

EXTENSION OF STORAGE LIFE OF CITRUS FRUITS BY APPLICATION OF CANDELILLA WAX EMULSION AND COMPARISON OF ITS EFFICIENCY WITH TAG AND FLAVORSEAL¹

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Abstract. A study was undertaken to compare the relative efficacy of candelilla aqueous wax emulsion with Tag and Flavorseal on citrus fruits like limes, oranges and grapefruit to extend the storage life in fresh state and improve quality. After treatment, the fruits were stored at ambient conditions ($20 \pm 2^\circ\text{C}$; 65 — 75 % RH) for 45, 60 and 120 days, for limes, oranges and grapefruit respectively. Considering the results of chemical analysis, storage losses and organoleptic evaluation, candelilla wax was found to be equal in performance to Tag and better than Flavorseal. Possibilities of commercial exploitation of this product for treatment of fresh citrus fruits for national as well as international markets have been discussed.

The use of skin coatings on fruits to extend the storage life in the fresh state has been known since the last half century. Probably the earliest patented work on commercial formulations of wax emulsion were by Thompson (1) and Sharma (2) in the nineteen thirties. Subsequently a number of research workers have reported the composition and efficacy of different types of wax emulsions based on inorganic petroleum waxes like paraffin, microcrystalline, polyethylene or organic waxes like the bees wax, sisal, carnauba, sugar cane waxes, etc. in combinations with mineral or vegetable oils, emulsifying agents with varying solids content and particle sizes. Subsequently the

efficiency of the emulsions was improved by addition of fungicides, growth regulating substances, artificial coloring matter and substances imparting brightness.

Some of these aspects have been reviewed by Srivastava (3). In the modern times most of the fresh citrus fruits sold in open markets in the developed countries as well as in many of developing countries are treated with skin coatings in order to extend storage life and to present a better marketing condition. In recent times two patented products namely Tag and Flavorseal are extensively used to treat citrus fruits in the Americas, Europe and some parts of Asia.

México has a total production of 2.89 million tons of citrus fruits value at 1436.5 million pesos or over a 100 million dollars distributed over an area 203863 hectares (4). The principal types are limes (*Citrus aurantifolia*), oranges (*Citrus sinensis*), mandarins (*Citrus reticulata*), grapefruit (*Citrus paradisi*) and lemons (*Citrus limon*). Although no exact figures are available it is estimated that approximately 10 percent of the total citrus fruits produced in the country is processed and the rest is sold in the fresh fruit market. Therefore, to reduce heavy post harvest losses, and to extend the storage life at ambient as well as refrigerated conditions the fruits require to be treated with protective skin coatings. The cost of imported waxes is considerable and also result in a drain on foreign exchange. Recently, a new wax emulsion produced in México based on candelilla wax has been found to be extremely useful in maintaining fresh fruit quality (5, 6, 7). Candelilla, a natural wax obtained from two species of the genus *Euphorbia* viz, *E. cerifera* and *E. antisiphyletica* is nontoxic (8), cheap and is available in enormous quantities in the arid zones of México and southern U.S.A. After preliminary studies in this laboratory on the efficacy of candelilla wax in extending the storage life of fresh citrus fruits, large scale trials were undertaken with limes, oranges and grapefruit. The main object was to evaluate the effect of candelilla wax emulsion on weight loss, storage life, spoilage, chemical composition and organoleptic quality of citrus fruits.

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Additional lots were also treated with Tag and Flavorseal, side by side, in order to have a relative comparison.

Materials and Methods

Of the three experiments, the one with limes was carried out in a commercial packing factory. Freshly harvested limes from nearby orchards of Colima were loaded on a conveyor system and, after routine grading for damaged, diseased and yellow limes, were washed and sprayed with candellilla wax (Test wax) and Tag and Flavorseal (commercial waxes), dried, graded and packed in fibreboard ventilated cartons. The consignment was transported by road in a pick-up and brought to the laboratory in México city. Each treatment had three replicates, each with 17 to 18 kilos of limes in each carton. In the second and third experiments, freshly harvested oranges ('Valencia' late) and grapefruit ('Marsh') grown in Veracruz were transported to the laboratory in México city by road and then treated as described above. Oranges and grapefruits had five replicates each, with 50 and 25 fruits per replicate respectively.

