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Studies in the Postharvest Handling of California Avocados

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Three studies were conducted on the postharvest storage behavior of California avocados during 1992-93. Each of these projects is summarized below.

1. The response of 'Hass' avocado to a fruit fly disinfestation treatment

[Research conducted in collaboration with J. S. Reints, Jr.]

The avocado is listed as a host for the Mediterranean fruit fly *(Ceratitis capitata)* and other fruit flies. Should the Mediterranean fruit fly ever be declared endemic throughout southern California, a postharvest quarantine treatment could be required before shipment. Postharvest quarantine treatments that are allowed for avocados from Hawaii are methyl bromide (MB) fumigation or a combination cold-MB treatment (USDA, 1979). It is highly likely that MB will not be available for postharvest use after the year 2001. Although not currently approved for avocados, a possible alternative to MB fumigation is a cold treatment between 0-2.2°C (32-36°F). The duration of such a treatment is dependent on the maximum pulp temperature maintained during treatment and the targeted fruit fly. We have previously demonstrated that a 14 day cold treatment at 1.1°C (34°F) will result in acceptable internal fruit quality, although there can be extensive external fruit damage (Arpaia *et al,* 1993a, 1993c). The external fruit damage is a surface scalding that is limited to the peel of the fruit. Much of this external scalding is masked by the natural darkening that occurs during ripening of the 'Hass' avocado. The purpose of this study was to continue evaluating the potential of a cold treatment (in comparison to standard 5°C (41°F) storage) as a quarantine treatment for 'Hass' avocado.

Fruits (size 48) were obtained three times during the 1993 'Hass' season (February, March, and June). Fruits were obtained from two individual grower lots at each procurement date. After sorting, 60 fruit from each lot were placed either at 1.1°C (34°F) or 5°C (41°F) for either 0, 2, or 3 weeks. Following storage, 25 fruit were placed at 20°C (68°F) for ripening, while five fruits were monitored for flesh firmness. Flesh firmness after storage and ripening were monitored. In addition, the length of time to eating ripeness (average flesh firmness of 1.5 Ibf or less), vascular (1-4) or flesh (0-5) discoloration, and the presence or absence of decay were recorded. External appearance was rated both before and after ripening. In both cases, 25 fruits were rated on a 0-5 scale for both chilling injury (scald-like symptoms) and the overall appearance of the fruit.

Table 1 summarizes the harvest data for the six grower lots used in the study. The three tests represented a range of fruit maturities as shown by the dry weight contents at harvest. There were also significant differences among the three procurement dates with respect to flesh firmness and the days to eating ripeness.

Table 1. Harvest data of fruit utilized for an evaluation of a post harvest insect disinfestation treatment.

Grower	Procurement Date (1993)	Dry Weight (%)	Flesh Firmness(lbf)	Days to Ripeness
1	2/12	25.8	31.1	12.0
2	2/12	22.8	31.1	12.6
3	3/18	27.0	29.6	10.8
4	3/18	29.1	29.1	10.2
5	6/10	31.4	23.6	6.0
6	6/10	29.6	25.6	5.4
Significance [z]		***	***	***

[z] ns, *, **, ***: Nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively

The influence of the two storage temperatures following 2 or 3 weeks of storage is reported in **Table 2.** Fruit stored at 5°C (41°F) were slightly softer following storage as compared to those fruits stored at 1.1°C (34°F). The time for the fruit to ripen decreased from an average of 9.5 days (0 weeks of storage) to 5.7 days (2 weeks of storage). After an additional week of storage, a slight but significant difference (0.5 day) in the time to ripening was detected between the fruit stored at 5°C (41°F) versus 1.1°C (34°F). No significant differences were observed with regard to flesh discoloration after ripening. This is not surprising since internal chilling injury is often not observed until greater than three weeks of storage. There was a slight but significant increase in vascular discoloration after three weeks of 1.1°C (34°F) storage. A fairly high level of fruit decay after ripening was observed in 1993. Fruit decay was primarily due to stem end rots, although lesions were often observed on the surface of the fruit. Interestingly, higher levels of decay were observed in fruit held at 1.1°C (34°F) for two weeks as compared to three weeks at the same temperature.

