

Handling and Processing Section

EFFECTS OF WASHING SEQUENCE ON THE DEGREENING RESPONSE AND DECAY OF SOME CITRUS FRUITS

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ABSTRACT

The rate of color development in fruit washed before degreening was compared with the rate in fruit washed after degreening. On Hamlin oranges, Robinson tangerines, and Marsh grapefruit washing sequence did not affect the rate of chlorophyll loss. In some tests with Hamlin oranges, washing before degreening reduced the incidence of stem-end decay. With Robinson tangerines, washing before degreening consistently reduced the incidence of stem-end decay. In this variety, fruit washed before degreening averaged 25 per cent decay, compared to 66 percent with the conventional system of washing after degreening. Washing prior to degreening was more effective for decay control than the chemical treatments used.

The standard practice in citrus packinghouses is to wash fruit after removal from the degreening rooms. This has been satisfactory when used with established fruit-handling procedures and has been supported by studies showing that washing retards color development (2). Work with color sorting (1, 3, 5) showed that washed fruit should be sorted more effectively than unwashed fruit. Other procedures might also be favored by washing fruit as it arrives at the packinghouse. This would include grading to minimize the volume of fruit degreened. Limited previous tests (3) did not show any appreciable effect of washing on chlorophyll changes during degreening. Since this contradicted other work (2), further tests were made to more fully evaluate the relationship between washing and degreening.

MATERIALS AND METHODS

Effects of washing on the degreening of Hamlin oranges, Robinson tangerines and Marsh grapefruit were studied in 1968 and 1969. In 1968 Hamlin oranges were harvested on November 17, 25, and December 2. In 1969 Hamlin oranges were harvested on October 14, November 17, and 24. Tests on Robinson tangerines were begun on October 6, 13, 22, November 5 and 10, 1969. A test on Marsh grapefruit was begun on November 24, 1969. Fruit was transferred to the degreening room within 6 hours of harvest.

Harvested fruit was randomized into two lots, one of which was washed immediately with a transverse brush commercial-type fruit washer using city tap water and a nonfungicidal commercial fruit cleaner. The other lot was washed in the same manner after degreening and 1 to 4 days later. The fruit was dried in a warm-air roller drier at 145° F for approximately 2 minutes. Color changes were not followed in all tests. Where such changes were studied, samples of 20 fruit were selected to provide similar initial fruit color in both treatments. These samples were measured for chlorophyll using a light-transmittance difference meter with an integrating-sphere sample system (4). Measurements made initially and daily during degreening were recorded as ΔOD 695-740 nm. (ΔOD readings are directly related to the chlorophyll concentration in the fruit with acceptable color being reached at about .250 ΔOD .) The degreening room was held at 85° F with 85-90% humidity and supplied with 10 ppm ethylene.

After degreening, the samples were transferred to 70° F and held for up to 3 weeks after harvest for decay observations. In addition to the color samples, most tests also included larger samples, usually of about 100 fruit, for decay observations. These were degreened with the associated color samples, but in 1969 they were also treated with a fungicide, thiabendazole

(TBZ), and waxed on completion of degreening. Additional treatments were added in several instances to evaluate the decay control observed in some tests.

RESULTS AND DISCUSSION

Washing apparently had no effect on the loss of chlorophyll from Hamlin oranges either in 1968 or 1969 (Fig. 1). These results confirm those found in previous tests (3) but contradict an earlier report (2). Results for Robinson tangerines and Marsh grapefruit in 1969 also showed little effect of washing (Fig. 2). These results indicate that washing did not affect the degreening rate of fruit.

The improved color resulting from degreening is due to the presence of carotenoid pigments which become more evident with the removal of chlorophyll. Although previous studies have not

shown any effect of degreening on carotenoid synthesis (6), initial studies suggest that ethylene does stimulate such synthesis. In most of these tests no differences in color between treatments were visible. Occasionally, however, washed fruit did not attain as deep an orange color as unwashed fruit. This inconsistent development of the orange color may explain the poorer degreening reported for washed fruit (2). Although this problem is not serious, studies are being continued to explain this response.

