

## THE EFFECTS OF CULTURAL AND POSTHARVEST PRACTICES ON POSTHARVEST DECAY AND RIPENING OF TWO TOMATO CULTIVARS

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**Abstract.** The effects of cultural and packing-house practices on the incidence of bacterial soft rot, alternaria decay, and total decay, as well as on ripening of tomatoes, were studied using fruits of the 'Walter' and 'Homestead' cultivars. Bacterial soft-rot incidence was affected by cultivars, mulching, and postharvest waxing. Alternaria rot was increased by the application of ethylene gas. Total decay was increased by waxing and ethylene gas application. The ripening rate of fruit of both cultivars was increased by mulching and ethylene application.

A number of changes have occurred in recent years in the Florida mature-green tomato industry. These changes involve cultivars, the use of mulched beds for growing plants, postharvest practice of treating fruit with ethylene gas, and a deemphasis of fruit waxing. For many years the 'Homestead' tomato was the dominant cultivar for mature-green harvest. However, within the last 5 yr., the 'Walter' cultivar has become dominant primarily due to its high fruit quality and resistance of plants to grey wall and Fusarium wilt race 2 (5). Plastic or paper mulches covering and planting beds have been developed for more efficient production systems (1). Ethylene gas is now used to induce faster and more uniform ripening of the tomatoes after harvest (2, 4). Waxing has been used primarily for reducing dehydration during ripening (3). With the use of ethylene, the ripening time required for

fruit is reduced, and the need for waxing is lessened.

The effects of these procedures, both pre- and postharvest, on postharvest decay have not been determined. The purpose of this work was to show the effects of these practices on postharvest decay and fruit ripening.

### Materials and Methods

Tomatoes at the mature-green stage were harvested at two locations, the Agricultural Research and Education Center, Bradenton, and the Agricultural Research Center, Immokalee. At each location, transplants of two cultivars, 'Homestead' and 'Walter', were grown on beds covered with a plastic mulch and on uncovered beds. At Immokalee, both the covered and uncovered beds were fertilized with 800 lb 5-8-2/A and 1000 lb 18-0-25/A. On the plastic mulch beds all fertilizer was applied prior to covering the beds. On the 18-0-25 uncovered beds, the 1000-lb 18-25/A was split into three equal side dress applications. At Bradenton, the plants were grown on mulched beds with 1500 lb 18-0-25-2/A and 500 lb superphosphate per acre; while uncovered beds received 4500 lb 6-8-8 split into three equal side dress applications. Two harvests were made from each planting in the spring 1971 season. Following harvest, tomatoes were brought to the U.S. Horticultural Research Laboratory at Orlando for postharvest treatment and holding. Tomatoes from each field plot were graded to eliminate culls and divided at random into lots of 50 fruit. The tomatoes of each cultivar grown on either mulched or uncovered beds, were washed in water and received one or a combination of the following postharvest treatments in this order: a) inoculated with bacterial cells of *Erwinia carotovora* (L. R. Jones) Holland, the causal agent of soft rot, b) waxed, and c) exposed to ethylene gas. The tomatoes were inoculated by spraying the fruit with a bacterial suspension at a concentration of  $10^8$  cells per ml to simulate packing-house contamination. The tomatoes were not mechanically injured. A petrolatum-based vegetable wax used commercially for waxing tomatoes, peppers, and cucumbers was brushed on

tomatoes in a commercial waxer. The ethylene treatment consisted of exposing tomatoes to 500 ppm ethylene at 21°C and a relative humidity of 90% for 3 days. All lots of fruit were held for 3 wk at 21°C and a relative humidity of 90%. After this period, at least 90% of the tomatoes from each lot had reached the red-ripe stage. Twice-weekly inspections were made during this holding period, and decaying fruit were identified, counted, and removed to reduce secondary contamination. Data were recorded as percent fruit decayed during the 3-wk holding period. The ripening rate of the tomatoes was estimated by calculating the percent of green fruit in each lot 4 days after harvest. All data were analyzed statistically for significance at the 5% level.

