Proc. Fla. State Hort. Soc. 96: 320-322. 1983.

IMPACT OF POSTHARVEST HANDLING PROCEDURES ON SOFT ROT DECAY OF BELL PEPPERS[1]

MARK SHERMAN AND JUDITH J. ALLEN
Vegetable Crops Department,
Institute of Food and Agricultural Sciences,
University of Florida,
Gainesville, FL 32611

Additional index words. Capsicum annuum, Erwinia carotovora, chlorination, vacuum cooling.

Abstract. **Bacterial soft rot or stem-end decay caused by** Erwinia carotovora **(L. R. Jones) Holland can be a devastating postharvest problem for bell peppers** (Capsicum annuum **L.). Studies were conducted at commercial packinghouses to determine the impact of several postharvest handling procedures on the severity of soft rot decay after a simulated transit and market period. In all cases inoculation with** Erwinia **greatly increased decay. An overnight delay before packing inoculated fruits resulted in a 23% decrease in marketable peppers after the simulated transit period, compared to only a 4% decrease for uninoculated fruits. In one test, chlorination of packinghouse spray-wash water resulted in a 12% increase in marketable peppers. In another study comparing peppers handled dry to others spray-washed with water or water plus chlorine, washing (water or water plus chlorine) of inoculated peppers resulted in a 17% increase in marketable fruits. Vacuum cooling peppers immediately after packing reduced decay by about 10% compared to uncooled fruits.**

Florida is the leading state in the production of fresh market bell peppers. During the 1981-82 season, Florida growers produced 7.9 million bushels of peppers with a total shipping point value of $55.6 million (3). Severe postharvest losses may be incurred from bacterial soft rot or stem-end decay (1, 2, 7). Florida shippers have not adopted the hot water treatment recommended for commercial control of bacterial soft rot in peppers (6). The objective of this study was to examine the impact of several postharvest handling practices on soft rot decay of bell peppers.

Materials and Methods

Commercially grown and harvested 'Early Calwonder' peppers were used in 2 experiments during May and June 1982. Both experiments were randomized complete blocks with 4 replications. Freshly harvested peppers were sorted to eliminate damaged fruits. Twenty peppers of medium size ($\approx$ 130g) were selected, jumble-packed in waxed corrugated cartons, and randomly assigned to a treatment.

In the first experiment treatments were a complete factorial arrangement of 2 inoculations [stem and calyx dipped in sterile buffered saline solution (control) or stem and calyx dipped in a buffered saline solution containing 1.0 x 10^6 cells ml^{-1} *E. carotovora*]; 2 chlorination levels (15-sec spray-wash with tap water or tap water plus 150 ppm free chlorine from NaHOCl); and 2 cooling methods (none or vacuum cooled). Vacuum cooling consisted of a 20 min cooling cycle with a minimum absolute pressure of 5.8 mm Hg.

Treatments in the second experiment were a complete factorial arrangement of 2 inoculations (as described above); 2 packing times (packed immediately or packed after an overnight delay at 23°C); and 3 washing methods (none, a 30 sec spray-wash with well water, or a 30 sec spray-wash with well water plus 150 ppm free chlorine from NaHOCl). All peppers in this experiment received a 20 min vacuum cooling following treatment.

Peppers from both experiments were transported to Gainesville and placed in storage at 13°C for 4 days with an additional 2 days at 20°C to simulate transit and market conditions. Following storage at each temperature, peppers were rated for decay with the following scale: 1=none; 2=slight, not objectionable; 3=moderate, objectionable; 4=severe, decay extended into walls of fruit; 5=extreme, completely decayed. The number of fruits receiving a decay rating of 1 was used to calculate the % decay-free. The number of fruits receiving a decay rating of 1 or 2 was used to calculate the % marketable. An analysis of variance was performed for each factor using the Statistical Analysis System (4) and means for main effects and interactions were separated with orthogonal comparisons where appropriate (10).

Results

Inoculation with *E. carotovora* significantly increased decay and reduced the marketable peppers after 6 days of simulated transit and market conditions (Table 1). An overnight delay between *Erwinia* inoculation and further handling and packing significantly increased decay and reduced the marketable peppers (Table 2). The effect of the handling delay was evident on all peppers after the 2 additional days storage at 20°C when the mean decay ratings were 1.8 and 2.0 for immediate and delayed handling, respectively. This resulted in 9% less marketable peppers for fruits receiving the delay before handling (73% and 64% marketable for immediate and delayed handling, respectively).

