Avocado Postharvest Quality

Continuing Project; Year 3 of 5

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Benefit to the Industry

This project will help to maintain and enhance the California avocado industry by continuing a project evaluating the potential of snap harvesting and initiating postharvest evaluation on patented and unreleased varieties. 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.

Objectives

A. To initiate a postharvest evaluation program on the unreleased plant material from the breeding program.
B. To develop a research program aimed at quantifying ripening of the 'Hass' avocado and development of a non-destructive ripening measure at point of sale.

Summary

A. To initiate a postharvest evaluation program on the unreleased plant material from the breeding.

In the summer of 1998, 1999 and 2000 we have harvested fruit from the UC South Coast Research and Extension Center (UC SCREC) from the breeding blocks. Only in 2000 were there sufficient fruit to do a full postharvest evaluation. In 2000 we selected by size and relative absence of defects (there was prevalent avocado thrips scarring on all fruit) approximately 300 fruit. We harvested fruit from 'Hass', 'Lamb Hass', 'Harvest', 'GEM', 'Marvel' (BL516), and 'Nobel' (BL667) trees in Field 46. We evaluated the tolerance to storage (0, 3, 6 weeks 41 F) by examining the days to ripeness, susceptibility to chilling injury and postharvest decay. Additionally, the feasibility of snap harvesting these varieties was assessed. One half of the fruit were treated for 24 hours with approximately 100 ppm ethylene to stimulate ripening. We also

conducted limited sensory evaluation on these varieties. The data from these studies has been collected and is currently being entered for statistical analysis. The results presented below are averages of the data but without any statistical analysis. All decayed fruit were given to Dr. Smilanick and D. Margosan for pathogen isolation and identification.

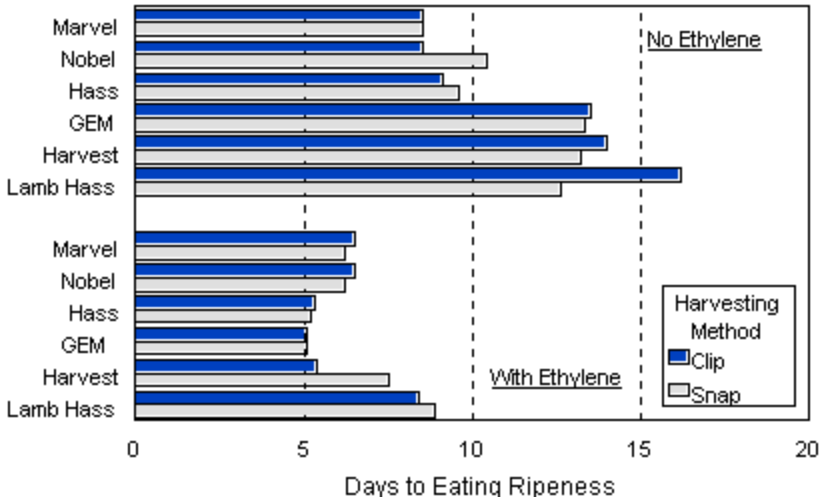
Harvest dry weight and the overall percentage of germinated seeds. Table 1 presents the average dry weight (5 fruit sample, individual determination) at the time of harvest and the percentage of the fruit when ripened and evaluated which had germinated seeds (seeds were evaluated as "germinated" if the seed was cracked).

Table 1. Dry weight and the percentage of germinated seeds for fruit harvested from UC SCREC in July 2000.

Selection	*Dry Weight (%)*	*Seed Germination (%)*
Hass	32.90	17.9
Lamb Hass	27.71	5.0
GEM	31.62	8.3
Harvest	28.75	0.8
Marvel	32.88	20.0
Nobel	33.88	18.2

