Effects of Preharvest and Postharvest Calcium Treatments of Peaches on Decay Caused by *Monilinia fructicola*

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ABSTRACT

Conway, W. S., Greene, G. M., and Hickey, K. D. 1987. Effects of preharvest and postharvest calcium treatments of peaches on decay caused by *Monilinia fructicola*. Plant Disease 71:1084-1086.

Jerseyland peaches were treated with solutions of $CaCl_2$ either by 10 weekly preharvest sprays at rates of 0, 30, 60, or 90 lb/acre or pressure-infiltrated (68.95 kPa) at harvest with 0, 2, or 4% solutions of $CaCl_2$. Fruit from all treatments were stored at 0 C for 3 wk. After removal from storage, the peaches were inoculated with a conidial suspension of *Monilinia fructicola*. After 3 days at 20 C, the fruit were rated for decay severity and analyzed for calcium content. Fruit sprayed at the rate of 90 lb/acre of $CaCl_2$ had 70% more calcium in the flesh than untreated fruit but showed no reduction in area of decay. Fruit pressure-infiltrated with 2 or 4% solutions of $CaCl_2$ had two and four times as much calcium in the flesh and 40 and 60% less decay, respectively, than untreated fruit, but the treatments caused injury to the fruit surface.

Increasing the calcium (Ca) content of apples with Ca salts has been responsible for increasing their storage life, because fruit Ca concentration is closely related to physiological and pathological disorders (4,9,11). Internal breakdown (2), bitter pit (8), and softening (7) have all been significantly reduced by postharvest Ca treatments. Likewise, postharvest infiltration of calcium chloride ($CaCl_2$) solutions can retard decay caused by *Penicillium expansum* Link: Thom (4). Even though peaches have a much shorter storage than apples, attempts have been made to extend the storage period or to maintain fruit quality by increasing the Ca content of the fruit. Peaches from trees grown in greenhouse sand cultures to which Ca was added in varying amounts realized an increase in quality (1). Preharvest spraying of peaches with calcium nitrate ($Ca(NO_3)_2$) increased their storage life by increasing the Ca content of the fruit, reducing physiological weight loss, reducing decay, maintaining fruit firmness, and retarding the rate of respiration (3,6,9).

Because both preharvest and postharvest Ca treatments have been used to increase the Ca concentration of peach fruit flesh, the objectives of this experiment were to increase the fruit Ca concentration by preharvest or postharvest Ca treatments and to determine the effect this increased Ca has on decay

Accepted for publication 12 June 1987.

caused by *Monilinia fructicola* (Wint.) Honey.

MATERIALS AND METHODS

Peach (*Prunus persica* (L.) Batsch) trees, cv. Jerseyland, were sprayed with 10 continuous weekly applications of $CaCl_2$ at rates of either 0, 30, 60, or 90 lb/acre. A standard fungicide treatment of benomyl was also applied to control blossom blight and brown rot. Untreated green ripe fruit from the same orchard were harvested and pressure-infiltrated (68.95 kPa) for 2 min with laboratory-grade USP calcium chloride ($CaCl_2$; 76%) made up as 0, 2, or 4% solutions. After treatment, the fruit were held in 0 C air storage. After 3 wk, the fruit were removed from storage and inoculated with a conidial suspension of *M. fructicola*. They were wounded on two sides to a depth of 2 mm by puncturing with the head of a nail 2 mm in diameter. The fruit were then immersed for 15 sec in a conidial suspension of 1×10^4 spores per milliliter and drained. After additional holding at 20 C for 3 days, the peaches were rated for decay severity by measuring the two orthogonal diameters of the decayed area as the mean of its width and length and then computing the area of decay from the formula πab, where a and b are the respective diameters. The experiment was set up as a completely randomized block with each tree representing one replicate. There were six replicate trees per treatment, with 10 fruits from each tree inoculated for a total of 60 fruits per treatment. The experiment was repeated.

Ca content of the fruit tissue was determined by first removing the peel and cutting a wedge of flesh the entire depth from two sides of the peach. After removal from the fruit, the flesh was immediately frozen in liquid nitrogen, freeze-dried, and ground. The two flesh segments from each of six peaches made up one sample, and five samples from each treatment were analyzed. From each sample, 0.250 ± 0.001 g was ashed at 500 C overnight and the residue was dissolved in 5 ml of 6 N HCl. The samples were then diluted and analyzed with a Jarrell-Ash atomic absorption spectrophotometer, and Ca values were calculated on a dry-weight basis.

