. Effect of wax coatings on cumulative weight loss(%) of sweet lime stored at 10°C and ambient temperature in 1990.

Treatment	1st month		2nd month		3rd month		4th month		5th month		Mean	
	10°C	Ambient storage	10°C	Ambient storage	10°C	Ambient storage	10°C	Ambient storage	10°C	Ambient storage	10°C	Ambient storage
Control	3.15 a†	5.18 a	3.67 a	6.51 a	6.14 a	10.56 a	9.36 a	13.41 a	9.21 a	32.59 a	6.31 a	13.65 a
0.4% TBZ§	3.23 a	4.07a	2.99 a	5.97 a	5.21 ab	8.18 ab	7.74 a	13.15 a	8.84 a	29.95 a	5.60 b	12.26 b
25% wax + 0.4% TBZ	2.82 a	3.72 a	3.29 a	5.64 a	3.59 b	7.87 ab	5.82 b	12.68 a	6.91 b	26.24 b	4.48 c	11.23 bc
50% wax + 0.4% TBZ	1.89 a	3.51 a	3.24 a	4.81 a	3.51 b	7.53 b	5.78 b	10.47 ab	7.16 b	20.76 c	4.32 c	9.41 d
75% wax + 0.4% TBZ	2.00 a	3.25 a	2.74 a	4.40 a	3.66 b	6.34 b	4.83 b	8.93 b	6.41 b	21.56 c	3.93 c	8.90 d
Commercial wax + 0.4% TBZ	2.52 a	3.53 a	2.95 a	4.78 a	4.34 b	7.03 b	5.79 b	10.93 ab	7.01 b	26.86 b	4.52 c	10.63 c

† Means followed by the same letter within each column are not significantly different at 5% level by Duncan's multiple range test.

§ TBZ = Thiabendazol.

Weight losses of coated fruits in both storage conditions were decreased as concentration of wax emulsion increased. Uncoated fruits in both storage temperatures and in both years had the highest weight loss, whereas the lowest weight loss was achieved with 75% wax-emulsion. The effects of wax emulsions on weight losses were significant after the 4th and 5th months of storage, especially when ambient storage was used (Tables 1 and 2). In 1989, reduction in weight loss of coated fruits in ambient storage was higher than in cold storage, while in 1990 reduction of weight loss in cold storage was slightly more than that in ambient storage (Table 3). At both storage temperatures, reduction in weight losses of fruits treated with commercial wax was slightly less than those treated with 50% wax emulsion (Table 3).

Table 3. The percentage of reduction in weight loss after 5 months of storage as affected by concentrations of wax and storage condition.

Treatment	1989		1990	
	10°C	Ambient storage	10°C	Ambient storage
25% wax emulsion	17.93	23.35	20.00	8.40
50% wax emulsion	11.83	30.72	22.85	23.24
75% wax emulsion	25.95	45.29	29.82	27.40
Commercial wax (1:2)	—	—	19.28	13.29

Moisture Content of Pulp and Peel

The results of various treatments of prepared wax-emulsion on the percentage of pulp and peel moisture of sweet lime are shown in Table 4. There were significant differences between coated and uncoated fruits in the percentage of peel moisture of sweet limes that were held in ambient storage in both years, and cold storage in 1990. Treatments had no effect on the moisture change of pulp but significantly changed the moisture content of peel.

Table 4. Effect of wax coatings on the moisture content (% fresh wt) of the pulp and peel of sweet lime stored for 5 months at different storage conditions.

Treatment	1989				1990			
	Cold storage(10°C)		Ambient storage		Cold storage(10°C)		Ambient storage	
	% pulp water	% peel water	% pulp water	% peel water	% pulp water	% peel water	% pulp water	% peel water
Control	91.11 a†	81.76 a	89.89 a	73.74 c	90.12 a	81.96 a	89.73 a	70.31 d
Fungicide	90.91 a	82.11 a	89.93 a	76.23 b	90.36 a	78.88 b	89.71 a	72.41 cd
25% wax	89.73 a	81.72 a	90.75 a	80.41 a	90.41 a	82.69 a	90.06 a	74.64 bc
50% wax	90.62 a	82.17 a	90.59 a	80.46 a	90.65 a	82.41 a	90.48 a	78.65 a
75% wax	90.78 a	82.75 a	90.47 a	81.46 a	90.34 a	82.78 a	89.70 a	78.75 a
Commercial wax (1:2)	—	—	—	—	90.80 a	81.26 ab	90.19 a	75.83 b

† Means followed by the same letter within each column are not significantly different at 5% level by Duncan's multiple range test.

Pulp to Peel Ratio

Regardless of wax coating, harvest year had a considerable effect on pulp/peel ratio of fruits stored. The pulp/peel ratio in 1990 was greater than 1989 (Table 5). The peel thickness of fruits stored in 1990 was less than fruits stored in 1989.

Table 5. Pulp to peel ratio of sweet lime treated with wax-emulsions and stored for 5 months at 10°C and Ambient storage.

