HortScience. 15(4):514-515. 1980

Association of Calcium in Chilling Injury Susceptibility of Stored Avocados[1]

Grantley R. Chaplin and K. J. Scott
CSIRO Division of Food Research and New South Wales Department of Agriculture, P.O. Box 52, North Ryde, NSW 2113, Australia

Additional index words. Persea americana, vacuum infiltration

Abstract. **Visible injury in chilled avocados *(Persea americana* Mill.) was observed first in the distal end of fruit. The proximal end remained apparently unaffected unless exposure to chilling temperature was prolonged. In contrast, the concentration of endogenous Ca of individual fruit was always highest in the proximal end and lowest in the distal end. Severity of visible injury in stored fruit was significantly reduced when Ca was applied to harvested fruit by vacuum infiltration of $CaCl_2$.**

Chilling injury (CI) may occur when most tropical and subtropical fruits are exposed to temperatures in the range 0-12°C. There are excellent reviews on this subject (3, 4). Visible injury is chiefly seen in chilled avocados as dark brown or gray discoloration in the mesocarp (1, 9). Treatments based on controlled atmosphere storage (5, 9) and modified atmosphere storage (6) have been developed which protect avocados from CI at least to some extent. However, the time required for injury symptoms to occur in stored avocados is often variable (5, 6, 9) which implies that intrisic susceptibility to injury may be affected by some endogenous fruit factor(s). The reasons for this variability have not been defined although there is evidence that chilling sensitivity changes at different stages of the respiratory climacteric (2).

In other fruits, Ca has been implicated in the incidence of numerous physiological disorders (8) and our results presented here suggest that Ca has an important role in the susceptibility of stored avocados to CI.

It has been consistently noted at this laboratory that visible CI symptoms occur first in the distal end of fruit while the proximal end remains apparently normal (Fig. 1). Symptoms become more severe and eventually extend to the proximal end as exposure times to chilling temperature increase. This observation suggests that there is a differential susceptibility to chilling within individual fruit. Subsequent investigations showed that the concentration of Ca in avocado mesocarp is not uniform but is invariably highest in the proximal end of fruit and lowest in the distal end (Table 1). This apparent relationship between endogenous Ca and the incidence of chilling symptoms is the first evidence that

[1] Received for publication December 24, 1979.
The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper must therefore be hereby marked *advertisement* solely to indicate this fact.

Ca may be associated with the susceptibility of stored avocados to CI.

Freshly harvested fruit of 2 common cultivars, 'Fuerte' and 'Hass', were vacuum infiltrated by the method of Scott and Wills (7) with $CaCl_2$ solutions of various concentrations and stored for 3 weeks at 5°C to test the hypothesis that fruit with high levels of Ca may be more resistant to CI. Fruit were transferred after storage to a ripening room and held at 20°C. Ripe fruit were cut longitudinally and assessed visually. Injury symptoms were scored for each fruit using a scale of 0 to 5, 0 indicating no apparent injury and 5 indicating severe injury. Mean injury scores are presented in Table 2.