Most of the decay observed in these tests was due to *Phomopsis citri*, *Diplodia natalensis* or *Collectotrichum gloeosporiodes*. Decay due to *Penicilium* spp. was not common and is not considered here. There was little decay in Hamlin oranges 1 week after harvest (Fig. 3). During the second week, extensive decay often developed. In two tests in 1968, the unwashed fruit had more decay than washed fruit. These results sug-

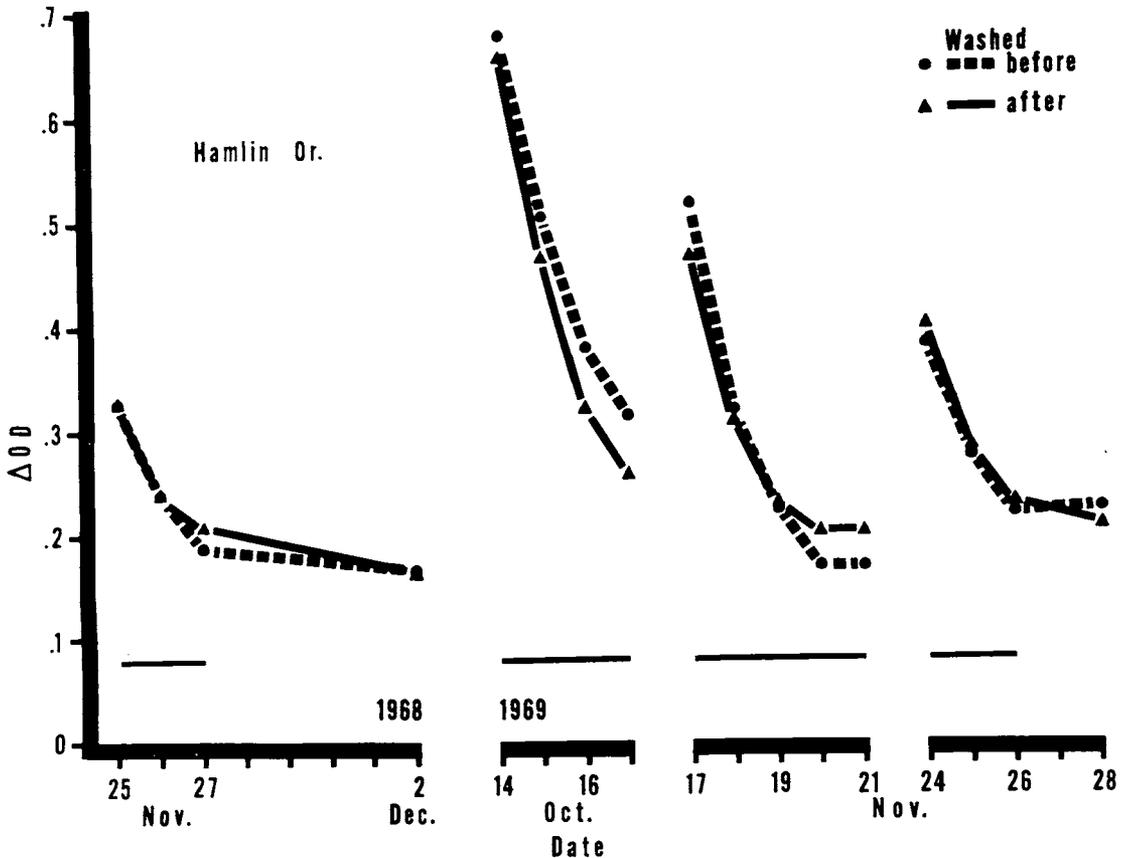


Figure 1.—Loss of chlorophyll during degreening as affected by time of washing of Hamlin oranges, 1968 and 1969. Bars indicate the length of the degreening period for each test.

