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Avocado Postharvest Quality

Continuing Project: Year 6

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Benefit to the Industry

This project will help to maintain and enhance the California avocado industry by continuing the postharvest evaluation on patented and unreleased varieties, continuing the examination of factors involved in postharvest decay development continuation of our collaborative effort to examine the impact of temperature and carbon dioxide on the ripening quality of ‘Hass’ avocado and initiation of research to further examine the susceptibility of avocados to mechanical injury following harvest. The final objective is to continue our adaptation of 2 postharvest manuals developed in New Zealand for the California industry for use in standardization of terminology and measurement of fruit quality at the packinghouse, wholesale and retail levels.

Each of these project objectives will assist the California avocado industry in shipping fruit of high quality to the consumer. This in turn will assist the grower to maximize their profit potential and further build a market identity for California avocados as fruit of the highest quality. This is critical as the California industry faces increased competition in the domestic market and elsewhere. The research expertise of the project team includes individuals trained in postharvest physiology (Arpaia, Woolf, and White), sensory evaluation (Collin), postharvest pathology (Sievert) and postharvest engineering and transit research (Thompson and Slaughter) as well as commercial handling (Tokar and DeLyser).

Objectives

A) To continue a postharvest evaluation program on plant material from the breeding program.
B) Continue a collaborative study with HortResearch to examine avocado oil in Hass and new selections from the breeding program.

C) Continue a collaborative study with A. Woolf and A. White to examine the effects of high temperature (>68ºF) and carbon dioxide on the ripening behavior and quality of ‘Hass’ avocado.
D) Evaluation of susceptibility of ‘Hass’ avocado to mechanical injury during ripening and handling.
E) Continue adapting AvoCare Quality Assessment Manual and Identification Handbook for California conditions in collaboration with A. White, A. Woolf, the CAC Merchandising Staff and interested packers.

Summary

Continue a postharvest evaluation program on plant material from the breeding program.

Postharvest evaluation of the Harvest and Gem varieties, which were released in 2003 from the breeding program, was conducted using Hass as a standard for each test. Fruit was obtained from the variety trial at the DeBusschere Ranch Variety Trial in Oxnard and the Hardison Ranch near Santa Paula on April 18, June 6, and July 11, 2005. An additional harvest was made at the Hardison Ranch on September 9, 2005. Fruit samples from all harvests were presented to volunteer panelists using protocols described previously in our annual reports after ripening (no storage). Dry weight on each fruit was also recorded so we can correlate the average sensory score for each fruit with the dry weight. Additionally, fruit were either snapped or clipped harvested and stored for either 0 or 3 weeks at 41F. Fruit were then treated either with 0 or ~50 ppm ethylene following storage to trigger ripening.

Storage quality this season was fairly good with no particular variety showing an advantage over the other. Data collection for the final harvest at the Hardison Ranch is near completion (10/6/05) but data entry is not completed. Figures 1 and 2 provide the data pertaining to dry weight accumulation at the 2 sites. The Harvest dry matter content at both sites is considerably lower than the dry matter content of Hass and Gem. At both sites, the dry matter of Gem exceeded the Hass after for most of the harvest dates. This is consistent with data that we have collected in previous years.

We also periodically harvested fruit from the UC Lindcove REC and Richardson Variety trials located in the San Joaquin Valley. We had planned to conduct storage evaluation work with fruit from these sites at the time of commercial harvest but had difficulty at both sites scheduling the commercial harvest. Tables 1 and 2 provide the dry weight data from both sites, respectively. Note that the Hass has the highest dry matter for most sampling dates.

Continue a collaborative study with HortResearch to examine avocado oil in Hass and new selections from the breeding program.

Preliminary report on samples collected in 2003 – 2004. Four avocado fruit were collected from each of four cultivars, ‘Hass’, ‘Lamb Hass’, ‘Gem’ and ‘Harvest’. Fruit were sampled May 21, 2004 from the DeBusschere variety block near Oxnard and again on August 4, 2004. In August we also collected samples from the Hardison site near Santa Paula (with the exception of ‘Harvest’). Within 24 hours of harvest unripe tissue was sampled (no skin or seed) from the equatorial part of each fruit using the Hofshi coring machine. Tissue samples were then freeze-dried, stored in nitrogen flushed foil bags and on 14th September 2004 transported to HortResearch in New Zealand where they will be used to extract oil. The dry weight of these samples is reported in Figures 1 and 2. At HortResearch the freeze-dried tissue was ground to a powder and the oil extracted using an accelerated solvent extractor machine ASE® 300 (Dionex). Total oil content results are shown in figures 3 and 4. The oil extracted from the samples is currently under analysis to determine its composition in terms of fatty acids and other compounds noted to have health benefits, such as, levels of beta sitosterol and alpha tocopherol (vitamin E).