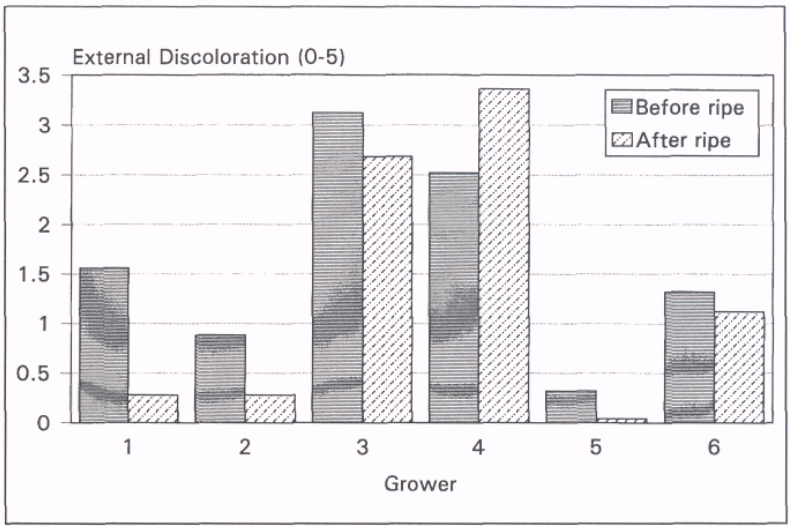

Figure 1. External discoloration of 'Hass' avocado fruits after three weeks of 1.1°C (34°F) storage and ripening at 20°C (68°F). Fruits were rated on a 0 to 5 scale where 0 was no external discoloration, 3 was moderate external discoloration, and 5 was severe external discoloration.

Table 3 reports the observations on the external appearance of the 'Hass' avocado before and after ripening. Significantly higher levels of chilling injury were observed after both 2 or 3 weeks of 1.1°C (34°F) storage. Chilling injury symptoms accounted for approximately 58% of the external score for fruit stored at 1.1°C (34°F). On the other hand, chilling injury accounted for little of the external score of fruit stored at 5°C (41°F). Fruit stored at 5°C (41°F) often showed depressed areas on the fruit lenticels and accounted for the scores reported here. After ripening, the overall appearance of the fruit changed little when the fruit had been stored at 1.1°C (34°F) although the chilling injury symptoms were not quite as apparent. Fruit stored at 5°C (41°F) showed a slight improvement in their overall appearance following ripening. **Figure 1** illustrates the differences between the grower lots that were observed after storage at 1.1°C (34°F).

Table 2. Flesh firmness after storage at either 1.1°C (34°F) or 5°C (4I°F) and fruit characteristics after ripening at 20°C (68°F) of 'Hass' avocado.

		Weeks of Storage	
		2	3
Initial Firmness (lbf)	1.1C	30.5	26.9
	5C	29.5	24.7
Significance	Grower (G)	ns	ns
	Temperature (T)	*	***
	G x T	ns	***
Days to ripeness	1.1C	5.75	4.88
	5C	5.72	4.39
Significance	Grower (G)	ns	ns
	Temperature (T)	ns	**
	G x T	ns	***
Flesh Discoloration (0-5)	1.1C	0.00	0.07
	5C	0.00	0.04
Significance	Grower (G)	ns	ns
	Temperature (T)	ns	ns
	G x T	ns	**
Vascular Discoloration (1-4)	1.1C	1.25	1.37
	5C	1.12	1.24
Significance	Grower (G)	ns	ns
	Temperature (T)	**	ns
	G x T	ns	***
Decay (%)	1.1C	23.0	16.7
	5C	15.0	14.7
Significance	Grower (G)	ns	ns
	Temperature (T)	*	ns
	G x T	***	***

[z] ns, *, **, ***: Nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively.