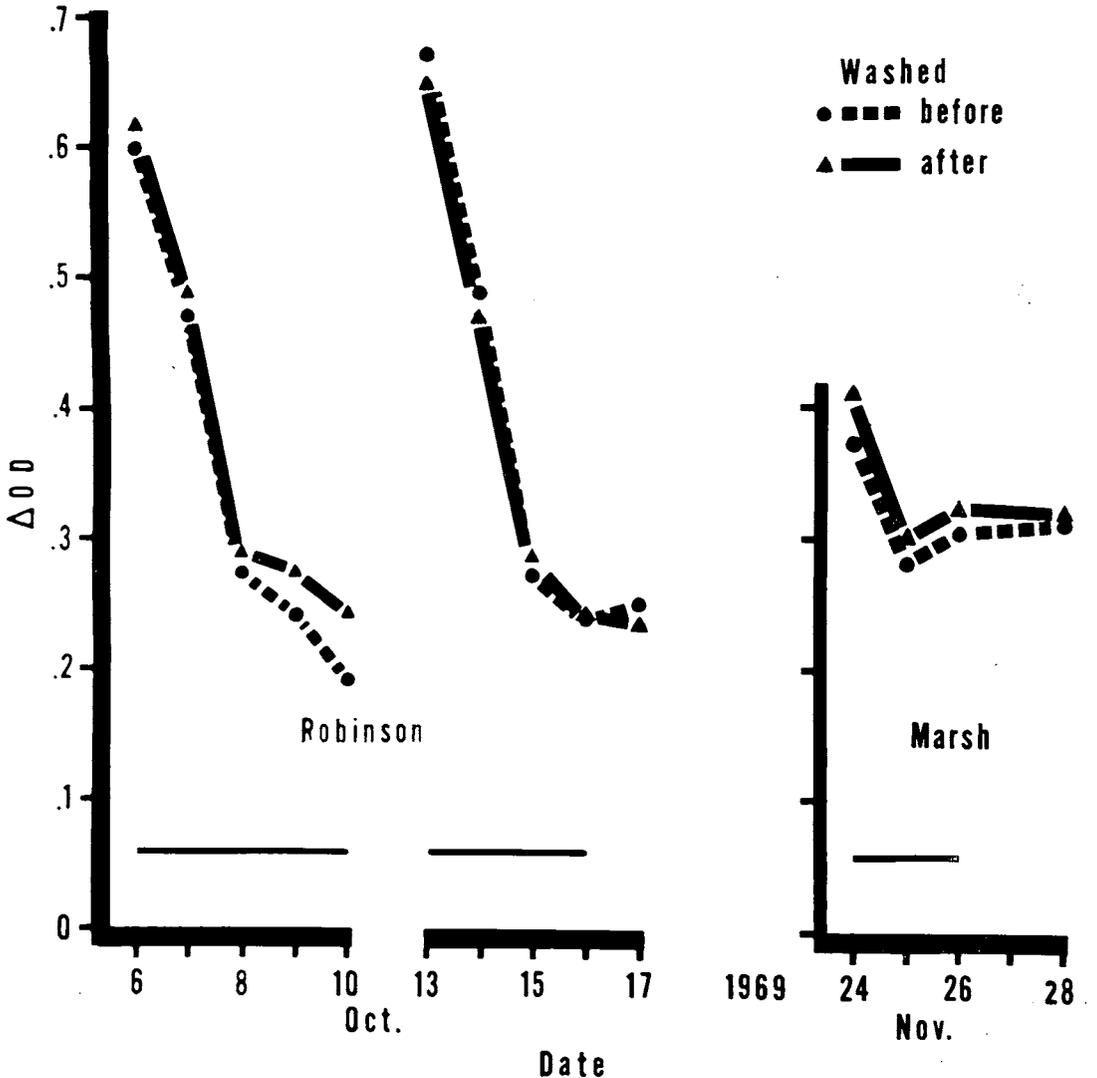


Figure 2.—Loss of chlorophyll during degreening as affected by time of washing of Robinson tangerines and Marsh grapefruit, 1969. Bars indicate the length of the degreening period for each test.

gested that washing helped to control decay, but this was not supported by the 1969 tests.

Robinson tangerines (Fig. 4) showed a higher incidence of decay than did Hamlin oranges, and the decay appeared earlier, frequently in less than 3 days from harvest. Decay losses in the unwashed samples were more than 50% by the end of every test, even with only 1 day's degreening. In contrast, decay developed much more slowly where the fruit was washed before degreening. Decay in the Robinson variety was

due primarily to *Colletotrichum* sp. This organism, which usually is not a major problem in other citrus, can be serious in mandarin-type fruits (8).

