1994 California Avocado Research Symposium pages 69-75
California Avocado Society and University of California, Riverside

# STUDIES IN THE POSTHARVEST HANDLING OF CALIFORNIA AVOCADOS

M. L. Arpaia
Department of Botany and Plant Sciences,
University of California, Riverside

During 1992- 1993 we conducted three separate but connected studies on the postharvest storage behavior of California avocados. Each of these projects is summarized below.

### *A) 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. A possible alternative to MB fumigation is cold treatment (32 - 36F). 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 34F will result in acceptable internal fruit quality, although there can be extensive external fruit damage. 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 4IF 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 was placed either at 34 F or 41 F for either 0, 2 or 3 weeks. Following storage 25 fruit were placed at 68F for ripening while 5 fruits were monitored to flesh firmness. Flesh firmness after storage and ripening were monitored. In addition, the length of time to eating ripeness (1.5 lbf or less flesh firmness), vascular (1-4) or flesh (0-5) discoloration and the presence or absence of decay was recorded. External appearance was rated both before and after ripening. In both cases, 25 fruits were rated on a 0-5 scaled for both chilling injury (scald-like symptoms) and the overall appearance of the fruit.

Table 1 summarizes the harvest data for the 6 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.

The influence of the two storage temperatures following 2 or 3 weeks storage is reported in Table 2. Fruit stored at 41F were slightly softer following storage as compared to those fruits stored at 34F. The time for the fruit to ripened decreased from an average of 9.5 days with no storage to 5.7 days after 2 weeks. 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 4 1F versus 34F. 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 3 weeks storage. There was a slight but significant increase in vascular discoloration after 3 weeks of storage at 34F. We observed a fairly high level of fruit decay after ripening in 1993. Fruit decay was primarily due to stem end rots although lesions were often observed on the surface of the fruit. Interestingly, we observed higher levels of decay in fruit held at 34F for 2 weeks as compared to 3 weeks at the same temperature.

Table 3 reports the observations on the external appearance of the 'Hass' avocado before and after ripening. After both 2 or 3 weeks storage at 34F, significantly higher levels of chilling injury were observed. Chilling injury symptoms accounted for approximately 58% of the external score for fruit stored at 34F. On the other hand, chilling injury accounted for little of the external score of fruit stored at 41F. Fruit stored at 41F 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 34F although the chilling injury symptoms were not quite as apparent. Fruit stored at 41F showed a slight improvement in their overall appearance following ripening. Figure 1 illustrates the differences between the grower lots which were observed.

We are continuing this study this year (1993-94). We plan to obtain fruit monthly from March through July and follow the same treatment protocols.

References:

USD A. 1979. Plant protection and quarantine treatment manual, T100, T107, T108, (rev. Nov. 1992). USD A, Animal and Plant Health Inspection Service. p.5.3, 5.55, 5.62.

***B) The postharvest storage performance of 'BL-122' as compared to 'Hass' avocado after 0, 3 or 6 weeks 41F storage.***

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

We obtained 'Hass' and "BL-122" fruit from the UC South Coast Research and Extension Center (SCREC) and 'BL-122' fruit from Ventura County during 1993. We had 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 41F). Fruits were evaluated similar to that described above except that no external rating was recorded. The dry weight contents of the fruit from the various harvests are reported in Table 4. Tables 5 through 7 report the observed fruit characteristics of the fruit after 0,

3, or 6 weeks, respectively. The 'BL-122' fruit tended to have higher amounts of vascular discoloration. We observed significant differences between the 'BL-122' fruit obtained from SCREC as compared from Ventura County. These differences were especially evident after 3 or 6 weeks 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 the '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[1] 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.

***C) The postharvest storage performance of 'Hass' avocado after 0,3 or 6 weeks 41F storage in relation to preharvest nutritional management***

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

At the Spring 1992 meeting we reported the response of "Hass" avocado to long term storage which were obtained from the Cashin Creek Fertilizer study in Valley Center. We reported at that time that we had observed a significant relationship between the leaf nitrogen level and the subsequent development of chilling injury. We repeated this study in 1993, using fruit again from the Cashin Creek project. We did not observe the same relationship during the second year of the project. There were very low levels of chilling injury observed in ripe fruit even after 6 weeks of storage. The reasons for this are unclear.

We also obtained fruit from the Thornhill Nitrogen Study in Ventura County. Fruits were harvested from individual trees from the intermediate nitrogen treatment, transported to UCR and stored for either 0, 3, or 6 weeks. Fruits were evaluated as described above. We observed a trend towards higher levels of chilling injury following 6 weeks storage at 41F (Figure 4) similar to that observed in 1993 with Cashin Creek fruit. The frequency of nitrogen application may influence the response to long term storage.