Table 3. External appearance of 'Hass' avocado after storage at either 1.1°C (34°F) or 5°C (41°F).

		Chilling Injury (0-5)		Overall External (0-5)	
		Weeks of Storage		Weeks of Storage	
		2	3	2	3
External Appearance -Unripe					
	1.1C	0.70	1.62	1.37	2.50
	5C	0.00	0.07	1.20	1.71
Significance					
Grower (G)		ns	ns	**	ns
Temperature (T)		**	***	*	***
G x T		***	***	***	***
External Appearance -Ripe					
	1.1C	0.85	1.28	1.35	2.03
	5C	0.06	0.00	0.69	0.81
Significance					
Grower (G)		ns	ns	Ns	ns
Temperature (T)		***	*	***	*
G x T		***	***	***	***

[z] ns, *, **, ***: Nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively

Table 4. Harvest dry weight content of 'Hass', 'BL-122', and 'Harvest' avocados[z].

	Cultivar					
Harvest Date (1993)	Hass (SCREC)	BL122A (SCREC)	BL122B (SCREC)	BL122 (Ventura)	Harvest (SCREC)	Significance[y]
			Dry Weight (%)			
3/18	30.43	20.83	20.44	-	-	
5/5	33.46	22.88	24.00	31.18	-	***
7/15	36.02	29.70	24.91	31.68	-	***
9/17	29.92	29.90	26.51	31.57	33.81	**

[z] Fruit obtained from two sources: SCREC is from the UC - South Coast Research and Extension Center in Irvine, CA and Ventura fruit is from Ventura County.
[y] ns, *, **, ***: Nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively.

2. The postharvest storage performance of 'BL-122' as compared to 'Hass' avocado after 0, 3, or 6 weeks 5°C (41°F) storage.

[Research conducted in collaboration with P. Robinson, S. L. Ontai, J. S. Reints, Jr., and G. Martin.]

During 1993, 'Hass' and 'BL-122' avocado fruit were obtained from either the UC South Coast Research and Extension Center (SCREC) or Ventura County. There was a single harvest of the new cultivar 'Harvest' in September. Twenty fruits were randomly selected and assigned to one of three storage treatments (0, 3, or 6 weeks at 5°C (41°F)). Fruits were evaluated similar to that described above except that no external ratings were recorded. The dry weight contents of the fruit from the various harvests are reported in **Table 4.** The observed fruit characteristics after 0, 3, or 6 weeks, respectively, are reported

in **Tables 5 through 7.** The 'BL-122' fruit tended to have higher amounts of vascular discoloration. Significant differences between the 'BL-122' fruit obtained from SCREC as compared from Ventura County were observed. These differences were especially evident after three or six weeks of storage. The reason for these significant differences in fruit behavior is unknown. **Figures 2 and 3** illustrate the differences between 'Hass', 'BL-122' from SCREC, and 'BL-122' from Ventura County with respect to flesh discoloration and vascular discoloration after ripening. These results indicate that 1) when comparing the fruit harvested from SCREC, one may conclude that the storage behavior of 'BL-122' is comparable to 'Hass' and 2) there are significant differences in storage behavior of the 'BL-122' fruit depending on the source of the fruit.

Table 5. Flesh firmness after storage for **0 weeks** at 5°C (41°F) and fruit characteristics after ripening at 20°C (68°F) of 'Hass', BL-122', and 'Harvest' avocados[z].