The treated and the untreated lots were stored at ambient conditions of $20 \pm 2^\circ\text{C}$ and 65-75% relative humidity. The temperature and humidity conditions were not fixed but recorded during the entire storage period.

Three replicates under each treatment for each citrus type fruit were set aside for making observations on physiological loss in weight. Other storage losses due to fungal spoilage, desiccation etc., were also noted periodically at convenient dates depending on the length of storage period. Organoleptic evaluation was conducted at the end of the experiments using a panel of men and women judges belonging to different age groups. Opinions

ORANGE VALENCIA LATE

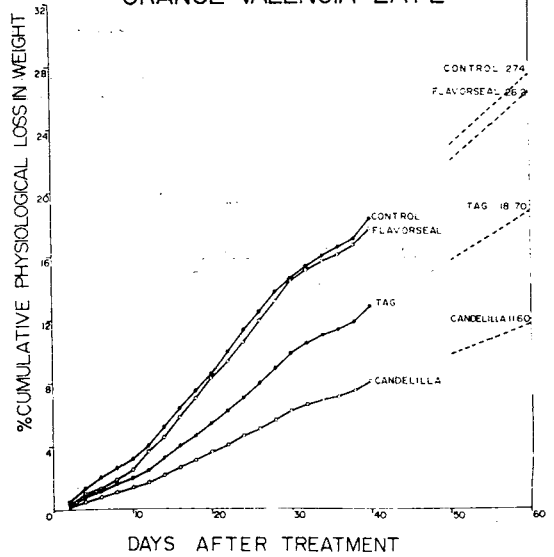


Fig. 2. Cumulative physiological weight loss in oranges.

regarding limes were collected on a sample of whole fruit, while for oranges and grapefruit, whole fruit and juice were separately evaluated. The influence of different wax emulsions on the rate of respiration and on the chemical constituents

LIME (C. aurantifolia)

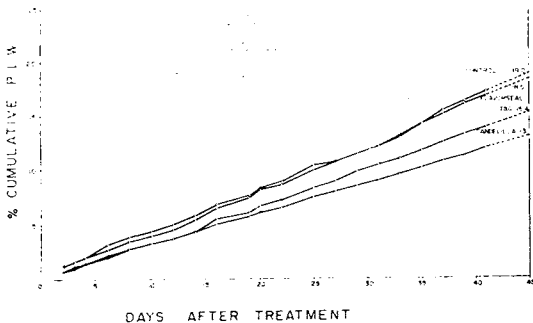


Fig. 1. Cumulative physiological weight loss in limes.

GRAPEFRUIT (C. paradisi)

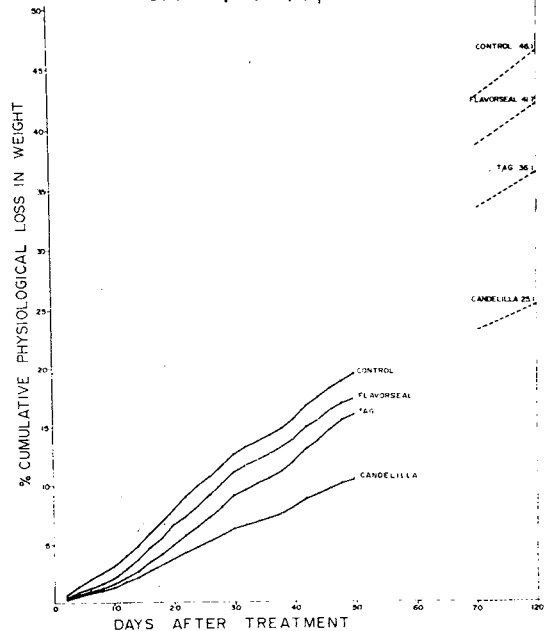


Fig. 3. Cumulative physiological weight loss in grapefruit.