Table 1. Harvest data of fruit utilized for an evaluation of a postharvest 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] ns, *, **, ***: Nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively.

Table 2. Flesh firmness after storage at either 34 or 41F and fruit characteristics after ripening at 68F of 'Hass' avocado.

| | Weeks of Storage | |
|---|---|---|
| | 2 | 3 |
| **Initial Firmness (lbf)** | | |
| 34 F | 30.5 | 26.9 |
| 41 F | 29.5 | 24.7 |
| *Significance* | | |
| Grower (G) | ns | ns |
| Temperature (T) | * | *** |
| G x T | ns | *** |
| **Days to ripeness** | | |
| 34 F | 5.75 | 4.88 |
| 41 F | 5.72 | 4.39 |
| *Significance* | | |
| Grower (G) | ns | ns |
| Temperature (T) | ns | ** |
| G x T | ns | *** |
| **Flesh Discoloration (0-5)** | | |
| 34 F | 0.00 | 0.07 |
| 41 F | 0.00 | 0.04 |
| *Significance* | | |
| Grower (G) | ns | ns |
| Temperature (T) | ns | ns |
| G x T | ns | ** |
| **Vascular Discoloration (1-4)** | | |
| 34 F | 1.25 | 1.37 |
| 41 F | 1.12 | 1.24 |
| *Significance* | | |
| Grower (G) | ns | ns |
| Temperature (T) | ** | ns |
| G x T | ns | *** |
| **Decay (%)** | | |
| 34 F | 23.0 | 16.7 |
| 41 F | 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 34 or 41 F.

| | Chilling Injury (0-5) Weeks of Storage | | Overall External (0-5) Weeks of Storage | |
|---|---|---|---|---|
| | 2 | 3 | 2 | 3 |
| **External Appearance - Unripe** | | | | |
| 34 F | 0.70 | 1.62 | 1.37 | 2.50 |
| 41 F | 0.00 | 0.07 | 1.20 | 1.71 |
| *Significance* | | | | |
| Grower (G) | ns | ns | ** | ns |
| Temperature (T) | ** | *** | * | *** |
| G x T | *** | *** | *** | *** |
| **External Appearance - Ripe** | | | | |
| 34 F | 0.85 | 1.28 | 1.35 | 2.03 |
| 41 F | 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 'BL122', 'Hass' and 'Harvest' avocados.

| Harvest Date (1993) | Cultivar Hass (SCREC) | BL122A (SCREC) | BL122B (SCREC) | BL122 (Ventura) | Harvest (SCREC) | Significance[z] |
|---|---|---|---|---|---|---|
| **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] ns, *, **, ***: Nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively.

Table 5. Flesh firmness after storage for 0 weeks at 41F and fruit characteristics after ripening at 68F of 'BL122', 'Hass' and 'Harvest' avocados.

| Harvest Date (1993) | Cultivar Hass (SCREC) | BL122A (SCREC) | BL122B (SCREC) | BL122 (Ventura) | Harvest (SCREC) | Significance[z] |
|---|---|---|---|---|---|---|
| **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] ns, *, **, ***: Nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively.

Table 6. Flesh firmness after storage for 3 weeks at 41F and fruit characteristics after ripening at 68F of 'BL122', 'Hass' and 'Harvest' avocados.

| Harvest Date (1993) | Cultivar Hass (SCREC) | BL122A (SCREC) | BL122B (SCREC) | BL122 (Ventura) | Harvest (SCREC) | Significance[z] |
|---|---|---|---|---|---|---|
| **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] ns, *, **, ***: Nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively.

Table 7. Flesh firmness after storage for 6 weeks at 41F and fruit characteristics after ripening at 68F of 'BL122', 'Hass' and 'Harvest' avocados.

| Harvest Date (1993) | Cultivar Hass (SCREC) | BL122A (SCREC) | BL122B (SCREC) | BL122 (Ventura) | Harvest (SCREC) | Significance[z] |
|---|---|---|---|---|---|---|
| **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] ns, *, **, ***: Nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively.

Figure 1. External discoloration of 'Hass' avocado after 3 weeks storage at 34F and ripening at 68F.