	Cultivar					
Harvest Date (1993)	Hass (SCREC)	BL122A (SCREC)	BL122B (SCREC)	BL122 (Ventura)	Harvest (SCREC)	Significance[y]
Initial Firmness (lbf)						
3/18	33.8	26.8	27.0		-	***
5/5	30.4	25.7	29.7	28.7	-	**
7/15	30.1	30.5	29.9	23.6	-	***
9/17	20.9	24.2	25.3	21.9		***
Days to ripeness						
3/18	10.7	11.7	11.4			***
5/5	7.3	7.2	7.0	7.0		*
7/15	8.5	8.7	8.7	8.6	-	ns
9/17	4.1	4.8	4.1	2.0	4.8	***
Flesh Discoloration (0-5)						
3/18	0.00	0.00	0.00	.	.	ns
5/5	0.00	0.00	0.00	0.00	.	ns
7/15	0.00	0.07	0.00	0.00		ns
9/17	0.00	0.00	0.00	0.00		ns
Vascular Discoloration (1-4)						
3/18	1.00	1.93	1.47			***
5/5	1.10	1.07	1.07	1.47	-	***
7/15	1.13	1.40	1.67	1.73		*
9/17	1.00	1.07	1.20	1.73	1.10	***
Decay (%)						
3/18	13.3	0.0	0.0	-		ns
5/5	0.0	0.0	0.0	0.0		ns
7/15	6.7	0.0	26.7	6.7		ns
9/17	0.0	0.0	0.0	13.3	10.0	ns

[z] Fruit obtained from two sources: SCREC is from the UC - South Coast Research and Extension Center in Irvine, CA and Ventura fruit is from Ventura County.
[y] ns, *, **, ***: Nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively.

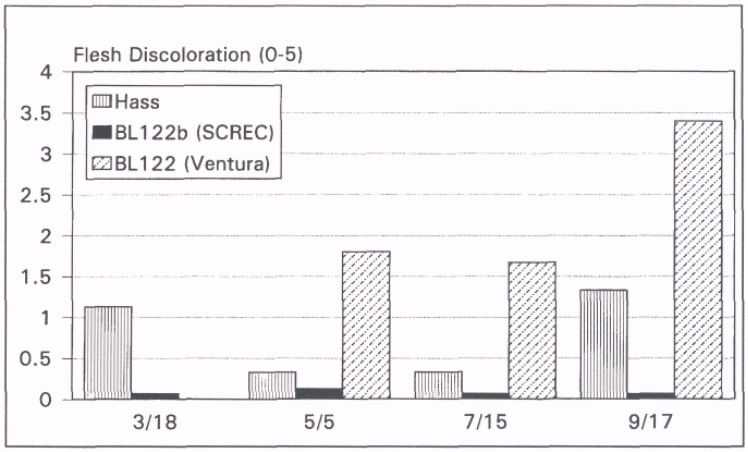

Figure 2. Flesh discoloration of 'Hass' and 'BL-122' avocado fruit after six weeks of 5°C (4l°F) storage and ripening at 20°C (68°F). 'BL-122' fruits were obtained from two sources; UC-South Coast Research and Extension Center in Irvine, CA and Ventura County. Fruits were rated on a 0 to 5 scale where 0 was no, 3 was moderate, and 5 was severe internal discoloration.

Table 6. Flesh firmness after storage for **3 weeks** at 5°C (41°F) and fruit characteristics after ripening at 20°C (68°F) of 'Hass', BL-122', and 'Harvest' avocados[z].

