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

J. WAKS, MINA SCHIFFMANN-NADEL, ELLA LOMANIEC, and E. CHALUTZ, Department of Fruit and Vegetable Storage, ARO, Volcani Center, Bet Dagan 50250, Israel

ABSTRACT

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

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 GA_3. Because these chemicals are less effective when applied in waxes than when applied in water, larger 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 ortho phenylphenate (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. The dry matter of each wax was about 17%. We withheld specific identification of the waxes (commercial names and composition) because of confidential obligation.

In some experiments with mold rots, fruit were individually wrapped in plain paper or in high-density polyethylene. After treatment, fruit were stored at the optimal temperature for each cultivar and at 90% relative humidity with adequate ventilation.

To test the effects of waxes on development of mold rots, fruit were inoculated by dusting with dry spores of *Penicillium* species. Spores were applied with a cotton puff previously dipped in a mass of spores. Dusting was done either before or after the application of wax. The effect of waxing on SER was evaluated without inoculation; naturally infected fruit were taken from orchards with a known high incidence of SER. The causal agent of SER was routinely identified after isolation.

Germination of spores in the waxes was tested in suspended wax droplets, in the original wax concentration, and in several water dilutions. All tests were carried out in the laboratory with 400 fruits per treatment, and in larger experiments, with 2,000 fruits per treatment. Four replicates were used in each treatment. The experiments were repeated twice.

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 also 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

Contribution from the Agricultural Research Organization, Volcani Center, Bet Dagan, Israel. No. 1152-E, 1984 series.

Accepted for publication 18 February 1985.

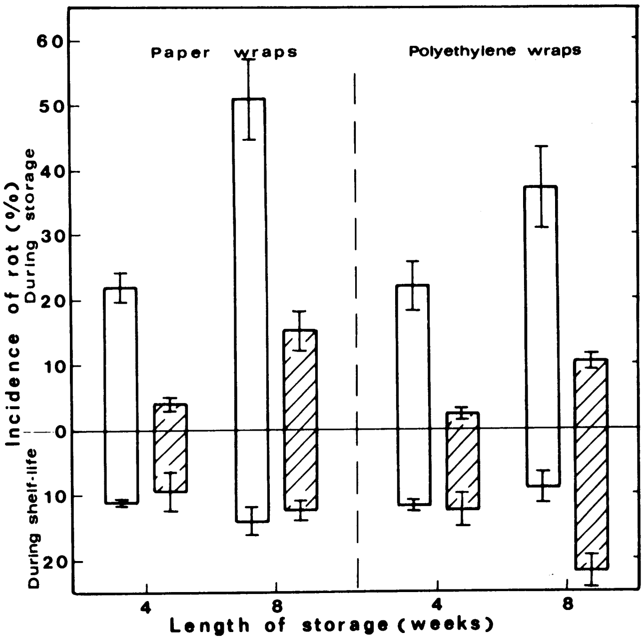

Fig. 1. Effect of waxing on incidence of mold rots in naturally infested Shamouti orange. □ = Unwaxed control; ▨ = waxed (wax A). Cold-storage temperature was 8 C followed by 2-wk shelf-life period at 17 C. Bars indicate standard error.

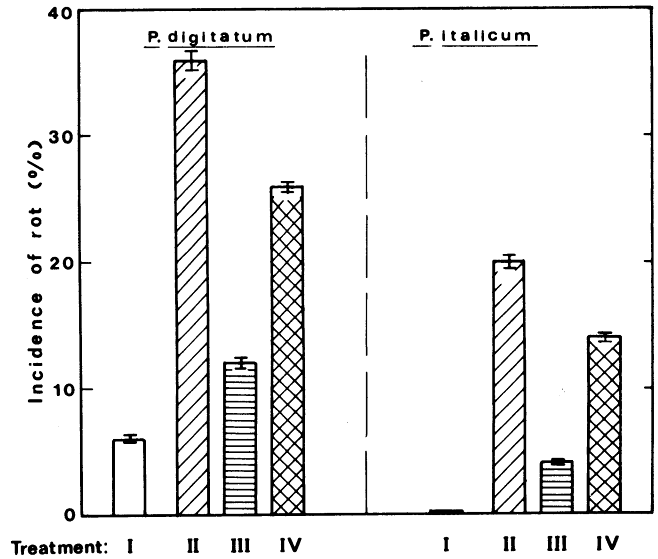

Fig. 2. Effect of waxing before or after inoculation on incidence of mold rots in Shamouti orange. I = Unwaxed, uninoculated control; II = unwaxed, inoculated; III = waxed, then inoculated; and IV = inoculated, then waxed. Fruit were waxed with wax C and stored at 17 C for 4 wk. Bars indicate standard error.