Table 1. Effect of inoculation with *Erwinia carotovora* on pepper decay rating, decay-free peppers, and marketable peppers after 6 days of simulated transit and market conditions.

Treatment	Decay[z]		Decay-free (%)		Marketable (%)	
	Expt. 1	Expt. 2	Expt. 1	Expt. 2	Expt. 1	Expt. 2
Control	1.2[y]	1.5[y]	85[y]	70[y]	95[y]	83[y]
Inoculated	2.6	2.3	35	45	58	53

[z]Decay rating: 1=none; 2=slight, not objectionable; 3=moderate, objectionable; 4=severe, decay extended into wall of fruit; 5=extreme, completely decayed.
[y]Significantly different from the inoculated treatment at 0.1% level by F test.

The addition of 150 ppm free chlorine to the spray-wash water increased the decay-free and marketable peppers in the first experiment (Table 3). The effect of chlorination on decay was most pronounced for peppers inoculated with *E. carotovora* (decay ratings of 1.3 and 1.2 for control peppers compared to ratings of 2.9 and 2.2 for inoculated peppers spray-washed in water or water plus chlorine, respectively). There were no significant differences between spray-washing peppers in water or water plus chlorine in the second experiment. However, spray-washing peppers inoculated with *E. carotovora* in water or water plus chlorine significantly reduced decay and increased the marketable peppers when compared to peppers not washed (Table 4).

[1]Florida Agricultural Experiment Stations Journal Series No. 4914.

Table 2. Effect of immediate and delayed handling and inoculation with *Erwinia carotovora* on the decay rating and marketable peppers after 4 days storage at 12.5°C.

Treatment	Decay[z]		Marketable (%)	
	immediate	delayed	immediate	delayed
Control	1.2[y]	1.4	97[x]	93
Inoculated	1.4	1.9	94	71

[z]Decay rating: 1=none; 2=slight, not objectionable; 3=moderate, objectionable; 4=severe, decay extended into wall of fruit; 5=extreme, completely decayed.
[y]Significantly different from the delayed and inoculated treatment at 5%level by F test.
[x]Significantly different from the delayed and inoculated treatment at 1% level by F test.

Table 3. Effect of chlorinating packinghouse spray-wash water on the decay-free and marketable peppers after 6 days of simulated transit and market conditions.

Spray-wash	Decay-free (%)	Marketable (%)
Water	50[z]	71[z]
Water + 150 ppm chlorine	70	83

[z]Significantly different from the chlorinated water treatment at 1% level by F test.

Table 4. Effect of washing treatment and inoculation with *Erwinia carotovora* on the decay rating and marketable peppers after 6 days of simulated transit and market conditions.

Treatment	Decay[z]			Marketable (%)		
	dry	water	water + 150 ppm Cl	dry	water	water + 150 ppm Cl
Control	1.6[y]	1.6	1.5	86[y]	79	84
Inoculated	2.6	2.0	2.2	42	61	58

[z]Decay rating: 1=none; 2=slight, not objectionable; 3=moderate, objectionable; 4=severe, decay extended into wall of fruit; 5=extreme, completely decayed.
[y]Orthogonal comparison for the interaction of inoculation x washing (dry vs. [water + water plus chlorine]) was significant at 5% level.

Vacuum cooling reduced decay and increased the decay-free peppers (Table 5). Wetting the peppers prior to vacuum cooling enhanced the removal of heat during the cooling cycle. Pepper temperatures averaged 24.5°C prior to cooling. For dry fruits pepper wall temperatures averaged 23°C after vacuum cooling; calyx and placenta temperatures were about 3°C lower. For wet fruits pepper wall temperatures averaged 20.5°C; calyx and placenta temperatures were about 3°C lower.

Table 5. Effect of vacuum cooling on the decay rating and decay-free peppers after 6 days of simulated transit and market conditions.

Treatment	Decay[z]	Decay-free (%)
Not cooled	2.0[y]	55[x]
Vacuum cooled	1.7	65

[z]Decay rating: 1=none; 2=slight, not objectionable; 3=moderate, objectionable; 4=severe, decay extended into wall of fruit; 5=extreme, completely decayed.
[y]Significantly different from the vacuum cooled treatment at 1% level by F test.
[x]Significantly different from the vacuum cooled treatment at 5% level by F test.

