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Induction of Chilling Injury in Stored Avocados with Exogenous Ethylene

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Abstract. **Fruit of avocado *(Persea americana* Mill.) were stored for up to 6 weeks in air or ethylene-enriched air at low temperatures. In one experiment, opposite ends of intact fruit were exposed individually to ethylene-enriched air. The severity of chilling injury of ripened fruit was significantly greater in fruit or fruit ends exposed to low ethylene concentrations.**

Chilling injury (CI) remains a major problem associated with long-term storage of avocados. Although the severity of injury is reduced by modified atmosphere (6, 7) and hypobaric storage (1), little is known about intrinsic factors that affect the chilling response. Fruit calcium concentration is associated inversely with the incidence of CI symptoms, which are more severe in the stylar end of the fruit and less severe in the pedicel end. CI was reduced by postharvest application of calcium (2).

Exposure of avocados to ethylene during storage increased anthracnose (4) and reduced shelf-life, primarily by advancing the time of ripening of the fruit (8). The effect of ethylene on CI development in avocados stored at low temperatures has not been investigated. In this paper, we have examined the effect of exogenous ethylene on the incidence of CI in avocados stored at low temperature.

Mature avocado fruit were obtained from a commercial orchard and used in the experiments within 24 hr after picking. 'Hass' fruit in expt. 1 were placed in 0.11 m^3 steel drums at either 5° or 1.5°C and supplied with air or ethylene-enriched air (10 ppm) at a rate of 5 liters • hr^{-1}. Fruit were removed from the drums and transferred to a ripening room at 20° after storage for 2, 4, and 6 weeks, respectively. CI in the mesocarp was assessed by visual rating after about 4 days, when the fruit softened.

The severity of CI in avocados after storage for 4 and 6 weeks, but not 2 weeks, was

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significantly greater at 5° C than at 1.5° (Table 1). Ethylene in the storage atmosphere had no significant effect on the severity of CI in fruit stored at either temperature for 2 weeks, but significantly increased CI injury after longer storage at 1.5°. Avocados stored at 5° with or without ethylene achieved the maximum CI score of 5 after 4 weeks.

Table 1. Effect of continuous ethylene (10 ppm) on CI rating of avocados stored for different times at 2 temperatures.

Storage treatment		CI rating[z]		
°C	Atmosphere	2 weeks	4 weeks	6 weeks
5	Air	1.5 ab[y]	5.0 f	5.0 f
	Ethylene	1.1 ab	5.0 f	5.0 f
1.5	Air	0.8 a	0.9 ab	2.7 d
	Ethylene	0.8 a	2.1 c	4.1 c

[z]CI ratings: 0 (no visible injury) to 5 (severe injury). Each value is the mean of 10 fruit.
[y]Mean separation by Duncan's multiple range test, 5% level.

'Fuerte' fruit were stored at 5°C for 3 weeks in expt. 2 in specially constructed chambers which permitted their entire surface, the pedicel half, or the stylar half to be exposed to air or to ethylene-enriched air (17 ppm) passed through the chamber at a rate of 5 liters • hr^{-1}.

All fruit were removed from the chambers and transferred to 20°C when storage was completed. After about 4 days, when the fruit ripened, the CI indices of the pedicel and stylar halves of each fruit were determined.

There was no significant difference between the CI index in pedicel and stylar halves of the fruit regardless of whether the entire fruit or pedicel or stylar ends were exposed to the flowing air stream (Table 2). However, when the entire fruit was exposed to ethylene, the level of CI in both halves of the fruit increased but the amount in the stylar half was significantly greater than that in the pedicel half. Exposing the stylar or pedicel half to ethylene increased the level of CI in the treated half. However, as in the entire fruit treatment, the increase of CI in the stylar half was significantly higher than that in the pedicel half. Treating the pedicel half with ethylene also caused a CI increase in the stylar half, whereas treating the stylar half did not affect CI in the pedicel half. This result cannot be explained by the available data, but could be due to differences in sensitivity to ethylene within the avocado mesocarp or to a uni-directional transmission of the stimulus by an unknown 'factor', perhaps through the well-developed vascular system of the fruit.

Table 2. Effect on CI severity of continuous ethylene (17 ppm) applied to various parts of avocados stored for 3 weeks at 5°C.

	CI index[z]			
	Air		Ethylene	
Fruit part treated	Pedicel[y]	Stylar	Pedicel	Stylar
Entire fruit	0.85 a[x]	1.00 ab	1.34 bc	2.20 e
Stylar end	0.74 a	0.93 ab	0.93 ab	2.02 e
Pedicel end	0.92 ab	1.09 ab	1.45 cd	1.88 de

[z]CI index determined by the method of Chaplin et al. (3). Each value is the mean of 5 fruit.
[y]Indicates part of the fruit assessed for CI.
[x]Mean separation by Duncan's multiple range test, 5% level.

This study indicates that comparatively low levels of exogenous ethylene induce earlier and/or more severe CI in avocados stored at low temperature than is the case in an ethylene-free atmosphere. Hence, ethylene scrubbing practices should be employed in avocado cool stores to minimize the CI risk.

Kosiyachinda and Young (5) reported that avocados become increasingly sensitive to chilling temperatures as the respiratory climacteric progresses to the peak. The peak of

the climacteric also corresponds with maximum endogenous ethylene production. Hence, the production of endogenous ethylene during storage also may be a factor associated with the development of CI of stored avocados. It could, therefore, be expected that the lower the storage temperature, the longer the time required to initiate endogenous ethylene production. This would explain the lower levels of CI found after storage at 1.5°C compared with those at 5° (Table 1). Further work on the possible interaction of ethylene and temperature on CI in stored avocados is, therefore, warranted.

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