Orange Peel Topography as Affected by a Preharvest Plastic Spray

L. Gene Albrigo and G. Eldon Brown

Florida Citrus Experiment Station, University of Florida, Lake Alfred

Abstract. Mature 'Valencia' oranges when sprayed 2 months prior to harvest in the spring of 1969 with a 1 or 3% solution of Pinolene, a liquid polyterpene plastic film former, were greener at harvest, lost less wt., and had better appearance than control fruit after 9 weeks of storage. Fresh and fixed sections of peel from control and plastic-treated 'Hamlin' orange fruit from trees sprayed 2 months before harvest with a 1% solution of Pinolene were observed with a scanning-electron microscope after harvest. The surfaces of control fruit showed considerable variation with some areas having essentially no epicuticular wax platelets while other areas were completely covered. On sprayed fruit, plastic often partially masked the wax platelet edges. On control fruit, the openings to the outer stomatal chambers were usually unobstructed although the stomatal pores between the guard cells were often plugged. In most cases, the openings to the outer stomatal chambers of sprayed fruit were partially or completely obstructed with plastic.

Fruit of most Florida orange cultivars are subject to physiological peel pitting disorders (2). Dehydration during handling prior to waxing usually increases the incidence of pitting (2,3). Predisposition to pitting varies from year to year. The lack of uniform distribution of the epicuticular wax on the fruit surface may affect transpiration and thereby influence pitting. Scott and Baker (6) observed the absorption of water and vital dyes through "weak" areas in the cuticle over recently divided cells or accessory cells of mature oranges susceptible to water spot. The number of naturally plugged stomata (1) might also have an influence on peel moisture loss and the ease with which moisture stress of the rind can occur. In this study, we report the effects of preharvest sprays of the antitranspirant plastic Pinolene (poly-1-p Menthen-8,9-diy1) on postharvest peel condition of orange and the subsequent observations with a scanning-electron microscope3,4 (SEM) of the deposition and distribution of epicuticular wax and Pinolene on the peel surface.

Sprays of 1 and 3% Pinolene were applied April 11, 1969 to mature 'Valencia' orange trees. Plots of 3 trees were replicated twice. Fruit was harvested on June 11, 1969. The intensity of the green color of 30 fruit from each plot was determined with a reflectance attachment on a Bausch and Lomb Spectronic 20 as absorbance at 675 mu. Wt loss was determined on 20 fruit per plot for 4 weeks at 4°C plus 5 weeks at 21°C.

Mature 'Hamlin' orange trees were sprayed with a 1% solution of Pinolene on September 16, 1969. Fruit was harvested twice (12/2/69 and 1/10/70) from 3 treated and nontreated trees. Following gentle washing, peel sections were removed from the stylar end of 6 fruit per treatment harvested 12/2/69 and were observed fresh with a SEM. (Cambridge Stereoscan) after metal coating (8) with Gold-Palladium (60% Au) on a rotating stage. Stylar and stem-end peel sections from 20 fruit harvested 1/10/70 were fixed at 4°C in 5% acrolein for 24 hr followed by 1% osmium tetroxide for 24 hr and then rinsed in H2O for 24 hr (8). The flavedo layer was removed, air-dried in covered plastic petri dishes, and coated. At least 6 randomly selected sections for each treatment were observed under the SEM.

Preharvest sprays of Pinolene to 'Valencia' trees significantly increased the green color (chlorophyll) of the peel and significantly reduced water loss during the 9-week storage period (Table 1). Even though the wt loss of the fruit was stored at 4°C for 4 weeks and 21°C thereafter.

Table 1. Influence of preharvest application of Pinolene to 'Valencia' oranges on green color at harvest and on moisture loss during storage.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Absorbance</th>
<th>% wt loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.02a3</td>
<td>13.1a</td>
</tr>
<tr>
<td>Pinolene 1%</td>
<td>3.28a</td>
<td>9.21b</td>
</tr>
<tr>
<td>Pinolene 3%</td>
<td>3.08a</td>
<td>9.32b</td>
</tr>
</tbody>
</table>

2 Fruit was stored at 4°C for 4 weeks and 21°C thereafter.
3 Data in columns followed by the same letter do not differ at the 5% level.

Pinolene-treated fruit was nearly 10% at the end of 9 weeks, Pinolene-treated fruit were conspicuously firmer and less wrinkled than control fruit.

An uneven distribution of epicuticular wax deposition as platelets was observed on the surface of unsprayed 'Hamlin' oranges with the SEM. Some surface areas had few wax platelets (Fig. 2A, C, and D) while other areas were heavily plated (Fig. 2B). It was not determined if additional wax was present as a thin layer next to the cuticle. If no relief was present, this type of layer would not be observed with the SEM. Wax deposition in platelets has also been observed on 'Sultana' grapes (5), pears, and apples (7). Insufficient stem-end sections were observed to determine possible morphological differences between the cuticle wax layering on the stem and stylar ends of the fruit. The openings to the outer stomatal chambers of control fruit were usually unobstructed (Fig. 2A, B, C, D, and E), but the stomatal pores between the guard cells were often plugged (Fig. 2A and F). At high magnification (Fig. 2F), this material appears to be wax-like. Only rarely were plate-like wax obstructions observed over the stomatal pores of nontreated fruit.

Fig. 1. 'Hamlin' orange peel surfaces; A-G, nontreated surfaces; H-L, Pinolene sprayed surfaces; A, C, D, E, G, H, K, and L are from fresh peel sections; magnification 660X except D (1320X), F (3200X) and I (150X).