TABLE 1. STORAGE LOSSES* IN SKIN COATED LIMES
(*C. aurantifolia*)

Days after harvest	(%) Diseased			(%) Desiccated and/or misshapen			(%) Acceptable		
	15	35	45	15	35	45	15	35	45
Treatment									
Control	2.46	8.22	9.35	0.0	24.49	26.61	97.53	67.30	64.05
Candelilla	1.74	4.40	4.54	0.0	6.15	6.28	98.26	89.45	89.18
Tag	1.50	6.04	7.00	0.0	10.27	11.30	98.5	83.69	81.70
Flavorseal	2.39	7.41	8.61	0.0	19.75	21.17	97.61	72.84	70.22

*Average of 3 replicates.

were also examined at regular intervals, but will be presented elsewhere.

Results and Discussion

In the first experiment, after the application of wax emulsions the limes were passed through a 8 meter long tunnel where hot air was blown from three blowers at temperatures of 35, 50 and 40°C. Under these conditions, the different wax emulsions used in this experiment took the following time to dry after application of the wax spray.

Candelilla emulsion — 1 min. 20 secs.

Tag — 50-60 secs.

Flavorseal — almost instantaneous

It is therefore necessary to reduce the drying time in candelilla wax emulsion to less than a minute which will greatly help in handling and packing.

Physiological loss in weight

Fig. 1-3 show the physiological loss in weight of limes, oranges and grapefruit respectively (the

values presented for the closing days of the experiment were obtained by extrapolation). It can be seen in all three experiments that fruit treated with candelilla wax showed significantly less loss in weight than either the corresponding controls or the commercial wax treated fruits.

Storage losses

Tables 1-3 show storage losses in the three types of citrus fruits. At the end of 45 days, limes treated with candelilla wax (Table 1) showed 89.18% acceptable fruit, which was higher than any other treatment or control. Storage losses due to microbial spoilage and desiccation were also reduced considerably by the candelilla wax treatment.

In case of oranges (Table 2), on the 60th day 81.2% of the fruit were acceptable in the candelilla treatment, which was lower than Tag showing 86.8%, acceptable fruits. The same trend was noted with regard to microbial spoilage and desiccation also. However, under the storage conditions described for this experiment, it is convenient to

TABLE 2 . STORAGE LOSSES* IN SKIN COATED ORANGES (*C. sinensis*)

Days after harvest	(%) Diseased				(%) Desiccated and/or misshapen				(%) Acceptable			
	21	35	49	60	21	35	49	60	21	35	49	60
Treatment												
Control	6.4	9.2	12.4	15.2	0.0	52.0	69.2	79.2	93.6	38.8	18.4	5.6
Candelilla	2.8	3.6	4.8	6.8	0.0	2.4	2.4	12.0	97.2	94.0	92.8	81.2
Tag	0.4	2.0	2.4	4.0	0.0	1.6	3.6	9.2	99.6	96.4	94.0	86.8
Flavorseal	6.0	11.2	12.8	19.2	0.0	16.0	26.4	45.6	94.0	72.8	60.8	35.2

* Average of 5 replicates.

TABLE 3. STORAGE LOSSES* SKIN COATED GRAPEFRUITS (*C. paradisi*)

Days after harvest	(%) Diseased				(%) Desiccated & or misshapen				(%) Acceptable			
	77	91	105	120	77	91	105	120	77	91	105	120
Treatment												
Control	15.2	17.6	19.2	33.6	12.0	52.0	64.8	66.4	72.8	30.4	16.0	0.0
Candelilla	1.6	5.2	10.4	12.8	0.0	0.0	0.8	0.8	98.4	94.8	88.8	86.4
Tag	2.4	4.0	12.8	16.0	0.0	4.8	7.2	17.6	97.6	91.2	80.0	66.4
Flavorseal	9.6	12.8	19.2	23.2	0.8	14.4	28.0	38.4	89.6	72.8	52.8	38.4

*Average of 5 replicates

TABLE 4. ORGANOLEPTIC EVALUATION* OF LIMES (*C. aurantifolia*) STORED FOR 45 DAYS .