Progress during 2004-2005. During this season we collected samples 5 times during the commercial harvesting season from the UC South Coast Research and Extension Center in Irvine, CA. Gem and Hass samples were collected three times (March 22, May 17 and June 28). Harvest and Lamb Hass samples were collected on July 26 and August 23. The samples have been prepared as described above and will be shipped to New Zealand in the near future. Table 3 provides the dry weight data of the fruit at the time of harvest.

Adapt AvoCare Quality Assessment Manual and Identification Handbook for California conditions in collaboration with A. White, A. Woolf, the CAC Merchandising Staff and interested packers.

Background. Two publications have been produced for use in identifying and rating postharvest disorders of New Zealand and Australian 'Hass' Avocados: 'The AvoCare Assessment Manual' and the 'Handbook of Postharvest Disorders of 'Hass' Avocados'. Both manuals provide high quality photographs and clear descriptions of avocado disorders. In addition, these manuals discuss a range of possible causes for the disorders. The reason for production of two manuals is that the Handbook (a smaller document) was intended for use by the wholesale and retail segments of the industry, primarily for identification of disorders rather than determining the severity of disorders. These manuals provide a means to communicate accurately any problems that are observed with quality, rather than using terms such as "cut black", which might describe many disorders. The internal quality disorders have been categorized into two groups: common and less common disorders.

The intent of this objective is to modify and adapt both the 'AvoCare Assessment Manual' and the 'Handbook of Postharvest Disorders of 'Hass' Avocados' for use by packers, merchandisers, receivers and other postharvest researchers in California. This effort is a continuation of our collaborative efforts, and it will bring postharvest terminology of avocado to a common ground for all interested parties. This objective will be achieved with input from the CAC Merchandising Staff, and other industry and research personnel.

Methodology. There have been several stages in the development of the assessment manual, which has been called 'The International Avocado Quality Manual'. The first version of 'The International Avocado Quality Manual' (Version 1.1) included three additional sections; preharvest damage, other commercial cultivars and postharvest damage scenarios. Feedback was obtained from a wide range of people including CAC staff, packers, wholesalers, importers and processors during visits to California.

Version 1.3 of 'The International Avocado Quality Manual' was then shipped to California, where a number of commercial and research personnel "road tested" the manual in a wide range of commercial and research settings. Further refinements/suggestions were then incorporated into the manual. Finally, following a review by the CAC Merchandising Department, California avocado industry players, and two academic reviewers (Gordon Mitchell and Adel Kader), additional changes were incorporated into the final version of the manual, which was promoted at the World Avocado Congress in Spain.

'The International Avocado Quality Manual' has now been printed and is available for purchase. Orders can be placed by contacting the following email address: intavomanual@hortresearch.co.nz. The cost of the manual is USD 75 plus postage and handling.

Revision of 'Handbook of Postharvest Disorders of 'Hass' Avocados' for California requirements has been delayed by industry feedback and discussions regarding the development of the 'Retail Quality Assessment Manual' sponsored by California Department of Agriculture's Buy California Program. Due to changes beyond our control it was decided that 'The International Avocado Quality Manual' would be used instead as the output from the Buy California Program rather than the 'Retail Quality Assessment Manual'. 100 copies of the Manual have now been printed and provided to the CAC for distribution throughout the industry.

Revision of the Handbook to compliment revisions to the Manual has been initiated. A meeting was held in September in Auckland with the following participants: Anne White and Allan Woolf (HortResearch), Mary Lu Arpaia (University of California), Guy Witney (CAC), Peter Hofman (QDPI Australia), and will also be observed by John Bower (South Africa). It is planned that a draft version will be sent to the CAC for limited comment and "beta testing" by the end of December 2005. A completed version of the Handbook should be available by November 2006.

Continue a collaborative study with A. Woolf and A. White to examine the effects of high temperature (>68F) and carbon dioxide on the ripening behavior and quality of 'Hass' avocado.

We focused on 2 aspects of ethylene treatment of Hass avocado this season. For both portions of this work we harvested fruit 3 times during the commercial harvesting season from an orchard in Goleta, CA. The fruit were harvested in the morning and then transported to the F. G. Mitchell Postharvest laboratory at the UC Kearney Ag Center. The fruit were held overnight at 54F then sorted and assigned to the various treatments the following day. The first aspect examined the influence of storage duration at 41F (0, 7, 14 and 28 days) on the rate of ripening at 68F following a 0, 24 or 48 hour ethylene treatment after storage. Figure 5 presents the data collected on the softening of the fruit from each harvest date. The amount of softening following the ethylene treatment increased with increasing maturity as well as longer storage duration. This data confirms that fruit held fruit ripening is influenced by fruit maturity and storage duration.