	Cultivar					
Harvest Date (1993)	Hass (SCREC)	BL122A (SCREC)	BL122B (SCREC)	BL122 (Ventura)	Harvest (SCREC)	Significance[y]
Initial Firmness (lbf)						
3/18	33.8	26.8	27.0	-	-	***
5/5	27.8	20.7	24.7	21.2	-	**
7/15	24.9	24.7	26.9	15.4	-	**
9/17	27.9	27.0	24.7	16.1	-	***
Days to ripeness						
3/18	4.7	4.9	4.7	.	-	ns
5/5	4.9	5.5	5.6	5.5	-	**
7/15	5.0	5.1	5.0	5.0	-	ns
9/17	4.1	5.3	4.3	3.1	3.4	***
Flesh Discoloration (0-5)						
3/18	0.00	0.00	0.00	-	-	ns
5/5	0.00	0.00	0.00	0.53	-	***
7/15	0.00	0.00	0.13	0.00	-	ns
9/17	0.00	0.00	0.07	0.67	0.00	***
Vascular Discoloration (1-4)						
3/18	1.20	1.87	1.80	-	-	*
5/5	1.13	1.33	1.73	2.73	-	***
7/15	1.00	1.13	1.27	1.60	-	***
9/17	1.00	1.00	1.07	1.73	1.00	***
Decay (%)						
3/18	6.7	13.3	6.7	-	-	ns
5/5	0.0	0.0	0.0	0.0	-	ns
7/15	0.0	6.7	0.0	20.0		ns
9/17	13.3	0.0	0.0	26.7	0.0	*

[z] Fruit obtained from two sources: SCREC is from the UC - South Coast Research and Extension Center in Irvine, CA and Ventura fruit is from Ventura County.
[y] ns, *, **, ***: Nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively.

Table 7. Flesh firmness after storage for **6 weeks** at 5°C (41°F) and fruit characteristics after ripening at 20°C (68°F) of 'Hass', BL-122', and 'Harvest' avocados[z].

	Cultivar					
Harvest Date (1993)	Hass (SCREC)	BL122A (SCREC)	BL122B (SCREC)	BL122 (Ventura)	Harvest (SCREC)	Significance[y]
Initial Firmness (lbf)						
3/18	16.3	20.2	11.3	-	-	ns
5/5	17.0	11.7	10.9	15.6	-	ns
7/15	28.5	25.0	23.2	6.3	-	***
9/17	23.6	17.9	20.0	8.9	-	**
Days to ripeness						
3/18	3.7	5.0	5.0	.	-	***
5/5	3.5	3.9	3.7	3.9	-	*
7/15	3.2	3.9	3.3	3.9	-	***
9/17	3.5	4.3	4.3	3.1	2.0	***
Flesh Discoloration (0-5)						
3/18	1.13	0.07	0.07		-	***
5/5	0.33	0.00	0.13	1.80	-	***
7/15	0.33	0.40	0.07	1.67	-	***
9/17	1.33	0.00	0.07	3.40	0.40	***
Vascular Discoloration (1-4)						
3/18	1.40	1.47	1.73	-	-	ns
5/5	1.13	1.33	1.73	2.73	-	***
7/15	1.00	1.67	2.00	2.67	-	***
9/17	1.27	1.00	1.53	2.89	1.00	***
Decay (%)						
3/18	6.7	0.0	0.0	.	-	ns
5/5	20.0	0.0	0.0	20.0	-	ns
7/15	0.0	6.7	6.7	40.0	-	**
9/17	33.3	0.00	0.00	86.7	0.00	***

[z] Fruit obtained from two sources: SCREC is from the UC - South Coast Research and Extension Center in Irvine, CA and Ventura fruit is from Ventura County.
[y] ns, *, **, ***: Nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively.

3. The postharvest storage performance of 'Hass' avocado after 0, 3, or 6 weeks 5°C (41°F) storage in relation topreharvest nutritional management.

[Research conducted in collaboration with D. Stottlemyer, M. V Yates, and J. S. Reints, Jr.]

At the Spring 1992 avocado research meeting, the results of a storage test utilizing 'Hass' fruit obtained from the Cashin Creek Fertilizer Study in Valley Center were reported (Arpaia *et al.* 1993b). At that time, it was reported that a significant relationship between the leaf nitrogen level and the subsequent development of chilling injury had been observed. This study was repeated in 1993, again using fruit from the Cashin Creek project. The same relationship was not observed during the second year of the project. There were very low levels of chilling injury observed in ripe fruit even after six weeks of storage. The reasons for this are unclear but may be related to crop load.