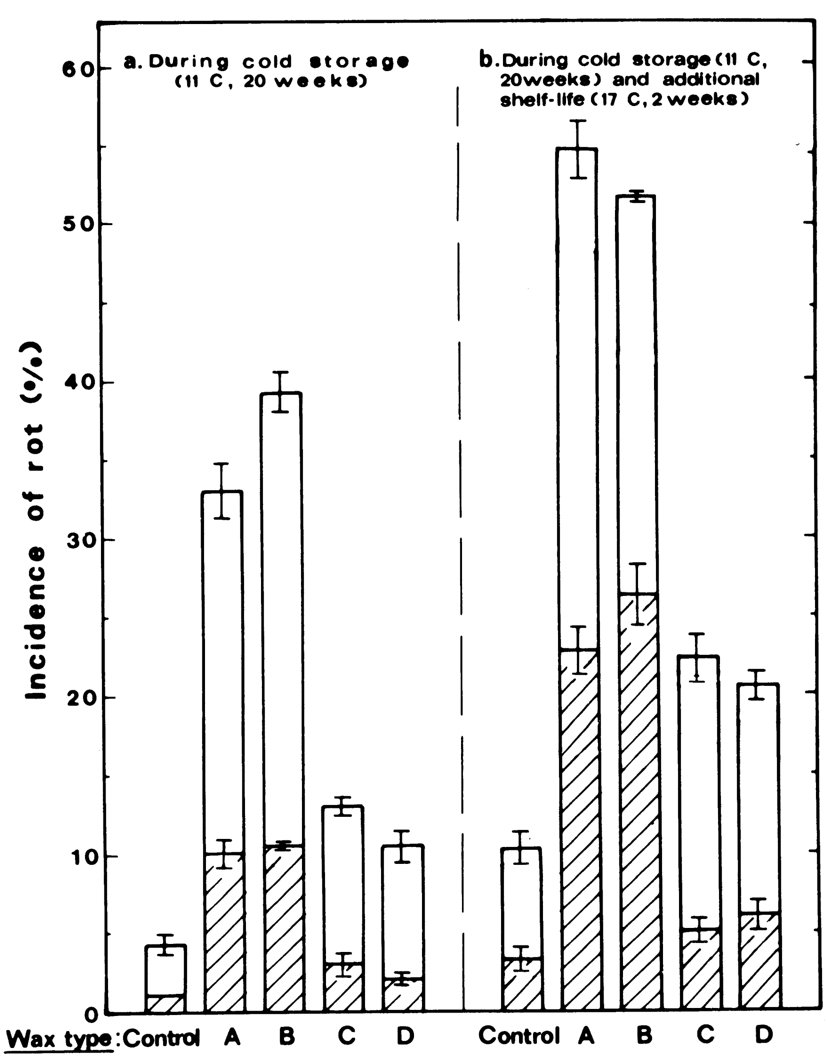

Fig. 3. Effects of different waxes on incidence of stem-end rots and internal core rot in Valencia orange stored 20 wk at 11 C. (a) Fruit were cut at the end of cold storage; (b) fruit were cut after cold storage and 2 wk of shelf life at 17 C. ▨ = Stem-end rot; □ = internal core rot. Incidences of stem-end rot and internal core rot are presented additively. 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

1. Bompeix, G., and Morgat, F. 1977. Coating waxes, antiscald components, fungicides and storage of apples. Fruits 32:189-195.
2. Brown, G. E. 1984. Efficacy of citrus postharvest fungicides applied in water or resin solution water wax. Plant Dis. 68:415-418.
3. Davis, P. L., and Hoffmann, R. C. 1973. Effect of coating on weight loss and ethanol build-up in juice of oranges. J. Agric. Food Chem. 21:455-457.
4. Gutter, Y. 1970. Effect of incorporating fungicides in Tag wax on their effectiveness in controlling green mold in oranges. Isr. J. Agric. Res. 20:135-137.
5. Schiffmann-Nadel, M. 1977. Chemical and physiological changes in citrus fruit during storage and their relation to fungal infection. Proc. Int. Soc. Citricult. 1:311-317.