The second component of our research was to examine the impact of pre-storage ethylene treatment on subsequent storage quality. We treated fruit with ethylene within 48 hours of harvest to varying stages of ripeness (20-30 lbf (just beginning to soften), 10-15 lbf (just past "button popping" stage, and 1-5lbf (ripe to nearly ripe)). Following ethylene treatment the fruit were stored at 32, 41 or 54F for 0, 4, 7 or 14 days. Figure 6 presents the data comparing the interaction of harvest date and softening at 41F. Note that with advancing maturity, the amount of additional softening that occurred for the 20 to 30 lbf category fruit increased (Figures 6B and 6C) even though we stored the fruit in a near ethylene-free environment. Figure 7 reports the data for subsequent softening for fruit harvested in June, partially ripened and then stored at 32, 41 or 54F. Note that once ripening commences that even low temperature storage will not greatly slow the ripening process. Also note that over the 14 day period that the greatest amount of softening occurred at 54F highlighting the importance of rapid and thorough cooling after ethylene treatment.

Evaluation of susceptibility of 'Hass' avocado to mechanical injury during ripening and handling.

Work on this portion of the project was conducted in collaboration with J. Thompson and D. Slaughter (Agricultural Engineering, UC Davis) as well as V. Tokar (consultant) and J. DeLyser.

Two studies were undertaken. The first was a study to evaluate alternative packaging for ripe and partially ripe avocados. We know from previous work (Arpaia et al., 1987) that avocados increase in susceptibility to mechanical injury as they ripen. We also know that fruit bruising is a major cause of fruit defects at the consumer level (Arpaia, various reports to the California Avocado Commission). The question we posed, therefore, was whether an alternative packaging method designed for fresh, ripe Bartlett pears would also protect differentially ripened 'Hass' avocados from mechanical damage during simulated transit conditions. To answer this question, fruit that were differentially ripened from hard to nearly ripe were separated based on fruit firmness and randomly assigned to one of 4 packaging types: standard tray pack, volume fill, clamshell beta and the UCD tray. The clamshell and UCR tray protected the fruit from movement during simulated transit conditions. The packed fruit (see Figure 8) were subjected to a simulated transit trip across the United States. Conditions were applied that were analogous to the worse-case position in a refrigerated container truck. Following treatment the fruit were evaluated (when ripe) for external and internal damage. Table 4 presents the overall fruit acceptability ratings and shows that when the fruit were protected during treatment that little fruit damage occurred. As expected, fruit damage incidence and severity increased with increased fruit ripeness and this is where the protective packaging was most helpful in reducing injury. Figure 9 presents the data for internal flesh bruising of fruit based on package type and fruit ripeness at the time of the test. The results of the volume fill and the UCD tray are compared but clearly illustrate the relationship between the stage of ripeness and fruit damage as well as the impact of package type.

A second test was also conducted in which differentially ripe fruit (partially ripe, nearly ripe and ripe) were mixed and placed on display at a retail store in the Los Angeles area in collaboration. The goal of the project was to quantify fruit damage at the consumer level. Unfortunately, we were not able to ascertain this since nearly all ripe and nearly ripe fruit were purchased during the store test (fruit were on ad). The results of this test however, confirmed that ripe fruit is purchased preferentially when the consumer has the choice.

Table 1. The average dry matter content (%) of avocado fruit harvested from the UC Lindcove Research and Extension Center variety block from November 2004 through July 2005. All varieties grafted onto clonal Thomas rootstock. Trees planted in May 1999.

	Sampling Date (2005)				
	Nov 3	Jan 18	Mar 11	Apr 15	Jul 7
Hass	22.5%	26.1%	29.2%	30.2%	32.0%
Lamb Hass	15.7%	16.2%	18.3%	20.9%	28.2%
GEM	16.1%	21.1%	27.3%	33.8%	34.4%
Harvest	15.3%	17.0%	18.6%	21.1%	24.7%
5-552	17.9%	22.1%	23.0%	23.0%	29.0%
BL516 (Marvel)	17.3%	22.9%	26.0%	29.6%	32.8%
BL667 (Nobel)	-[z]	19.8%	22.4%	27.6%	-
Pinkerton	19.7%	-	-	-	-
SirPrize	19.8%	-	-	-	-
Zutano	20.1%	-	-	-	-

[z] Not sampled.

Table 2. The average dry matter content (%) of avocado fruit harvested from the Richardson variety block from November 2004 through May 2005. All varieties grafted onto clonal Thomas rootstock. Trees planted in May 1999.