Treatment	1989		1990	
	10°C storage	Ambient storage	10°C storage	Ambient storage
Control	3.78† a	5.15 a	4.48 ab	6.38 a
Fungicide	3.90 a	4.78 a	4.74 a	4.68 b
25% wax	3.97 a	3.85 b	4.36 ab	4.28 b
50% wax	3.53 a	3.82 b	4.25 b	4.84 b
75% wax	3.80 a	3.56 b	4.24 b	4.80 b
Commercial wax (1:2)	—	—	4.74 a	5.02 b

Means followed by the same letter within each column are not significantly different at 5% level by Duncan's multiple range test.

DISCUSSION

The results of a two-year study revealed that coated fruits with 25, 50 and 75% prepared wax emulsion significantly reduced weight loss more than commercial wax and uncoated fruits. The reduction of weight loss by prepared wax-emulsion was probably due to the decrease in transpiration from the skin because 90% of total loss of weight is

shown to be due to transpiration (2). The maximum reduction in weight loss was achieved by a 75% wax-emulsion. The greater efficiency of higher concentration of wax-emulsion in reducing transpiration was due to producing a good barrier to water vapor diffusion, whereas, 25% wax-emulsion produced a broken layer of coating. This finding is in agreement with the results of Ben-Yehoshua *et al.* (3) who showed the new surface layer after wax coating had many pits and breaks.

The 75% wax emulsion effectively reduced weight loss without affecting fruit flavor, suggesting that anaerobic conditions were not present. Similar results have been reported by Ben-Yehoshua (2) who showed that waxing with Tag (a commercial wax) inhibited transpiration without affecting fruit flavor.

The lower pefcentage of peel moisture and increased pulp/peel ratio of uncoated fruits indicates that the weight loss of peel was proportionally higher than the pulp. Similar results have been previously reported (4, 7). During two-years of study sweet limes in ambient storage lost more weight than fruits stored at 10°C. This is likely due to differences in temperature and relative humidity, because the rate of water loss from fruits and vegetables depends upon the vapor pressure deficit (VPD) (6).

In ambient storage of sweet lime, coated limes with thicker peel had less weight loss compared to those with thinner peel. It may be suggested that the high level of surface to mass ratio of peel in thinner peel sweet limes, might be responsible for the increase in moisture loss of peel (5). Thus tending to increase in resistance of peel to water vapor transport. The same observation was made by Pfeffer (11) who indicated that as the cell wall dried, the permeability to gas diffusion declined. Therefore, in sweet limes with thinner peels the effectiveness of wax coating in ambient storage is reduced. Cold storage is probably more suitable for keeping thinner peel sweet limes.

LITERATURE CITED

1. Bennett, H. 1947. Practical Emulsions. 2nd ed., Chemical Publ. Co., Inc., New York, U.S.A. 568p.

2. Ben-Yehoshua, S. 1969. Gas exchange, transpiration and the commercial deterioration in storage of orange fruit. J. Amer. Soc. Hortic. Sci. 94:524-528.

3. Ben-Yehoshua S., S.P. Burg and R. Young. 1985. Resistance of citrus fruit to mass transport of water vapor and other gases. Plant Physiol. 79:1048-1053.

4. Ben-Yehoshua, S., I. Kobiler and B. Shapiro. 1979. Some physiological effects of delaying deterioration of citrus fruit by individual seal-packaging in high density polyethylene film. J. Amer. Soc. Hortic. Sci. 104:868-872.

5. Burg, S.P. and R. Kosson. 1983. Metabolism, heat transfer and water loss under hypobaric conditions. *In:* M. Lieberman, (ed.). Postharvest Physiology and Crop Preservation. Plenum Press, New York, U.S.A. 399-424.

6. Kader, A.A. 1985. Postharvest biology and technology: An overview. *In*: A.A. Kader (ed.). Postharvest Technology of Horticultural Crops. Univ. Calif. Coop. Ext. Serv. 3311, Davis, CA, U.S.A. 3-7.

7. Lodh, S.B., S.K. Mukherhee and A.N. Bose. 1963. Storage of mandarin oranges. II. Effects of hormones and wax coatings. J. Food. Sci. 28:519-524.

8. Mathur, P.B. and H. Subramanyam. 1956. Effect of a fungicidal wax coating on the storage behaviour of mangoes. J. Sci. Food. Agric. 7:673-676.

9. McCornak, .A.A., W.F. Wardowski and G.E. Brown. 1976. Postharvest decay control recommendation for Florida citrus fruit. Univ. Florida. Coop. Ext. Serv., Circ. 359-A.

10. Paredes-Lopes, O., E. Camaro-Rubio and Y. Gallardo-Navaro. 1974. Use of coatings candelilla wax for the preservation of limes. J. Sci. Food Agric. 25:1207-1210.

11. Pfeffer, W.F.P. 1897. The Physiology of Plants. 2nd ed. Translated and edited by A.J. Evart. Clarendon Press, Oxford. (Cited by Ben-Yehoshua, 1969).

12. Waks, J., M. Schiffmann-Nadel, E. Lomaniec and E. Chalutz. 1985. Relation between fruit waxing and development of rots in citrus fruit during storage. Plant Disease 69:869-870.

13. Watkins, J.B. 1971. Waxing fruit and vegetables (Abstr). Fruit World and Market Grower 72:39.