Fruits were obtained in July 1993 from the Thornhill Nitrogen Study in Ventura County. Fruits were harvested from individual trees from the intermediate nitrogen treatment, transported to UCR, and stored at 5°C (41°F) for either 0, 3, or 6 weeks. Fruits were evaluated as described above. A similar trend toward higher levels of chilling injury following six weeks of 5°C (41°F) storage **(Figure 4)** with increasing leaf nitrogen levels was observed. The frequency of nitrogen application may influence the response to long term storage.

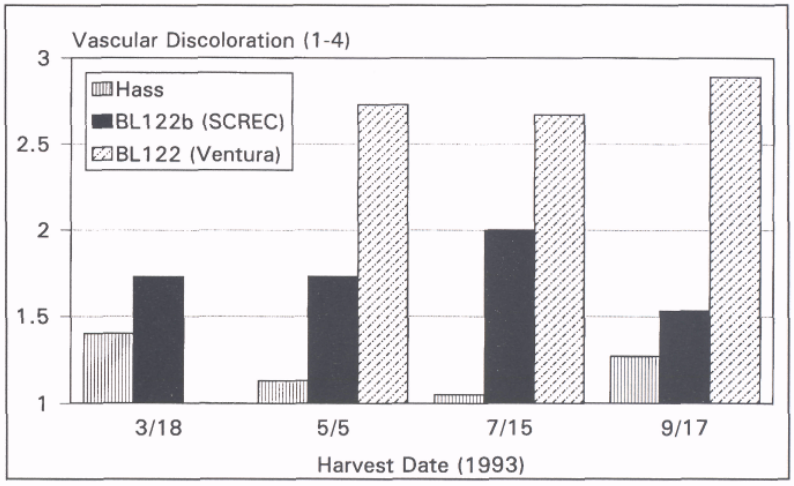

Figure 3. Vascular discoloration of 'Hass' and 'BL-122' avocado fruit after six weeks of 5°C (41°F) storage and ripening at 20°C (68°F). 'BL-122' fruits were obtained from two sources; UC-South Coast Research and Extension Center in Irvine, CA and Ventura County. Fruits were rated on a 1 to 4 scale where 1 was no and 4 was severe internal discoloration.

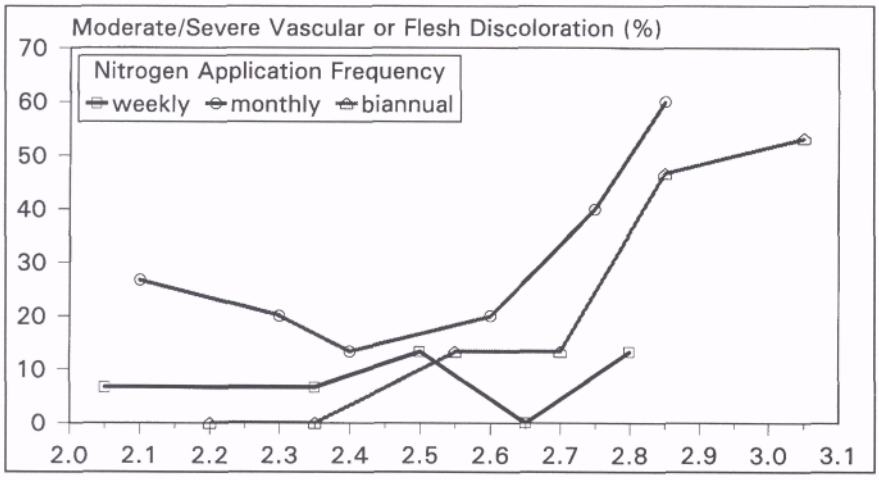

Figure 4. The relationship between leaf nitrogen content and the development of moderate or severe chilling injury in 'Hass' avocado fruits after six weeks of 5°C (41°F) storage and ripening at 20°C (68°F). Fruits were determined to have moderate or severe chilling injury if either vascular or flesh discoloration was rated as moderate or severe.

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