	Sampling Date (2004-2005)						
	Nov 3	Nov 22	Dec 14	Jan 18	Mar 11	Apr 15	May 13
Hass	21.0%	23.6%	25.6%	26.5%	30.4%	29.8%	34.7%
Lamb Hass	15.7%	17.1%	17.9%	19.7%	22.1%	25.0%	26.5%
GEM	19.5%	19.6%	21.2%	22.9%	27.3%	32.2%	33.8%
Harvest	16.8%	17.6%	18.7%	22.2%	23.7%	27.5%	24.9%
Pinkerton	25.9%	27.1%	28.2%	31.7%	29.4%	31.6%	28.9%
SirPrize	20.0%	20.3%	21.0%	23.9%	22.3%	23.8%	-[z]
Zutano	20.4%	22.6%	21.4%	27.9%	23.2%	27.4%	-
5-552	18.8%	-	-	23.5%	27.8%	-	24.4%
BL516 (Marvel)	19.7%	-	-	24.8%	-	28.1%	-
BL667 (Nobel)	-	-	20.2%	-	-	-	27.2%

[z] Not sampled.

Table 3. The average dry matter content (%) of avocado fruit harvested from the UC South Coast Research and Extension Center variety block from March through August 23, 2005. Samples will be sent to HortResearch in New Zealand for subsequent analysis.

	Sampling Date (2005)				
	Mar 22	May 17	Jun 28	Jul 26	Aug 23
Hass	32.5%	34.8%	34.0%	-[z]	-
GEM	32.3%	35.9%	38.9%	-	-
Lamb Hass	-	-	-	26.4%	25.4%
Harvest	-	-	-	29.0%	25.4%

[z] Not sampled.

Table 4. Overall fruit acceptability for packaging test conducted in June 2005. Fruit were differentially ripened and varied in firmness from hard to nearly ripe and separated into individual packages based on firmness. Means below are for all firmnesses combined. Fruit were deemed acceptable if there were no external craters in the fruit, there was no significant flesh adhering to the inside of the peel (scores 0, 1, or 2) and there were no significant bruises in the flesh (scores 0, 1, or 2). Mean separation using Tukey's Test for Overall Quality Index (Minimum Significant Difference = 16.7%. Means with the same letter are not significantly different).

Package Type	Average Fruit Acceptability (%)	
Clamshell Beta	85.4% 96	a
UCD Tray	84.4% 96	a
Not Vibrated Control	83.3% 96	a
Standard Tray	59.4% 96	b
Volume Fill	41.7% 96	c

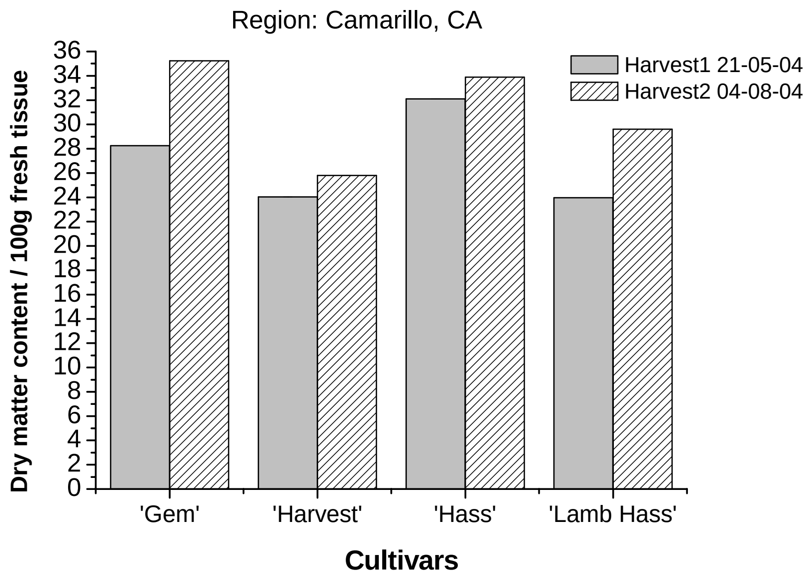


Figure 1. Dry matter content of four avocado cultivars; ‘Gem’, ‘Harvest’, ‘Hass’ and ‘Lamb Hass’ harvested two occasions, May and August 2004. Fruit harvested from the DeBusschere Variety Trial (Camarillo).