### Results and Discussion

**Soft rot.** With inoculated tomatoes soft rot incidence was significantly affected by cultivars, mulching plants, and postharvest fruit waxing. Fruit of the 'Walter' cultivar averaged 21.5% decay, significantly more than the 12.2% decay average for fruit of the 'Homestead' cultivar (Table 1). Incidence of decay in tomatoes of both cultivars from mulched beds was 22.2%, significantly more than in tomatoes for uncovered beds averaging 11.4%. 'Walter' tomatoes from mulched beds had 28.5% decay incidence, significantly more than the 14.2% average for tomatoes of the same cultivar from uncovered beds, and also significantly more than the 16.0% decay rate for 'Homestead' tomatoes from mulched beds. This 16.0% decay rate of 'Homestead' fruit from mulched beds was significantly more than the 8.5% decay incidence of tomatoes from uncovered beds. By waxing fruit, the average decay incidence was increased significantly from 11.5% to 21.2%. The decay increase of 'Walter' fruit from 14.0% to 22.7% was not significant but the increase from 9.0% to 19.7% due to waxing the 'Homestead' fruit was significant.

The ethylene treatment significantly increased decay of waxed 'Walter' fruit from mulched beds from 28.0% to 42.5%. The ethylene treatment had no significant effect on unwaxed fruit, on 'Homestead' tomatoes, or on 'Walter' tomatoes from uncovered beds.

With 'Walter' tomatoes the effects of waxing and ethylene on soft rot were greater on fruit from mulched than from uncovered beds and were greater than effects on 'Homestead' fruit from mulched or uncovered beds. The more susceptible the fruit is to soft rot, the greater the effect of postharvest waxing and ethylene treatment on decay incidence.

Noninoculated tomatoes that were washed only had soft rot with no significant difference between the two cultivars, whether they were grown on mulched or uncovered beds. The waxing and ethylene treatments had no significant effect on decay.

**Alternaria decay.** . . . Cultivars, mulching, and waxing had no significant effect on the incidence of alternaria decay (*Alternaria tenuis* auct.) Treating the tomatoes with ethylene gas significantly increased the incidence of alternaria decay from 11.2% to 15.6% on waxed fruit and to 18.2% on unwaxed fruit (Table 2). There was no significant difference in alternaria decay between ethylene-treated 'Homestead' and 'Walter' tomatoes from mulched or uncovered beds. This alternaria decay occurred even though the tomatoes were not subjected to chilling temperatures either in the field or after harvest.

**Total decay.** Total decay consisted of bacterial soft rot, alternaria rot, and other miscellaneous decays. These miscellaneous decays were classified as anthracnose, *Colletotrichum coccodes* (Wallr.) Hughes, rhizopus rot, *Rhizopus stolonifer* (Fr.) Ehr., sclerotium rot, *Sclerotium rolfsii* Sacc., and sour rot, *Geotrichum candidum* Pers. emend Carmichael. These miscellaneous decays affected less than 1% of the total fruits

Table 1. Incidence of bacterial soft rot in inoculated tomatoes, after 3 weeks at 21°C as influenced by cultivar, mulching, and postharvest practices.

Postharvest treatment	Percent soft rot								
	Walter cultivar			Homestead cultivar			Total <sup>2</sup>		
	Mulch	Uncovered	Avg.	Mulch	Uncovered	Avg.	Mulch	Uncovered	Avg.
Washed	17.5	10.5	14.0	12.0	6.0	9.0	14.7	8.0	11.5
Washed, waxed	28.0	17.5	22.7	25.5	14.0	19.7	26.5	15.7	21.2
Washed, waxed, ethylene	42.5	18.5	30.5	19.5	8.0	13.5	31.0	13.5	22.1
Washed, ethylene	26.0	10.5	18.2	7.5	6.0	6.5	16.7	8.2	12.5
Average	28.5	14.2	21.5	16.0	8.5	12.2	22.2	11.4	

<sup>2</sup>Average of Walter and Homestead cultivars.

