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# STUDIES ON AVOCADO FRUIT RIPENING USING CALCIUM[1]

T. L. DAVENPORT
*IFAS, University of Florida,*
*Tropical Research and Education Center,*
*18905 SW 280 St., Homestead, FL 33031*

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*Abstract.* **Many commercial avocado cultivars grown in South Florida ripen in a shorter time after harvest than California-grown cultivars. Experiments were conducted to evaluate the potential use of calcium to increase avocado fruit ripening time. Infusion of calcium chloride into fruit increased the time to ripen by 50% or longer; however, increased time to ripen was accompanied by calcium dependent fruit breakdown in over 50% of the fruit. Calcium infusion is thus not recommended for commercial use to increase avocado shelf life.**

Climacteric fruits are those which exhibit a marked rise in ethylene gas production and respiration prior to and during ripening. Avocado and mango are good examples of such fruit. Ethylene is considered by many to be the prime initiator of the increase in respiration rate and associated ripening process. Climacteric fruits can be induced to ripen early when ethylene is supplied prior to their normal ripening time. This principle is the basis for commercial ripening rooms where ethylene is applied to mature, green banana, tomato, and mango fruit prior to shipment. Conversely, if the pre-climacteric rise in endogenous ethylene production can be delayed, fruits will ripen later than normal.

Calcium has been known to affect ripening processes in climacteric fruits for a number of years. Tomatoes (4, 6), apples (1, 2), and mangos (3) have been shown to respond to applied calcium by a delay in fruit ripening. Furthermore, this delay is associated with a marked inhibition of ethylene production. Wills and Tirmazi (5) delayed ripening time of high quality 'Fuerte' and 'Hass' fruit by 50% using $CaCl_2$ infusion (4% w/v). They also reported other advantages such as a greater amount of vitamin C compared to controls. We felt that application of this principle to Florida's avocado industry could result in a significant increase in the shelf life of avocado which might make Florida fruit more competitive with California grown fruit.

Presently, at least one major avocado packinghouse operation utilizes hydrocooling of fruit as soon as possible after harvest. This approach markedly slows the onset of ethylene production and, hence, fruit ripening, but it is a comparatively expensive operation. Calcium infusion into fruit is potentially less expensive and relatively simple and adaptable to small as well as large fruit packing operations. The following experiments were conducted to examine the suitability of this principle to South Florida's avocado industry.

## Materials and Methods

Two avocado cultivars, Reed and Monroe, were evaluated over a 2 year period. With some modification as noted in the text, each experiment was conducted as described here. Mature fruit were taken directly from the field during commercial harvest seasons. They were separated into 2 or more replicate groups per treatment, each replicate consisting of 5 to 8 fruits. Treatment consisted of vacuum infusion of calcium into the fruit. Infusion was accomplished by completely submersing the fruit in a solution of 4% (w/v) $CaCl_2$ in tap water contained in a plastic jar designed to accommodate vacuum conditions. A weighted plate was placed on top of the fruit to insure complete submersion. The container was sealed, and the pressure was quickly reduced from one atmosphere to 308 or 120 mm Hg for up to 5 min. These levels are approximately 40% and 16% of atmospheric pressure, respectively. The fruit effervesced as the air in the intercellular spaces of the fruit expanded and escaped through the lenticels under the influence of reduced pressure. Liquid was forced into the fruit, replacing the displaced air, when the vacuum condition was released. The fruit were retained under liquid for 3 to 5 min following release of the vacuum to insure ample infusion time. Controls consisted of tap water dip and/or vacuum infusion of tap water into the fruit.

Following treatment, the fruit were held at 21-22°C in ventilated containers until ripe. Control fruit were kept separate from treated fruit. Ripened fruit were subjected to a taste panel to evaluate effects of the treatment upon edible quality.

## Results

'Monroe' avocados were used in the initial experiment. A strong alcoholic odor emanated from the container of treated fruits on the second day following treatment. The controls exhibited no odor.