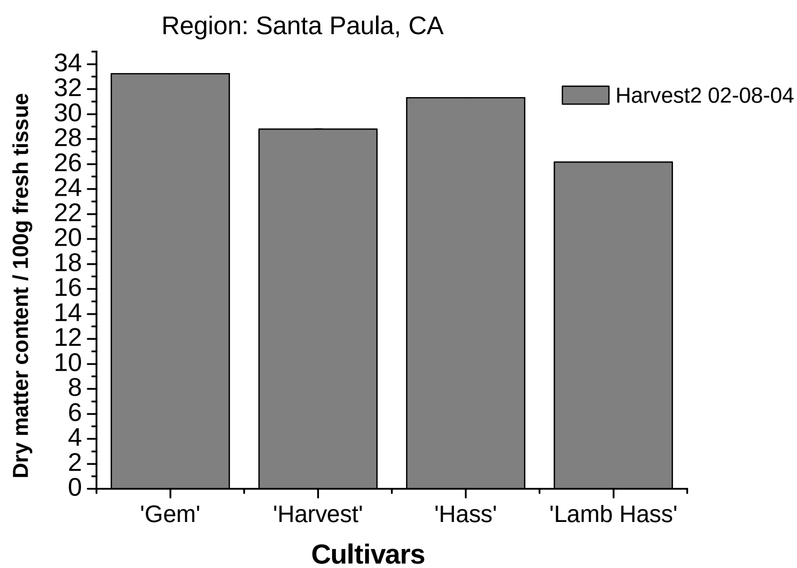


Figure 2. Dry matter content of four avocado cultivars; ‘Gem’, ‘Harvest’, ‘Hass’ and ‘Lamb Hass’ harvested in August 2004 from the Hardison Variety Trial (Santa Paula).

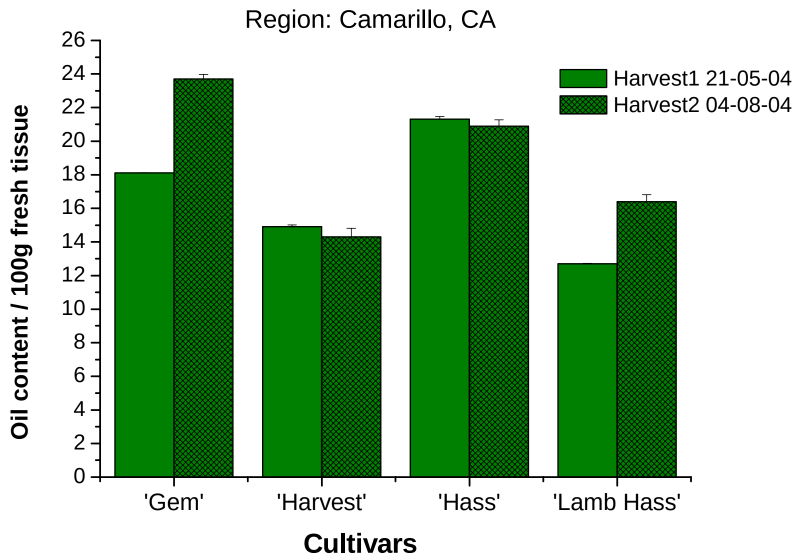


Figure 3. Oil content of four avocado cultivars; ‘Gem’, ‘Harvest’, ‘Hass’ and ‘Lamb Hass’ harvested in May and August of 2004. Fruit harvested from the DeBusschere variety trial (Camarillo).

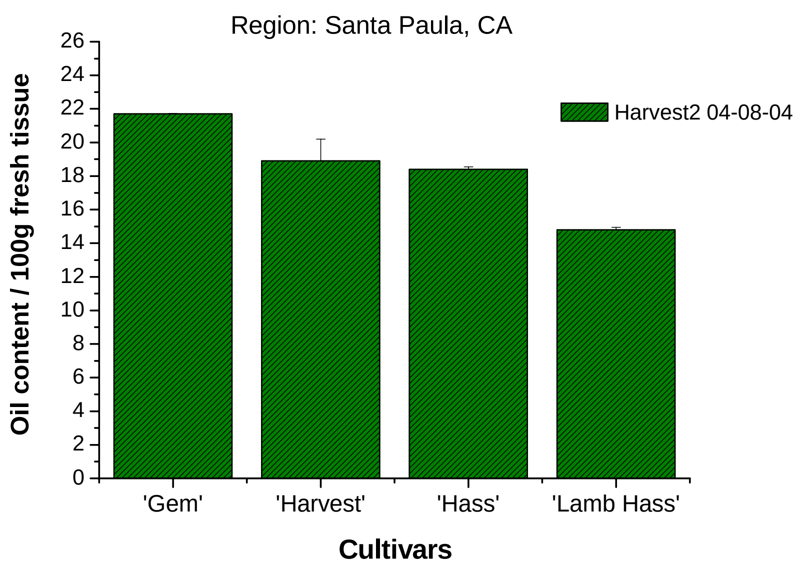
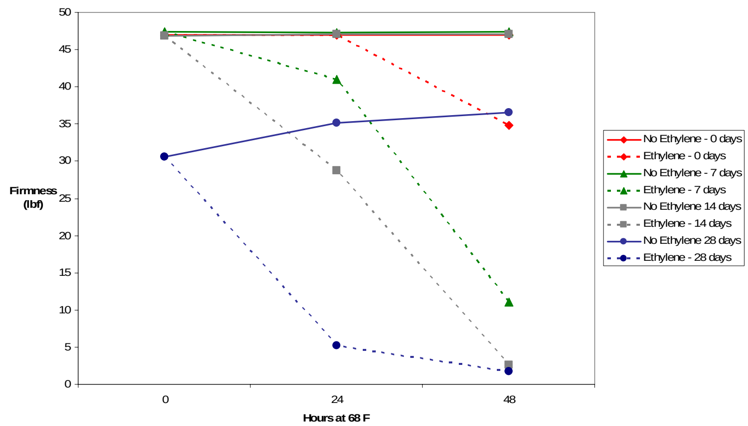