Discussion

The devastating effect of inoculation with *Erwinia carotovora* (Table 1) underscores the need for strict sanitation measures during pepper harvesting and handling procedures. Fundamentally these measures should begin with the exclusion of decayed fruit during harvest and clean picking and transport containers. Fruits should be handled carefully to avoid mechanical injuries which are easily inoculated. Harvest crews should be instructed not to overfill the transport containers.

The fact that harvest needs to be coordinated with packinghouse operations is evident from the detrimental effect that an overnight delay before subsequent handling had on marketable fruits (Table 2). Harvest operations should be curtailed before the packing capacity is exceeded.

Chlorination of vegetable packinghouse water has been recommended for many years (5). However, data on the effectiveness of chlorine for decay reduction are conflicting (8). Our own results are also conflicting. In the first experiment there was clearly a benefit from adding chlorine to the spray-wash water (Table 3). In the second experiment washing with water alone was as effective in reducing decay as washing with chlorinated water (Table 4). Both washing treatments were far better than not washing inoculated peppers. Chlorination of the wash water is relatively inexpensive and serves to prevent the buildup of inoculum on the rollers, brushes, and conveyors that the peppers contact further along the packing line. Therefore, it would seem most practical to include chlorination of spray-wash water as a routine sanitation practice for bell peppers.

Vacuum cooling was clearly beneficial when compared to not cooling peppers (Table 5). This result was consistent with an earlier study (9) where thoroughly cooling peppers to 10°C soon after harvest effectively delayed soft rot decay. Forced-air cooling is another effective cooling method for peppers (9), but the portability of vacuum cooling equipment may make it more widely available to Florida pepper shippers.

None of the handling procedures studied in this paper provided absolute control of postharvest decay caused by *Erwinia carotovora*. However, packers and shippers can reduce their losses by careful attention to detail during handling. Modern pepper harvesting and packing should include strict sanitation procedures to prevent fruit inoculation, prompt careful handling to prevent mechanical damage, and thorough cooling soon after harvest.

Acknowledgements

The authors gratefully acknowledge the assistance and cooperation of South Bay Growers, Inc., South Bay, and R. G. Thomas, LaCrosse.

Literature Cited

1. Ceponis, M. J. and J. E. Butterfield. 1974. Causes of cullage of Florida bell peppers in New York wholesale and retail markets. Plant Dis. Rptr. 58:367-369.
2. Ceponis, M. J. and J. E. Butterfield. 1974. Market losses in Florida cucumbers and bell peppers in metropolitan New York. Plant Dis. Rptr. 58.558-560.
3. Florida Crop and Livestock Rep. Serv. 1983. Vegetable summary 1982. Fla. Agr. Statistics, Orlando.
4. Helwig, J. T. and K. A. Council (eds.). 1979. SAS user's guide, 1979 ed. SAS Institute, Raleigh, N.C.
5. Hicks, J. R. and R. H. Segall. 1971. Water chlorination for vegetable packinghouses. Vegetable Crops Fact Sheet, VC-1, Univ. Florida, Gainesville.
6. Johnson, H. B. 1966. Bacterial soft rot in bell peppers. Cause and commercial control. U. S. Dept. Agr., Agr. Market Res. Rpt. 738.
7. McDonald, R. E. and P. P. Q. deWildt. 1980. Cause and extent of cullage of Florida bell peppers in the Rotterdam terminal market. Plant Dis. 64:771-772.

8. Ryall, A. L. and W. J. Lipton. 1979. Handling, transportation, and storage of fruits and vegetables. Vol. 1 (2nd ed.). Avi Publ. Co., Westport, Connecticut.
9. Sherman, M., R. F. Kasmire, K. D. Shuler, and D. A. Botts. 1982. Effect of precooling methods and peduncle lengths on soft rot decay of bell peppers. HortScience 17:251-252.
10. Steel, R. G. D. and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill, New York.

Proc. Fla. State Hort. Soc. 96: 322-324. 1983.

EFFECT OF SCRUBBING ETHYLENE DURING STORAGE OF TOMATOES[1]

L. A. Risse and W. R. Miller
U.S. Department of Agriculture,
Agricultural Research Service,
2120 Camden Road,
Orlando, FL 32803

Additional index words. color, firmness, decay, export.