Little decay occurred in Marsh grapefruit. Effects of washing could not, therefore, be evaluated in this test.

The decay control observed in Robinson tangerines washed before degreening has not been explained. Apparently *Colletotrichum* is more susceptible to control than other decay organ-

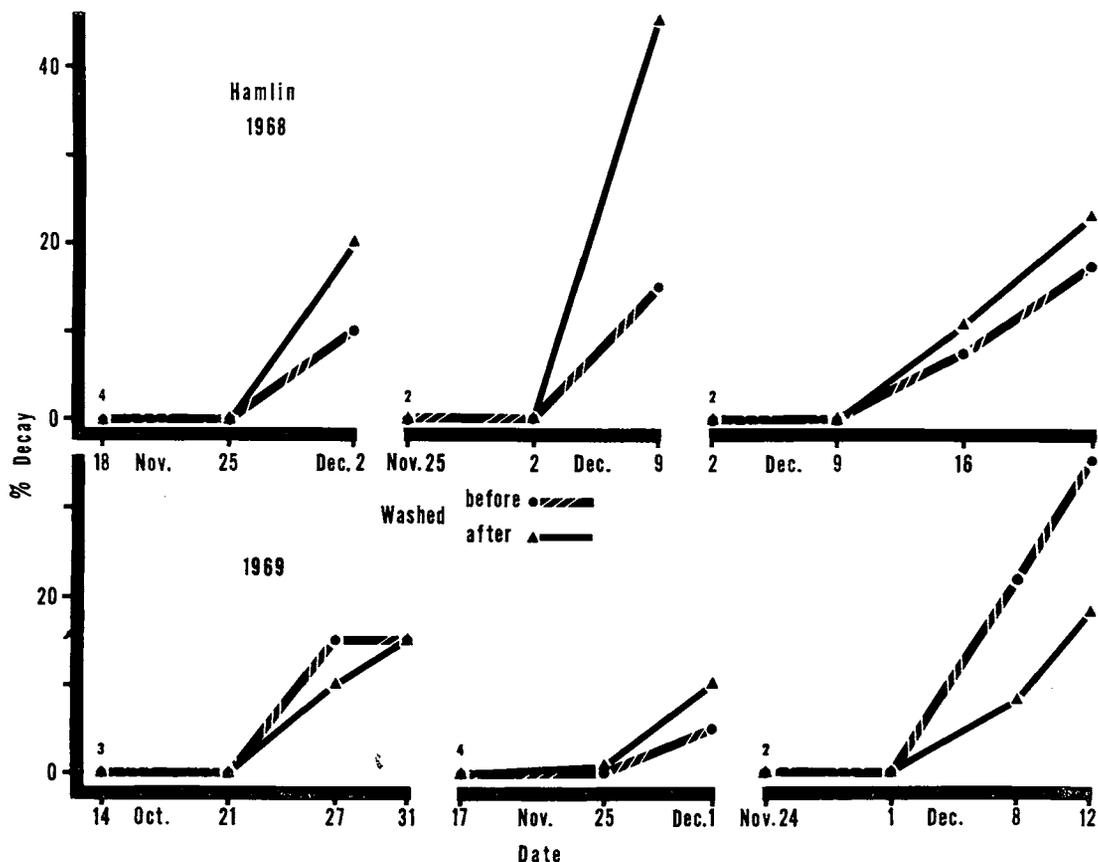


Figure 3.—Occurrence of decay following degreening as affected by time of washing Hamlin oranges, 1968 and 1969. Numbers above initial data points indicate the number of days fruit was degreened.

isms during washing or drying. The mechanical brushing of the fruit during washing may aid in reducing or removing the organism which is already present on the fruit. Washing with non-recirculated water also contributed to this removal of the organism. The city water was chlorinated, but the residual chlorine level was too low to have any fungicidal value. At 145° F the drier was at a temperature above the range found to be effective for the hot-water treatment of oranges for decay control (7) although the 2-minute drying time is shorter than that used for the hot-water treatment. Possibly *Colletotrichum* is more susceptible to heat than are *Phomopsis* and *Diplodia*.