Figure 4. Oil content of four avocado cultivars; ‘Gem’, ‘Harvest’, ‘Hass’ and ‘Lamb Hass’ harvested in August 2004 from the Hardison variety trial (Santa Paula).

A.



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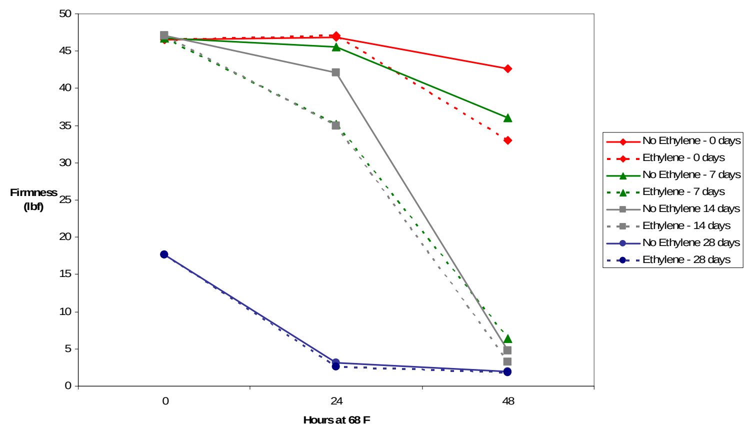

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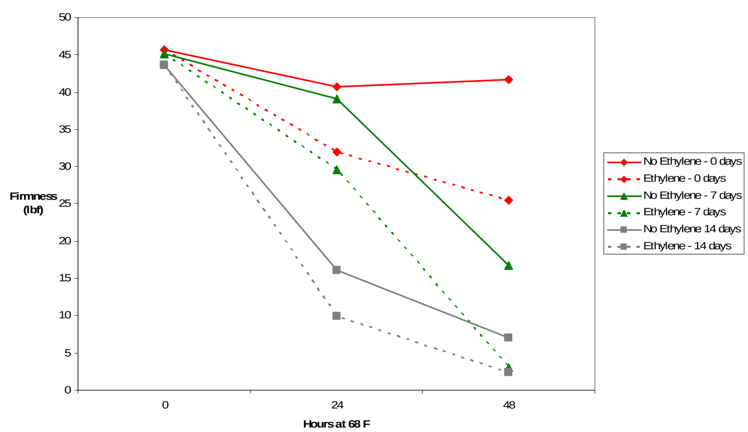


Figure 5. The interaction between fruit maturity, ethylene treatment (0, 24 or 48 hours) and storage duration on the softening of 'Hass' avocado following either 0, 7, 14 or 28 days at 41F (~90% RH). Fruit harvested from Goleta area on April 25, June 20 and August 16, 2005. Harvest dry matter was 34.1%, 31.8% and 32.7%, respectively at the time of harvest. Ethylene concentration ranged from 40 to 60 ppm. A. Fruit harvested April 25, 2005. B. Fruit harvested June 20, 2005. C. Fruit harvested August 16, 2005 (at time of report, data not entered for 28 day evaluation).

A.

B.

C.

