Relation Between Fruit Waxing and Development of Rots in Citrus Fruit During Storage

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ABSTRACT

Waxing of citrus fruit reduced mold rots caused by Penicillium digitatum and P. italicum and increased stem-end rots and internal core rot caused by Alternaria citri, Diplodia natalensis, and Fusarium spp. Different commercial waxes tested increased, to different degrees, stem-end rot and internal core rot of the fruit.

Citrus fruits intended for export are disinfested and waxed in packinghouses. The purpose of waxing is to impart a shiny appearance to the fruit and to reduce weight loss by slowing down senescence during storage. Waxes may also serve as carriers of fungicides, such as thiabendazole and benomyl, or growth regulators, such as 2,4-D and GA3. Because these chemicals are less effective when applied in waxes than when applied in water, large amounts are generally used in waxes than in water (2,4).

Our preliminary observations indicated that waxing itself may affect the development of mold rots and stem-end rots in citrus fruit. The aims of this study were to learn if common waxes used in the citrus industry in Israel have a similar effect on development of the mold rots caused by Penicillium digitatum Sacc. and P. italicum Wehmer and to determine the effect of the different waxes on stem-end rot (SER), caused mainly by Alternaria citri Ell. & Pierce or Diplodia natalensis P. Evans, and on internal core rot (ICR), caused mainly by A. citri or Fusarium spp.

MATERIALS AND METHODS
Freshly harvested grapefruit (Citrus paradisi Macf.) 'Marsh Seedless' and oranges (C. sinensis (L.) Osbeck) 'Shamouti' and 'Valencia' were used in all experiments. Fruit were disinfested with a 0.5% solution of sodium orthophenylphenolate (SOPP) and then waxed. Four waxes widely used commercially in the citrus industry in Israel and elsewhere were tested. Three waxes, designated A, B, and C, contain polyethylene, whereas D is a natural wax without polyethylene.

RESULTS AND DISCUSSION
Mold rots. Waxing suppressed development of rots in different citrus cultivars during storage. For example, in a storage experiment with Shamouti oranges, the incidence of mold rot was lower in waxed fruit than in unwaxed control fruit (Fig. 1). The same effect of waxing was evident when fruit were wrapped in polyethylene (Fig. 1). Similar results were obtained with Marsh Seedless grapefruit and Valencia oranges stored at different temperatures.

To test the conditions under which wax suppressed mold rot, Shamouti oranges were dusted with dry spores of P. digitatum and P. italicum without wounding. Application of wax either before or after inoculation suppressed the incidence of the mold rots (Fig. 2). Similar results were found for Valencia oranges and for Marsh Seedless grapefruit.

The lower incidence of mold rots in fruit waxed before inoculation could be related to the action of wax as a barrier, which prevents contact between the spores and wounds on the fruit peel caused during picking or handling. A wax barrier may prevent spore germination and fruit infection. Germination of spores of P. digitatum and P. italicum in different waxes was examined. Germination was tested in drops of waxes at the concentrations used for waxing citrus fruit in packinghouses (17% dry matter) as well as in water dilutions of 1:2 and 1:4. Germination in water served as the control. Spores of P. digitatum and P. italicum germinated only in waxes A and B. Moreover, spores germinated only in diluted waxes. This may be significant since during wax application in the packinghouse, the initial wax concentration is diluted on the fruit because they are not entirely dry before waxing.

Since spore germination occurred in waxes A and B and not in C and D, one would expect that more mold rot might develop in fruit waxed with A or B than in those waxed with C or D. Indeed, this did occur in different citrus cultivars. For example, in Shamouti oranges after 10 wk of storage at 11 C, 10% incidence of mold rot occurred in fruit with wax A compared with 1% in fruit with wax C. The respective figures after a 2-wk shelf-life period at 17 C were 27 and 4%. Corresponding results were obtained in fruit treated with waxes B and D. The different effects of the waxes on spore germination and on mold rot development may be related to the differences in their composition or physical properties.

Stem-end rot. The incidence of SER and ICR was higher in waxed than in unwaxed fruit, but there were differences in incidence between fruit treated with the different waxes. This increase was evident in fruit disinfested with SOPP as well as in nondisinfested control fruit. The incidence of SER in nondisinfested grapefruit after 10 wk of storage at 25 C was 15% in unwaxed and 55% in waxed (wax A) fruit. The corresponding numbers for disinfested fruit were 9 and 37%, respectively.

In Valencia oranges stored for 20 wk at
Fig. 1. Effect of waxing on incidence of mold rots in naturally infested Shamouti orange. □ = Unwaxed control; ◯ = waxed (wax A). Cold-storage temperature was 8 C followed by 2-wk shelf-life period at 17 C. Bars indicate standard error.

11 C, more SER and ICR developed during storage in fruit waxed with A or B than with C or D. The lowest amount of these rots occurred in unwaxed control fruit (Fig. 3). During two additional weeks of shelf life at 17 C, SER increased mostly in fruit waxed with A or B. The amount of ICR found in fruit cut at the end of the shelf-life period was markedly higher in fruit waxed with A or B than with C or D (Fig. 3b). Least SER and ICR developed in unwaxed control fruit. Similar results were obtained with other citrus cultivars.

Increased ethanol content of the fruit during storage (3) could be related to the increased incidence of rots (5). Thus changes in the composition of the internal atmosphere might be related to the increased incidence of SER and ICR in waxed fruit.

The effect of waxing on the incidence of postharvest rots apparently is not unique to citrus fruits. It was also reported for Starking apples attacked by Gloeosporium sp., the cause of apple bitter rot (1).

LITERATURE CITED