Table 2. Incidence of alternaria rot in tomatoes after 3 weeks at 21°C as influenced by cultivar, mulching, and postharvest practices.

Postharvest treatment	Percent alternaria rot								
	Walter cultivar			Homestead cultivar			Total <sup>2</sup>		
	Mulch	Uncovered	Avg.	Mulch	Uncovered	Avg.	Mulch	Uncovered	Avg.
Washed	10.5	11.0	10.7	14.2	7.0	10.6	12.4	10.0	11.2
Washed, waxed	8.0	13.7	10.8	15.5	8.0	11.7	11.7	10.8	11.2
Washed, waxed, ethylene	15.2	15.5	15.3	17.7	14.5	16.1	16.5	15.0	15.6
Washed, ethylene	8.9	20.2	14.5	24.0	19.0	21.5	16.9	19.6	18.2
Average	10.8	15.2	13.0	17.8	12.6	15.2	14.4	13.8	

<sup>2</sup>Average of Walter and Homestead cultivars.

used in these tests and were not significantly affected by any of the treatments. Bacterial soft rot and alternaria decay were predominant in the total decay.

Factors significantly affecting total decay were postharvest waxing and ethylene treatment. Total decay was not significantly influenced by the cultivars or the mulching treatment. For 'Walter' tomatoes, waxing increased decay from 20.3% to 27.4% (Table 3). Ethylene gas treatment of these waxed tomatoes increased the decay to 34.2%. Waxing 'Homestead' tomatoes increased total decay incidence from 16.2% to 24.5%. On fruit from mulched beds, waxing increased decay from 20.3% to 28.2%, and from uncovered beds, from 15.3% to 23.6%. Thus, waxing significantly increased total decay on tomatoes of both cultivars from mulched and uncovered beds, while ethylene gas significantly increased the decay of waxed 'Walter' tomatoes from mulched beds only.

**Ripening.** The riping rate of tomatoes, as reflected by percent green fruit 4 days after harvest, was significantly influenced by mulching and by postharvest ethylene treatment. Neither cultivars nor waxing had any significant effect on ripening. Of the tomatoes harvested from mulched beds, 31.8% were green, significantly fewer than the 49.3% green fruit harvested from uncovered beds (Table 4). The ethylene treatment reduced the amount of green fruit significantly from 57.3% to 25.1% for unwaxed fruit and from 57.4% to 22.7% for waxed fruit.

The ethylene treatment also had a significantly greater effect on ripening of tomatoes from mulched beds, reducing the percentage of green fruit from 57.3% to 15.2% from mulched beds, and from 65.4% to 32.2% from uncovered beds for waxed fruits. The ethylene gas treatment was more effective in increasing the ripening of 'Homestead' than of 'Walter' tomatoes. The ethylene treatment reduced the percentage of waxed green fruit from 58.7% to 30.7% for 'Walter' tomatoes and from 54.0% to 16.5% for 'Homestead' tomatoes. Similar results were obtained for unwaxed fruit.

The data presented demonstrate that cultivars, cultural and postharvest practices all affect the incidence of postharvest decay and the ripening rate of Florida-grown tomatoes. Before recommendations for changes in cultivars or cultural practices are made, their effects on other postharvest characteristics should be determined.

### Interpretive Summary

The effects of cultivars, cultural, and packing-house practices on the incidence of postharvest decays and ripening of tomatoes were studied. Bacterial soft rot was influenced by the cultivars, growing plants on beds covered with a plastic mulch, and postharvest waxing. Alternaria decay was increased by postharvest ethylene application. The ripening rate was influenced by growing plants on mulched beds and ethylene treatment.