Applications of TBZ (a standard fungicide) to washed Robinson tangerines before or after degreening did not appreciably affect the control pattern resulting from the time of washing.

Limited studies with preharvest applications of benomyl (an experimental fungicide) indicated better but still inadequate control (data not shown). Similar results were found by Smoot *et al* (9) in tests with TBZ and other fungicides on both Robinson and Dancy tangerines. These and other tests (8) have shown fungicides to be relatively ineffective in controlling *Colletotrichum* on mandarin-type fruits, particularly when degreening is required. Therefore, any procedure which will aid in reducing the incidence of decay is useful. No evidence of rind injury or breakdown was observed on any fruit in these tests.

These results indicate that washing of fruit before degreening may be done without risk of delaying or seriously impairing the resulting color development. This procedure should provide greater flexibility in the handling of fruit than

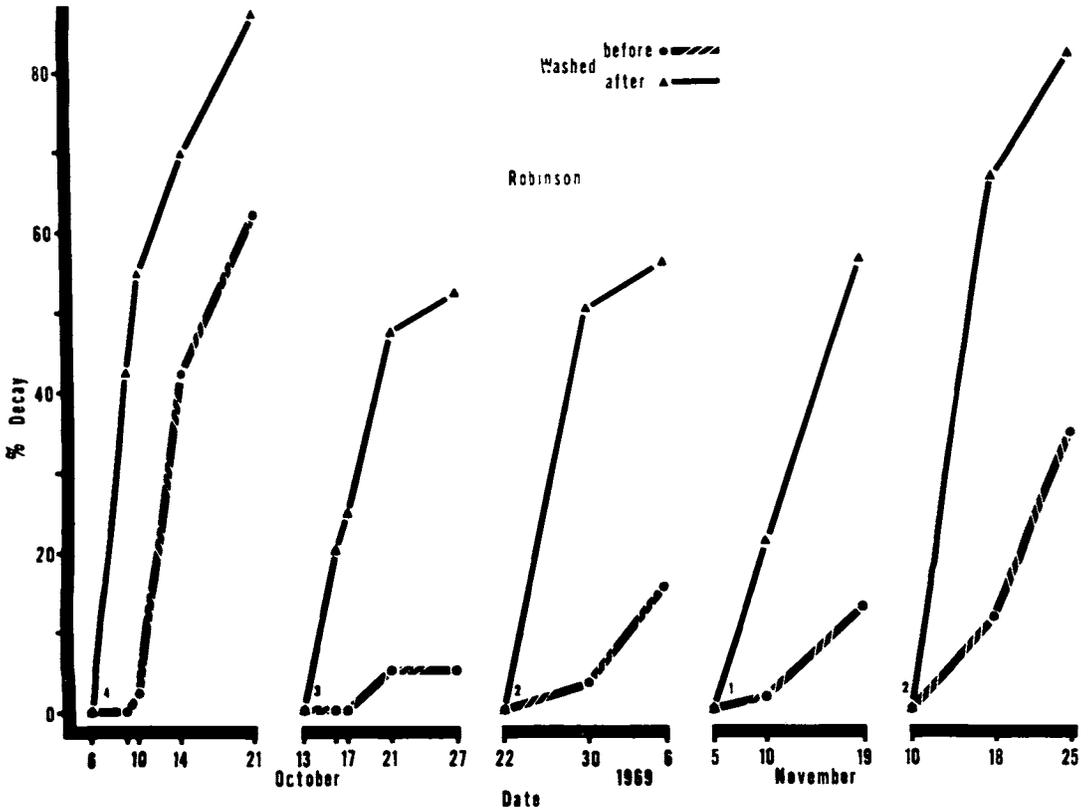


Figure 4.—Occurrence of decay following degreening as affected by time of washing Robinson tangerines, 1969. Numbers above initial data points indicate the number of days fruit was degreened.

is possible with present packinghouse designs. Washing incoming fruit would permit such practices as grading or color sorting before degreening. Washing fruit before degreening would also permit an earlier treatment with a fungicide which should improve decay control. This would be in addition to the decay control that may result directly from the washing of fruit.

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