Treatment	Colour	Aroma	Taste & flavour	Market ability
Control	1.15	1.60	2.10	1.35
Candelilla	2.20	1.75	2.15	2.10
Tag	2.10	2.00	2.30	2.25
Flavorseal	2.00	1.85	2.10	2.20
Market sample	3.40	2.45	3.35	3.35

*Figures shown above are the average scores obtained by a panel of 20 judges.

Scores: 0 - bad, 1 - fair, 2 - good, 3 - very good, 4 - excellent

store oranges for not more than 7 weeks as spoilage then remained within 10%.

Table 3 shows that grapefruit treated with candelilla wax emulsion had 86.4% acceptable and less than 1% fruit desiccated after 4 months storage. This was better than all other treatments. However, at 3 months storage, the candelilla wax and Tag showed less than 10% spoilage, with the former better than the latter.

Organoleptic evaluation

The results of organoleptic evaluation are presented in Tables 4, 5 & 6 for limes, oranges and grapefruit respectively. On an overall basis, the treatment with Tag was the best, followed by candelilla for limes and oranges. The big differences noticed with regard to market sample in limes (Table 4) was due to its green color, suggesting nearly all judges preferred green limes to yellow ones. In the case of oranges, all the three wax treatments proved significantly better than

TABLE 5. ORGANOLEPTIC EVALUATION* OF ORANGES (*C. sinensis*) STORED FOR 60 DAYS

Treatment	WHOLE FRUIT				JUICE			
	Colour	Appearance	Aroma	Market ability	Colour	Aroma	Taste & flavour	Acceptability
Control	1.19	0.50	0.88	0.88	2.25	1.50	2.00	1.75
Candelilla	1.94	2.06	1.38	2.06	2.69	2.25	2.63	2.44
Tag	2.81	2.69	1.63	2.50	2.44	1.88	2.44	2.44
Flavorseal	2.19	1.25	1.13	1.63	2.69	2.19	2.50	2.31
Market sample	1.00	1.44	1.13	1.75	2.13	1.69	1.69	2.19

*Figures shown above are the averages scores obtained by a panel of 16 judges.

Scores: 0 - bad, 1 - fair, 2 - good, 3 - very good, 4 - excellent

control or the market sample (Table 5). The market sample scored less in this experiment as the fruits were not uniformly yellow. The results obtained with grapefruit (Table 6) indicated that fruit treated with candelilla wax emulsion were better than any other treatments.

TABLE 6. ORGANOLEPTIC EVALUATION* OF GRAPEFRUIT (*C. paradisi*) STORED FOR 120 DAYS.

Treatment	WHOLE FRUIT		JUICE	
	Appearance	Acceptability	Taste & Flavour	Acceptability
Control	0	0.33	1.60	1.53
Candelilla	3.33	3.10	2.53	2.60
Tag	1.87	1.93	2.20	2.27
Flavorseal	2.00	2.00	2.20	2.40

*Figures shown above are the average scores obtained by a panel of 15 judges.

Scores: 0 - bad, 1 - fair, 2 - good, 3 - very good, 4 - excellent

On the basis of the data presented here, it appears that wax emulsion based on candelilla can play a very important role in the preservation of fresh fruits in México, and possibly in the international market. This product is also less expensive and may prove more economical than any imported wax emulsions in México. As a preharvest antitranspirant (e.g. 9) candelilla also merits attention as a base product for use in horticulture.

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