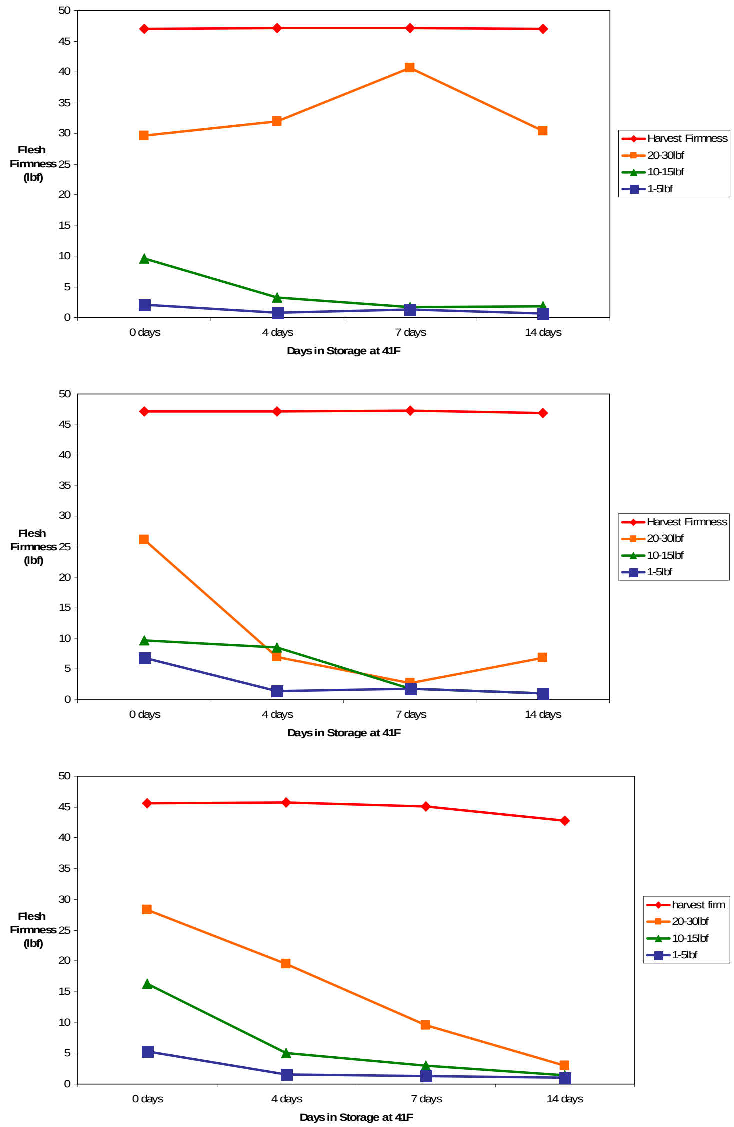
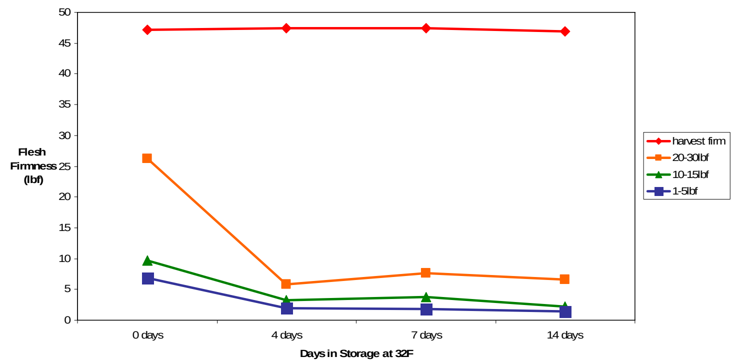


Figure 6. The interaction between fruit maturity, fruit firmness prior to storage (target firmnesses of 20-30 lbf, 10-15 lbf and 1-5lbf) and storage duration (0, 4, 7 or 14 days) at 41F (~90% RH) on the softening of 'Hass' avocado. Fruit harvested from Goleta area on April 25, June 20 and August 16, 2005. Harvest dry matter was 34.1%, 31.8% and 32.7%, respectively at the time of harvest. Target firmnesses achieved by treating fruit with 40-60 ppm ethylene for varying lengths of time. A. Fruit harvested April 25, 2005. B. Fruit harvested June 20, 2005. C. Fruit harvested August 16, 2005.

A.



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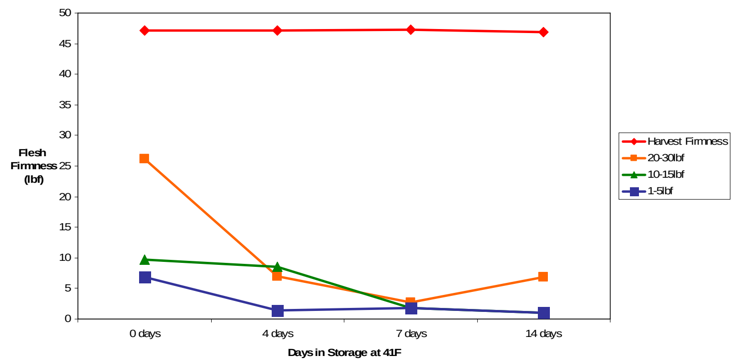