Control fruit ripened within 6 to 9 days following harvest (Fig. 1). Approximately 25% of the calcium-treated fruit ripened 12 to 16 days after harvest. This near doubling of shelf life, however, was overshadowed by the large extent of apparent rotting in substantial portions of many treated fruits (Fig. 2). Lesions began to form 3 days after treatment and steadily increased in both surface area and intensity, throughout the incubation period. Infected areas exhibited brown skin patches with water soaked, soft mesocarp extending approximately 1 cm deep into the fruit. Nearly 75% of the fruit were discarded after 18 days because they were completely decayed and showed no signs of ripening. Controls exhibited no surface lesions.

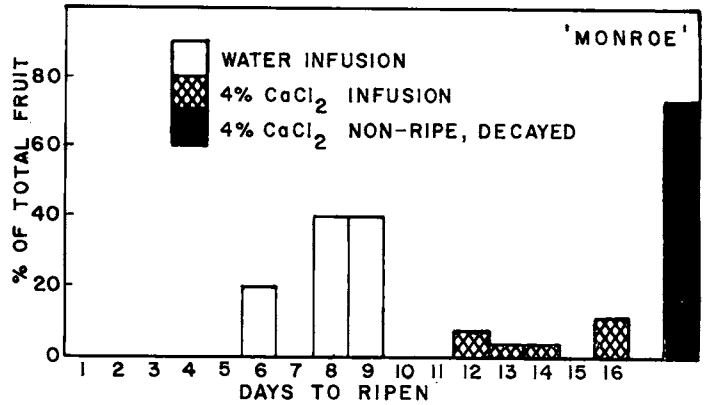


Fig. 1. Effect of infused $CaCl_2$ on shelf life of 'Monroe' avocado. Fruit were held at room temperature until ripe. Solid bar represents fruit which were discarded due to complete decay.

Unaffected portions of the fruit were not judged ripe until they became soft in a manner typical of fruit ripening. A taste panel determined that flavor of treated fruits was similar to controls. In cases where the fruit were rotted, those portions were cut away, and the unaffected, ripe

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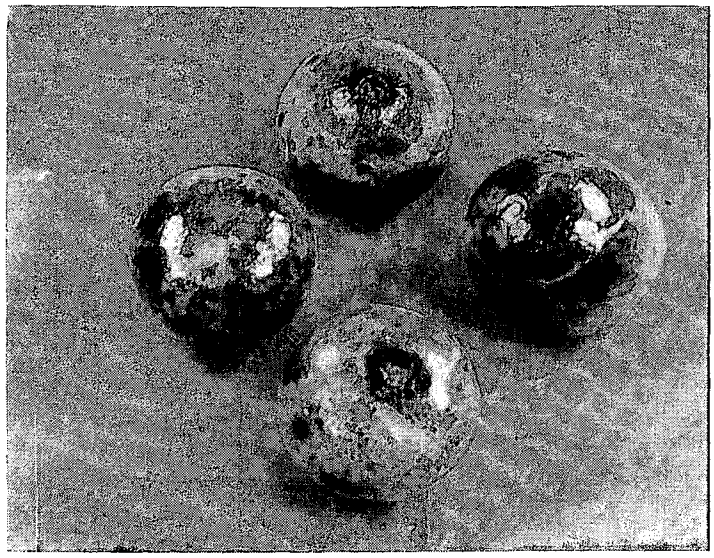

Fig. 2. Typical lesion formed on fruit following $CaCl_2$ infusion. The time to develop an extent of deterioration appeared to depend upon cultivar.

portions were tasted. The unaffected portion was judged to be the same eating quality as controls.

A similar experiment was conducted on 'Reed' avocados. Because of the high incidence of decay in the treated 'Monroe' fruits in the previous experiment, the fruit used in this second experiment were dipped for 1 min in 1% hypochlorite solution followed by 1 min dip in gas-chlorinated water in an attempt to surface sterilize the fruit prior to vacuum infusion.