Table 3. Incidence of total decay in tomatoes after 3 weeks at 21°C as influenced by cultivar, mulching, and postharvest practices.

Postharvest treatment	Percent total decay								
	Walter cultivar			Homestead cultivar			Total <sup>2</sup>		
	Mulch	Uncovered	Avg.	Mulch	Uncovered	Avg.	Mulch	Uncovered	Avg.
Washed	22.0	19.7	20.3	20.5	12.0	16.2	20.3	15.3	18.3
Washed, waxed	26.0	29.0	27.4	30.7	18.2	24.5	28.2	23.6	26.0
Washed, waxed, ethylene	39.2	29.2	34.2	29.0	23.0	26.0	34.1	26.1	30.1
Washed, ethylene	24.7	30.5	27.6	28.7	18.2	26.5	26.7	27.2	26.8
Average	28.0	26.8	27.4	27.2	17.8	23.2	27.6	23.1	

<sup>2</sup>Average of Walter and Homestead cultivars.

Table 4. Ripening of tomatoes after 4 days at 21°C as influenced by cultivar, mulching, and postharvest practices.

Postharvest treatment	Percent of green tomatoes								
	Walter cultivar			Homestead cultivar			Total <sup>2</sup>		
	Mulch	Uncovered	Avg.	Mulch	Uncovered	Avg.	Mulch	Uncovered	Avg.
Washed	49.5	65.2	56.3	45.9	68.7	56.3	57.6	67.0	57.3
Washed, waxed	52.0	65.5	58.7	42.7	65.2	54.0	57.3	65.4	57.4
Washed, waxed, ethylene	17.0	44.5	30.7	12.7	19.6	16.5	15.2	32.2	22.7
Washed, ethylene	21.5	40.5	30.5	12.7	24.5	18.6	17.2	33.0	25.1
Average	35.0	54.2	44.0	28.6	44.5	36.6	36.8	49.3	

<sup>2</sup>Average of Walter and Homestead cultivars.

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## VISCOMETRY AFFECTED BY PECTIC CONSTITUENTS IN 45° BRIX FROZEN CONCENTRATED ORANGE JUICE<sup>1</sup>

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solids were determined on samples to establish consistency correlations.

Average values for the percentage of total pectin soluble in water, ammonium oxalate, and sodium hydroxide, representative of 200 commercial samples, were 46.9, 12.2, and 40.9%, respectively. Water-insoluble solids ranged from 466 to 838 mg/100 g of concentrate.

Consistency or viscosity measurements of frozen concentrated orange juice (FCOJ) are important to the designer of mechanical equipment in citrus processing plants and are of value to the technologist as a quality factor that must be kept under control. Most liquid type foods have a non-Newtonian behavior and FCOJ falls into this category because of its heterogeneous mixtures of water-insoluble solids (suspended solids) and the colloidal pectic substances. Fruit puree and FCOJ usually exhibit pseudoplastic properties (4, 11) because their apparent viscosity decreases as the shear-rate increases.

Flow behavior properties of citrus juices and concentrates have been studied using various inexpensive equipment ranging from pipettes to expensive cone-plate viscometers (2, 4, 7, 11). Three types of viscometers have been used at this Center for measuring the resistance of citrus juices and concentrates to flow. Ezell (3) meas-

**Abstract.** Three viscometers were investigated for their practicability in measuring consistency of non-Newtonian frozen concentrated orange juice at the 45° Brix level. Viscosity measurements by the tube viscometer and Brabender Visco-Corder were highly correlated ( $r^2 = 0.91$ ). Viscosity measurements by the Brookfield LVT viscometer were not as highly correlated to either the tube ( $r^2 = 0.80$ ) or to the Brabender ( $r^2 = 0.79$ ). The percentage of apparent viscosity retained as measured by the Brabender at different shear rates indicated that several of the orange concentrates approached Newtonian fluids. Pectic fractions, total pectins, and water-insoluble

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