Abstract. **In 3 storage tests, Florida mature-green tomatoes were stored at 55°F for 1, 2 and 3 wk in sealed chambers with and without the circulating air being filtered through potassium permanganate/aluminum oxide to remove ethylene from the circulating air. After 55°F storage, the tomatoes were evaluated each day for color and held at 70°F until each tomato reached full red color, at which time firmness and decay were also recorded. Generally, the removal of ethylene from the storage atmosphere only increased the number of days for the tomatoes to reach full red color after 1 wk of storage and they were firmer than tomatoes stored without ethylene removal after all storage periods. Removal of ethylene during storage did not affect the amount of decay.**

Florida is the largest producer of fresh market tomatoes and for many years shippers and receivers have been interested in exporting Florida tomatoes to Europe. Florida tomatoes generally do not meet commercial trade standards on arrival in Europe. The most successful shipments have been of vine-ripened fruit or large-sized mature-green tomatoes that have been treated with ethylene. Many European receivers have indicated that they would import larger quantities if tomatoes arrived consistently in good condition and of uniform color and size.

Recommendations for the transit and storage of ethylene-treated (ET), mature-green tomatoes generally specify that temperatures be maintained at 55° to 70°F, and for ripe tomatoes at 45° to 50°F (1, 3, 6, 8, 9). There are many studies which describe the climacteric (respiration) cycle of tomatoes during the ripening process (7), and studies describing the roles of ethylene (4, 5) and CO_2 (2) activity during ripening. Generally, Florida producers harvest their tomatoes during the mature-green stage and then treat them with ethylene for the initiation of the ripening process. However, there is very little known about the effects of scrubbing (removal) endogenously produced ethylene from the storage area of ethylene-treated mature-green tomatoes during the ripening process. The objectives of this study were to determine the effects of scrubbing ethylene from the storage area on tomato ripening and quality.

[1]Mention of a trademark, warranty, proprietary product, or vendor does not constitute a guarantee by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

Materials and Methods

An initial experiment with 3 replications was conducted to determine if Ethysorb® (potassium permanganate/aluminum oxide) absorbs ethylene during storage, air samples were obtained every 24 hr from each of 2 chambers and analyzed for presence of ethylene. Each chamber contained 60 gasses ET mature-green tomatoes (cultivar FTE-12), 20 each of 3 ripening stages (turners, pinks and light reds). In both chambers, the air was circulated, in one chamber through 0.53 oz of Ethysorb® and in the other chamber without Ethysorb® The gas samples were analyzed on a gas chromatograph.

Mature-green tomatoes (cultivar FTE-12) were obtained from a Dade County packinghouse. Three tests were conducted at ca. 5-wk intervals starting in January 1983. The mature-green tomatoes were commercially packed but not gassed (ET to initiate ripening) at the packinghouse. Tomatoes (size 6 x 6) were brought to the Orlando USDA Laboratory immediately after packing. Immediately on arrival in Orlando, the tomatoes were gassed for ca. 72 hr with 50 ppm ethylene at 70°F (21°C). After gassing, fruit were color sorted into lots of breakers and pinks in accordance with United States Standards for Grades of Fresh Tomatoes (10).

For each treatment, 20 (6.5 lb.) tomatoes were placed on polystyrene foam trays. Each tray was placed in a sealed chamber (28 x 28 x 14 inches) where the contained air was continuously circulated by means of an electric pump and tubing. The temperature of all chambers was maintained at 55°F and 80-85% relative humidity. One tray of each of the following treatments was stored for 1, 2 or 3 wk. The following is a breakdown of the treatments:

Treatment 1 (B+)—1 tray of breaker tomatoes in a sealed chamber and circulated air.
Treatment 2 (B—)—1 tray of breaker tomatoes in a sealed chamber and circulated air filtered through 0.53 oz of Ethysorb®.
Treatment 3 (P+)—1 tray of pink tomatoes in a sealed chamber and circulated air.
Treatment 4 (P—)—1 tray of pink tomatoes in a sealed chamber and circulated air filtered through 0.53 oz of Ethysorb®.

Tomatoes were removed from the test chambers after each specific storage period of 1, 2, or 3 wk, and were then stored at 70°F (21°C) and 88-92% relative humidity. Each fruit was inspected daily and removed on reaching the full red color stage. All color measurements were made with a Hunter® colorimeter (Model D25-9) signal processor with a Model D25-L optical sensor. The tomatoes were called red when the external 'a' value of readings on the colorimeter averaged 32.0 which was judged to be fully red and matched the USDA standards. External color readings were