Foliar Calcium Sprays to Improve Peach Fruit Quality
Dr. R. Scott Johnson
University of California, Davis, Kearney Agricultural Center

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Project Leader: R. Scott Johnson
Cooperators: Carlos H. Crisosto, Robert Beede, Harry Andris and Kevin Day

Calcium plays a key role in cell wall strength of fruits and vegetables. When it is deficient, various disorders involving tissue breakdown can occur. For example, bitter pit of apple and blossom end rot of tomato are related to calcium deficiency. In peaches and nectarines no specific disorders have yet been associated with calcium deficiency. However, many growers routinely apply foliar calcium sprays based on the belief that they induce firmer fruit with a greater storage potential and shelf life. Although there are some physiological reasons to expect such practices to be effective, there is little experimental evidence to support them. Several preliminary studies have shown no effect. Because of all the calcium materials being applied to peach and nectarine orchards, we felt it would be worthwhile conducting an extensive field experiment, applying multiple sprays of several commercially available calcium formulations and using enough replications to be able to pick up subtle effects.

Procedure

A Flavorcrest peach orchard planted in 1993 on a 17'x 17' spacing was used for the experiment. Eight calcium formulations representing different chemistry and particle sizes were compared to a water sprayed control. Rates were adjusted to supply the same amount of calcium (about 400 ppm) for each treatment (Table 1). This rate of calcium was based on the mid range recommended by manufacturers of most of the products. A randomized complete block design was used with ten single tree reps per treatment. Treatments were made every 2 weeks starting at petal fall on March 26. The last spray was applied on June 4, 3 weeks before harvest, for a total of 6 applications. Trees were sprayed by handgun to thoroughly wet leaves and fruit. The equivalent of about 200-250 gals/acre or 1.5 gals/tree was applied.

Leaf and fruit samples from all 90 trees were collected after the 4^{th} and 6^{th} applications and at the 3^{rd} harvest on June 29. Leaf samples were washed, dried, ground and sent to a lab for nutrient analysis. Fruit were washed and scrubbed to remove the peach fuzz and any calcium residues remaining on the surface. Two samples were then collected from the fruit for nutrient analysis. First, the skins were removed using a potato peeler. Second, the layer of flesh 1 to 2 cm under the skin was also removed in thin slices. Both samples were oven dried, ground and sent to the same lab for analysis. All samples were analyzed for total calcium and nitrogen.

The following fruit quality variables were measured at harvest: flesh firmness, soluble solids concentration (SSC), titratable acidity (TA) and pH. Flesh firmness was measured in pounds-force (lbf) on the flesh using a University of California firmness tester with a 8-mm tip. A longitudinal wedge from each fruit was removed and combined to form a composite sample. From this composite sample juice was extracted by a hand press, filtered through two layers of

cheesecloth, and SSC was measured as % Brix using a temperature compensated refractometer (Atago ATC-1). Subsamples were diluted with deionized water to measure the initial pH, then titrated to an endpoint of 8.2 with 0.1 N NaOH to determine titratable acidity expressed as percent malic acid. The SSC/TA ratio was then calculated from the TA value.

After harvest, eighty fruit per tree were randomly selected, placed in labeled cardboard boxes, and transferred into cold storage; 40 fruit at 5 ^{o}C (41 ^{o}F), and $\pm$40 fruit at 0 ^{o}C (32 ^{o}F). After 7 and 14 days a group of 20 fruit were removed from cold storage at 5 ^{o}C. Half the fruit were warmed to room temperature and immediately evaluated for firmness as previously described to determine the rate of fruit softening. The rest were placed in labeled trays, and exposed to 20 ^{o}C (68 ^{o}F) to ripen until soft to the touch. In addition after 7, 14 and 21 days a group of 12 fruit were removed from storage at 0 ^{o}C. Half the fruit were warmed to room temperature and immediately evaluated for firmness as previously described to determine the rate of fruit softening. The rest were placed in labeled trays, and exposed to 20 ^{o}C (68 ^{o}F) to ripen until soft to the touch. When fruit were ripe (2-3 lbs.) each fruit was cut at the equatorial diameter and visually scored for texture, flesh bleeding, internal browning, and decay. Textural characteristics were scored as juicy, mealy or leathery. Bleeding was scored as yes (if 30% or more) or no. Flesh browning was related from one to six, from least to most extreme. General market life of stone fruit (peaches, plums, nectarines) is determined when more than 25% of the fruit were mealy or greater than 15% had a score of 3 or higher for internal browning.

Results and Discussion

Calcium concentrations in peach leaves are generally quite high (1-2%) as has been shown in this experiment (Table 2) and many others. Therefore, it is not surprising that these calcium sprays of only 400 ppm (0.04%) had no effect on increasing leaf levels in any of the treatments. On the other hand, fruit concentrations are considerably lower and they are dropping continually during fruit development. By harvest, skin calcium was 0.077% (770 ppm) and flesh calcium was 0.037% (370 ppm) in control trees (Table 2). One might expect six sprays of 400 ppm calcium to be sufficient to increase these levels. However, our data showed this was generally not the case. None of the calcium formulations significantly increased flesh calcium concentrations and only one material, the amino acid complex, increased skin concentrations on all three sample dates (Table 2). Ironically, this one material was sprayed on at a lower rate than the other materials (see Table 1) because of an error in measuring the calcium concentration of the original formulation.

Physiological measurements of fruit performance at harvest and during storage also indicated no calcium was effectively moved into the fruit by these treatments. Firmness at harvest (Table 3) and after 1to 3 weeks of cold storage (Table 4) showed no improvement by any of the calcium formulations. Although the tables indicate some significant differences, they were small, random and not consistently associated with any one treatment. Even the amino acid complex which slightly increased skin calcium, seemed to induce some improvement in firmness after one week of storage (Table 4) but the effect did not persist. Similarly, the calcium treatments showed no improvements in fruit size (Table 5) or decay, or reduction in internal breakdown symptoms such as juiciness, browning, or bleeding (Table 6).

Even though this experiment essentially showed no benefit from applying multiple sprays of calcium materials to peach trees, it did provide some hope for future studies. Since the amino acid complex was able to increase skin calcium by about 20%, perhaps higher rates could increase it more and even move calcium into the flesh of the fruit. Future studies will concentrate on this aspect to see how much higher concentrations can be used without causing

phytotoxicity. If calcium concentrations can be increased substantially, there should be an improvement in postharvest performance of the fruit.

Table 1. Calcium materials sprayed on Flavorcrest peach trees. Rates were calculated to deliver the same amount of calcium (approx. 400 ppm) for each material. Calcium concentrations were measured in the spray tank after mixing and averaged for 3 different spray dates.

Material	Formulation	% Ca	% N	Rate/ 200 gals/acre	Measured Ca concentration in solution (ppm)
Calcium chloride	Liquid	12	0	2.0 qts	373
Calcium nitrate	Liquid	11	7	2.0 qts	383
Calcium acetate	Liquid	10	5	2.4 qts	421
Calcium carbonate (small particle size)	Suspension	24	4	.8 qts	402
Calcium sulfate and phosphate	Powder	20	0	3.3 lbs.	372
Calcium sulfate and phosphate (small particle size)	Suspension	8	0	2.9 qts	365
Carboxylic acid complex	Liquid	8	6.5	3.0 qts	412
Amino acid complex[z]	Liquid	8	5	3.2 qts	275

[z]This material was applied at a lower rate due to an error in measuring the calcium concentration of the original formulation.