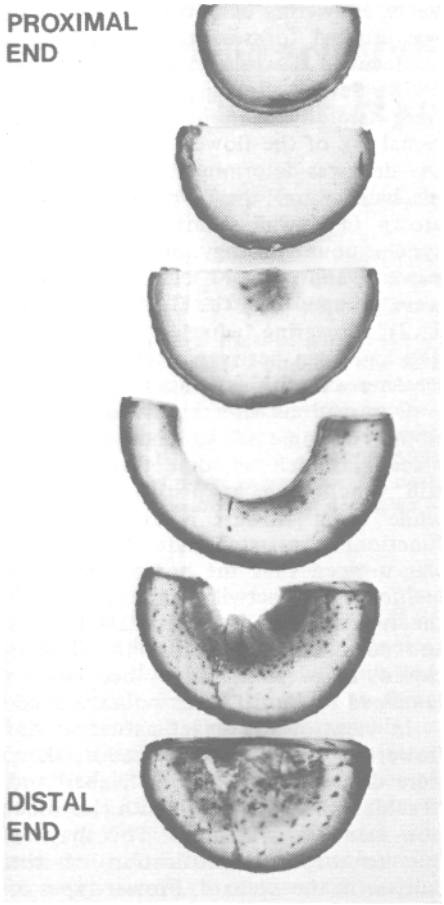

Fig. 1. Transverse sections (about 20 mm) of chilled avocado fruit showing longitudinal gradient of injury symptoms; injury observed in the distal fruit end sections and proximal end sections apparently normal. Chilling injury is mainly in the vascular bundles and darkening of the flesh nearest the seed.

Table 1. Ca concentration in different transverse sections of the flesh of avocado fruit.

Fruit section[z] No.	Ca concn. (μg/g fresh wt)
1	181
2	116
3	73
4	53
5	53

[z]Transverse sections about 20 mm thick. Section 1 at the proximal end and section 5 at the distal end.

Table 2. Chilling injury score in ripe 'Fuerte' and 'Hass' avocados with added Ca[z] after 3 weeks storage at 5°C.

Concentration of $CaCl_2$ (% wt/vol)	Injury score[y]
0 (control)[w]	4.69 a[x]
1	3.68 b
5	2.91 c
7.5	0.94 d

[z]Postharvest calcium treatments were applied by immersing fruit in a $CaCl_2$ solution and reducing the pressure above the solution to 250 mm Hg for 30 sec.

[y]Each value is a mean of 12 replicates.

[x]Mean separation within column by Duncan's multiple range test, 5% level.

[w]Control fruit were untreated but had the same picking to storage delay as treated fruit.

There were significant and distinct differences in the severity of CI among treatments. Severity decreased as the concentration of applied Ca was increased. This result, achieved by presumably raising the Ca concentration of avocado fruit, is consistent with the relationship observed previously between endogenous Ca and CI. It is therefore postulated that Ca status has an important role in the determination of susceptibility of stored avocados to CI.

Literature Cited

1. Jacobs, C. J. 1974. Probleme by die Koelopberging van avokado's. *Citrus Sub Trop. Fruit J.* 48 5:16-21.
2. Kosiyachinda, S. and R. E. Young. 1976. Chilling sensitivity of avocado fruit at different stages of the respiratory climacteric. *J. Amer. Soc. Hort. Sci.* 101:665-667.
3. Lyons, J. M. 1973. Chilling injury in plants. *Annu. Rev. Plant Physiol.* 24:445-456.
4. Pantastico, E. B., A. K. Mattoo, T. Murata, and K. Ogata. 1975. Chilling injury, p. 339-362. *In* E. B. Pantastico (ed.) Postharvest physiology, handling and utilization of tropical and subtropical fruits and vegetables. AVI, Westport, Conn.
5. Salama, S. B., W. Grierson, and M. F. Oberbacher. 1965. Storage trials with limes, avocados, and lemons in modified atmospheres. *Proc. Fla. State Hort. Soc.* 78:353-358.
6. Scott, K. J. and G. R. Chaplin. 1978. Reduction of chilling injury in avocados stored in sealed polyethylene bags. *Trop. Agr.* (Trinidad) 55:87-90.
7. _____ and R. B. H. Wills. 1977. Vacuum infiltration of calcium chloride; a method for reducing bitter pit and senescence of apples during storage at ambient temperatures. *HortScience* 12: 71-72.
8. Shear, C. B. and M. Faust. 1975. Preharvest nutrition and postharvest physiology of apple, p. 35-42. *In* N. F. Haard and D. B. Salunkhe (eds.) Postharvest biology and handling of fruits and vegetables. AVI, Westport, Conn.
9. Spalding, D. H. and W. F. Reeder. 1975. Low-oxygen high-carbon dioxide controlled atmosphere storage for control of anthracnose and chilling injury of avocados. *Phytopathology* 65:458-460.