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2Assistant Horticulturist, University of Florida, IFAS, and Plant Pathologist III, State of Florida, Department of Citrus, respectively.
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fruit (Fig. 2B). Reduced atm pressures required during the coating process caused dehydration and distortion of the peel edges of fresh sections (note rolled edges of Fig. 2C, G, and H). Under the conditions imposed by this stress, the platelets of wax on the control fruit adhered to the epidermis (Fig. 2G), while the platelets on Pinolene-treated fruit tended to separate from the rest of the surface (Fig. 2H). This was consistently observed on several sections along the entire edge. Discontinuity of the plastic coat is evident in Fig. 2I where the edge of the plastic has separated from the fruit surface. The partial masking of the natural wax platelets extends in the plastic-coated area and partial constriction of the opening to the outer stomatal chamber can be seen in Fig. 2J. This particular area appears to have an exceptionally heavy coat of plastic. In some cases, plastic partially or completely covered the opening to the outer stomatal chamber (Fig. 2K and L) much as Malcolm and Stolzy (4) predicted from studies with plastic films on punctured aluminum foil.

Pinolene beneficially improved orange peel quality by reducing dehydration and aging. Observations with the SEM revealed that wax platelets coating the orange surfaces were unevenly distributed. This uneven distribution occurred to some extent even on the same sample. Pinolene formed a relatively continuous plastic coating which covered all surfaces including the stomata and areas with and without epicuticular wax platelets. Pinolene's main effect in improving peel quality may be through reduced peel moisture loss during the daytime on the tree and after harvest. Fruit water loss appears to be primarily through the cuticle (5). Reduced gas exchange through the constricted stomatal openings may also play a role in quality improvement by reducing the respiration rate of the peel.

Though microscopic observations were made on peel of 'Hamlin' oranges, studies on moisture loss in storage were made using 'Valencia' because of potential long-term storage of this cultivar for sale during the summer months. In other studies, Pinolene has also improved peel of 'Hamlin' and 'Pineapple' oranges.

Abstract. Visual observations of chilling-injury symptoms and respiration data indicated that discs from 'Lacatan' banana, 'Taylor' avocado, 'Key' and 'Persian' limes, and 'Marsh' grapefruit on tissue-culture medium and intact fruits had similar responses when stored at chilling and non-chilling temperatures.

Tissue culture may offer a means whereby small samples can replace intact specimens in certain studies of postharvest physiology such as the chilling-injury syndrome encountered in many tropical and subtropical fruits. The possible utility of tissue culture was recognized in 1902 (2). The technique has since been employed in numerous investigations of nutrition, metabolism, growth, differentiation, organogenesis, etc. (1, 2, 3, 5, 6, 10, 11, 13). Substitution of tissue discs for whole fruits would save much labor and space in storage experiments, thus making exploratory studies more convenient.

Mature green 'Lacatan' bananas harvested in Costa Rica were obtained from the Banana Trading Company, Tampa, Florida. 'Key' limes and 'Marsh' grapefruit were picked from plots at the Florida Citrus Experiment Station, Lake Alfred. 'Persian' limes were secured from the H. E. Kendall Company, Goulds, and 'Taylor' avocados from the Ridge Lime and Avocado Growers Association, Lake Placid, Florida.

Tucker's culture medium (11), with indolebutyric acid (IBA) substituted for 2,4-dichlorophenoxyacetic acid (2,4D), was used. Benlate (methyl)-(butyl)-carbamyl)-2-benzimidazole carbamate] at 100 mg active ingredient per liter was added to control fungus growth (6). Medium in portions of 10 ml was transferred to screw top vials, autoclaved for 15 min at 20 psi, and solidified on a 45° slant. Fruits were surface sterilized with 1:10 sodium hypochlorite solution for 5 to 10 min. Plugs 2 to 4 mm thick were removed under sterile conditions with a 10 mm cork borer from the peel (flavedo and albedo) of limes and grapefruit and peel of bananas and avocados. Discs were taken from representative areas of the fruits. Intact fruits as controls and tissue discs were stored at 40° and 60°F. Visual observations and respiration measurements were made on bananas after 1, 3, 5, 7, and 10 days on tissue discs and intact fruits. 'Persian' limes were also stored at 50°. Holding periods were 10-12 days for bananas, 4 weeks for avocados and limes, and 5 and 10 weeks for grapefruit.

A Warburg respirometer was used to measure oxygen uptake. Intact fruits and tissue discs were transferred from storage to 70OF for 6 hr, after which respiration was determined at 86OF. Discs were obtained from control fruits 0.5 hr prior to insertion in the respirometer. Results were expressed as μliter O2 uptake per g fresh weight per hr. Experiments were repeated 4 times for bananas once for avocados and immature and mature grapefruit, and twice for both varieties of lime.

Banana. Both the tissue discs and intact fruits began to darken by the second day at 40°F. Typical chilling injury symptoms intensified thereafter, the skin being very dark by the eleventh day. Color changes indicative of normal ripening began by the second day in discs and fruits held at 60°F. Subsequent changes, including gradual separation of the skin from the flesh, etc., were similar, with both discs and fruits being overcome and flecked with brown spots by the eleventh day. Respiration (Fig. 1) followed about the same course in both the tissue discs and intact fruits at

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A Tissue Culture Technique for Studying Chilling Injury of Tropical and Subtropical Fruits

N. Vakis, W. Grierson, J. Soule and L. G. Albrigo

University of Florida, Gainesville

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