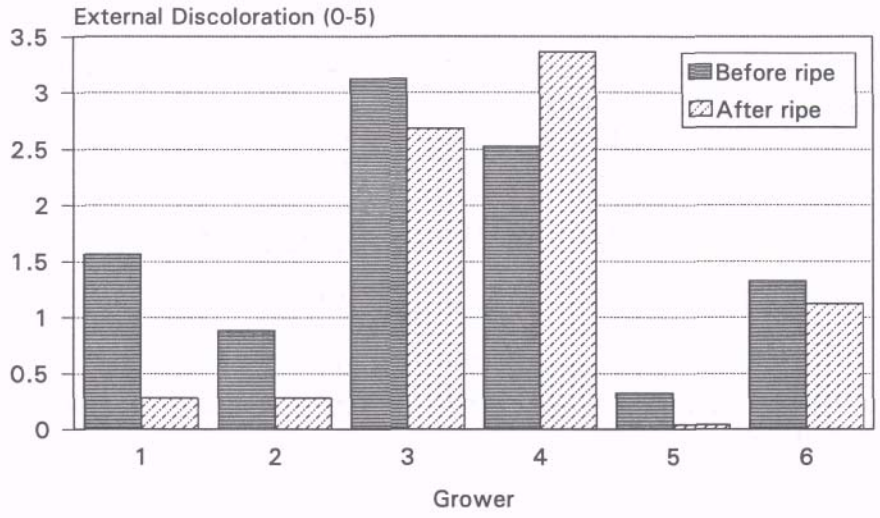


Figure 2. Flesh discoloration after 6 weeks of 41F storage.

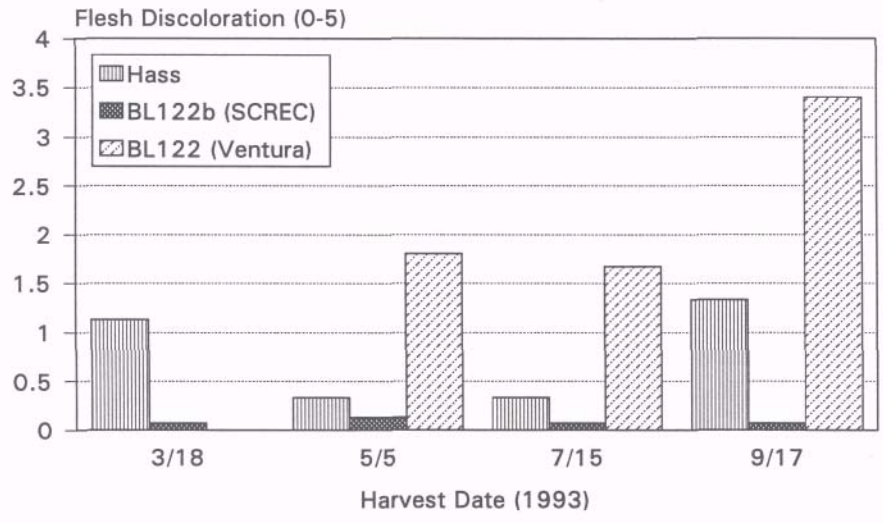

Figure 3. Vascular discoloration after 6 weeks of 41F storage.

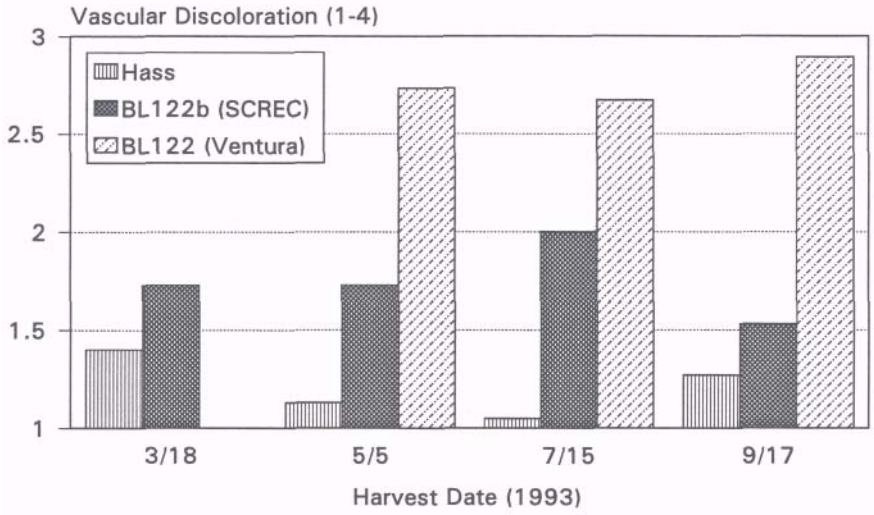


Figure 4. The relationship between pulp nitrogen content and leaf nitrogen content in avocados harvested at Thornhill Ranch, August 1993.