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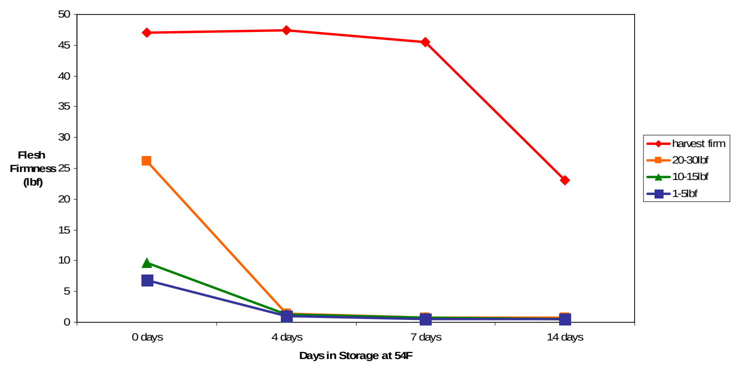


Figure 7. The interaction between storage temperature (32, 41 or 54F, ~90% RH), fruit firmness prior to storage (target firmnesses of 20-30 lbf, 10-15 lbf and 1-5lbf) and storage duration (0, 4, 7 or 14 days) on the softening of ‘Hass’ avocado. Fruit harvested from Goleta area on June 20, 2005. Harvest dry matter was 31.8% at the time of harvest. Target firmnesses achieved by treating fruit with 40-60 ppm ethylene for varying lengths of time. A. Fruit stored at 32F. B. Fruit stored at 41F. C. Fruit stored at 54F.

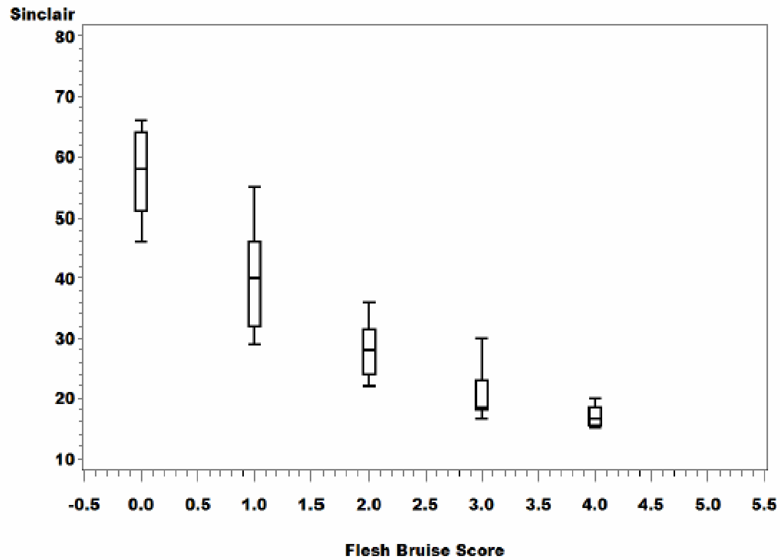
Type 1

Type 2

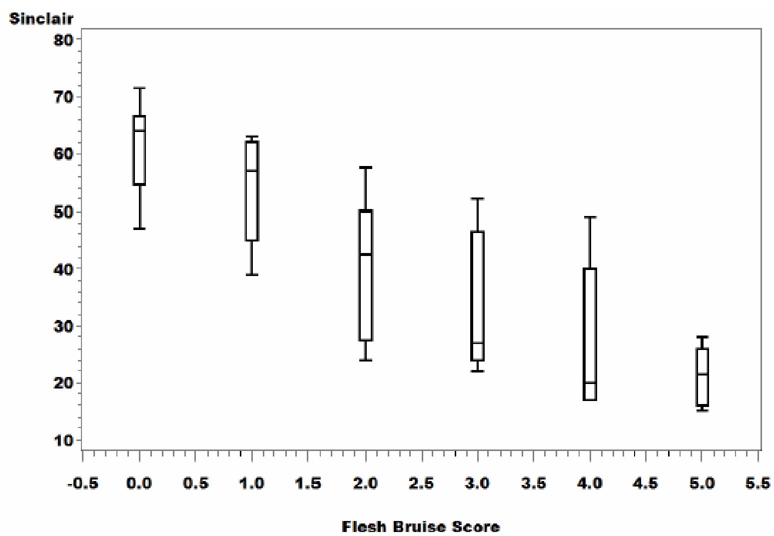
Type 3

Type 4

Figure 8. Examples of package types used in June 2005 packaging test: Type 1, UCD Tray; Type 2, Clamshell Beta; Type 3, Standard Tray; Type 4, Volume Fill.



A.



B.

Figure 9. The relationship of fruit firmness to internal flesh bruising following simulated transit conditions across the United States. A. UCD tray type (results not significantly different from the non-vibrated control. B. Volume fill package. Fruit firmness measured using a Sinclair Firmness Detector. The lower the number, the less firm (more ripe) the fruit.