Results were similar to those found in the first experiment (Fig. 3). Calcium infusion delayed ripening of the fruit by 50%; however, over 60% of the fruit were found with some level of decay at ripening. This decay affected 25 to 75% of the fruit surface area. Surface sterilization did not to inhibit breakdown associated with calcium treatments.

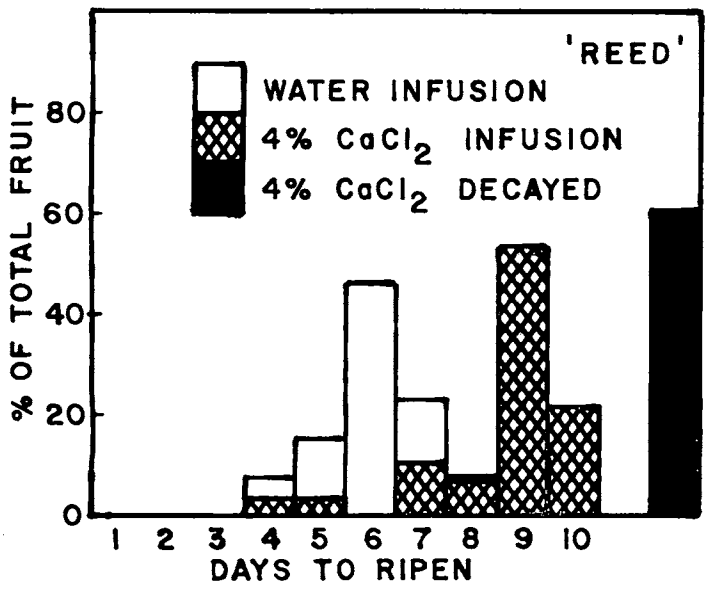


Fig. 3. Effect of infused $CaCl_2$ on shelf life of 'Reed' avocado. Fruit were held at room temperature. Solid bar represents the fruit which had decay symptoms. Lesions covered 25 to 75% of the surface of affected fruit.

## Discussion

The results reported here agree with those reported by Wills and Tirmazi (5). Calcium, when infused into avocado fruit tissue soon after harvest, inhibits ripening of the fruit. It can potentially double the shelf life of avocados. Although we did not evaluate ethylene production or respiratory rate in this study, it is likely that inhibition of both of these processes accompanies the delay in fruit ripening (5). Our efforts to extend their research to packinghouse operations failed because of extensive fruit breakdown. Similar breakdown was noted by Wills & Tirmazi (5), to occur in fruit treated with 8 and 12% $CaCl_2$. In more recent experiments, we were unable to effect a delayed fruit ripening response without incurring serious fruit damage when using various calcium salts in various concentrations with and without surface sterilization. Our climate is notably wetter than that encountered by Wills and Tirmazi (5) and we used avocados representing races which may be more susceptible to such damage. Breakdown occurred in over 60% of the treated fruits making the infusion process unsuitable for commercial use unless some measure of decay control can be developed.

Some cultivars appear to be more susceptible to breakdown than others. For example, the number of affected fruit and the extent of infection within each fruit was much greater in 'Monroe' than in 'Reed'. In subsequent experiments, surface-sterilized 'Waldin' avocados also appeared to be more susceptible than 'Reed'. The infusion process alone does not appear to be responsible since infusion of water into the fruit does not cause breakdown of the fruit. Hence, drawing bacteria into the fruit does not appear to be a plausible explanation for the breakdown. Dipping fruit in water or calcium solutions does not affect ripening or the onset of breakdown. It is only when calcium is added to the infusion solution in concentrations sufficient to inhibit ripening that breakdown occurs.

In conclusion, our results agree with earlier reports (5) that vacuum infused calcium inhibits ripening of avocado and that the eating quality of sound fruit is good; however, under conditions prevalent in the South Florida area, the incidence of breakdown of such treated fruit is too high to warrant its use in commercial practice. Therefore, it is not recommended that vacuum infusion of calcium be used at this time to increase avocado shelf life.

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