The injury rating, done after 3 wk of storage at 0 C, was done by visually assessing injury on the fruit surface and assigning a value between 0 (severe) and 5 (no injury). Ten fruits from each of the six replicates per treatment were examined, and the final rating was the mean of the ratings of two observers.

RESULTS

The increase in Ca concentration of the peach flesh was greatest from postharvest pressure-infiltration of $CaCl_2$ solutions and there was also a significant increase after postharvest spray applications (Table 1).

Table 1. Effects of treating peaches with $CaCl_2$ on Ca content of flesh, decay severity, and fruit surface injury

Treatment	Ca concentration in flesh (μg Ca/g dry wt)	Decay severity[x] (mm^2)	Surface injury[y]
Untreated check	287 a[z]	323 a	5.00 a
Fungicide check	285 a	297 a	5.00 a
$CaCl_2$ spray (30 lb/acre)	338 a	311 a	5.00 a
$CaCl_2$ spray (60 lb/acre)	364 a	305 a	5.00 a
$CaCl_2$ spray (90 lb/acre)	490 b	305 a	5.00 a
Postharvest water check	284 a	320 a	4.84 b
2% $CaCl_2$ postharvest infiltration	762 c	187 b	4.82 b
4% $CaCl_2$ postharvest infiltration	1088 d	131 c	4.44 c

[x] Determined by measuring the two orthogonal diameters of the decayed area and then computing the area of decay from the formula πab, where a and b are the respective diameters.
[y] Injury rating: 0 = severe, 5 = no injury.
[z] Mean separation by Duncan's multiple range test ($P = 0.05$).

The only significant reduction in area of decay caused by *M. fructicola* resulted from the postharvest pressure-infiltration treatments (Table 1). Fruit treated with the 2 and 4% $CaCl_2$ solutions had 40 and 60% less decay area, respectively, than the untreated fruit; however, there was also some injury to the fruit surface in the form of brown skin mottling or slightly sunken, discolored areas (Table 1). This injury was caused primarily by the pressure-infiltration technique, with some exacerbation by the 4% $CaCl_2$ solution, because both the 0 and 2% $CaCl_2$ treatments resulted in similar injury. No fruit injury resulted from any of the field spray treatments.

DISCUSSION

An increase in Ca concentration of peach fruit can be realized using spray treatments of $CaCl_2$ if the concentration in the spray solution is high enough. In other work with peaches, sprays with $(Ca(NO_3)^2)$ resulted in sufficient uptake of Ca by the fruit to reduce physiological weight loss and respiration, maintain firmness, and reduce decay of naturally infected fruit (3,6,10). In our experiments, however, $CaCl_2$ applied as preharvest sprays did not reduce decay, but the severalfold increase in flesh Ca concentration resulting from postharvest pressure-infiltration of $CaCl_2$ solutions was reflected in the considerable decay reduction in wound-inoculated peaches.

In this study, fruit were inoculated after storage to determine the effectiveness of the various treatments in retarding decay over the 3-day period after storage. This time interval simulated the movement of fruit in marketing channels during which little effort would be made to maintain the 0 C temperature required to maintain fruit quality. This procedure, then, determined the ability of peaches to resist decay in the condition in which they come from storage. The conditions under which this study was done, including wound inoculation and high inoculum concentration, were especially severe and were similar to those used for testing fungicide efficacy.

Preharvest sprays of $Ca(NO_3)_2$) have resulted in a reduction in decay of naturally infected peaches, mainly caused by *Rhizopus stolonifer* Ehrenb. ex Fr., during storage (3,6,10). The injury resulting from the pressure-infiltration treatments made the peaches unacceptable for the fresh market, but because there was little internal injury, they would be adequate for processing. As with apples (4,5), however, different peach cultivars may vary in their susceptibility to injury from pressure-infiltration of $CaCl_2$ solutions. Increasing the Ca content of peach flesh can significantly reduce decay, but this treatment might be more successful with cultivars other than the one used in this investigation.

ACKNOWLEDGMENTS

The authors acknowledge the valued assistance of George Brown, Gerald Cutshall, Marshall Garretson, James May, and Robert Peters, biological laboratory technicians.

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