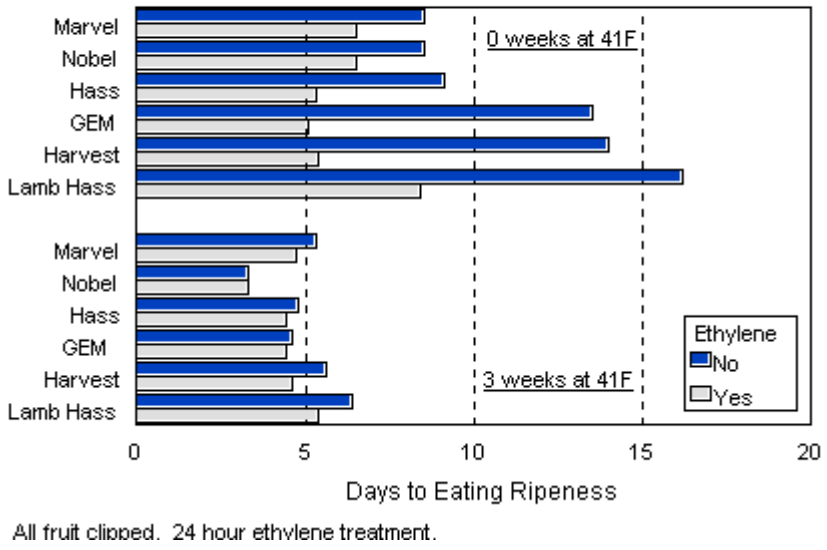
The days to eating ripeness as influenced by harvesting method. Figure 1 illustrates the average time to eating ripeness (as determined by penetrometer measurement) for fruit either "clipped" or "snapped" harvested. Note that there appears to be no consistent differences in the rate of ripening based on the harvesting method. No apparent differences were also noticed in the relative rate of ripening following either 3 or 6 weeks storage between harvesting methods (data not presented).

Figure 1. The influence of harvesting method on the days to eating ripeness at 68F following no storage.



The days to eating ripeness as influences by ethylene and storage duration. Figure 2 illustrates the average time to eating ripeness following a 24 hour ethylene treatment either after 0 or 3 weeks of storage at 41F. The use of ethylene enhanced the relative rate of ripening by 40 to 60% when the fruit had not been stored. The magnitude of this effect is related to variety and most likely fruit maturity since it is known that the time for ripening is dependent on fruit maturity; the more mature the shorter the time for ripening. The obvious effect of ethylene on the rate of ripening is lessened considerably following 3 weeks of storage. Although the fruit treated with ethylene for the most part ripened faster, the magnitude of difference ranged from 0 to 20% faster.

Figure 2. The influence of storage duration on the days to eating ripeness at 68F following storage.



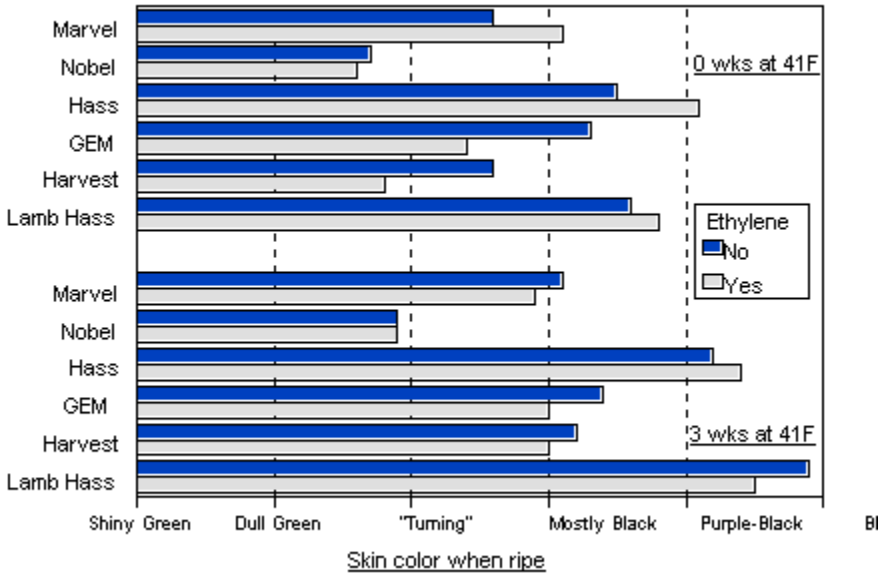
All fruit clipped. 24 hour ethylene treatment.

The influence of ethylene and storage on the final skin color of ripe fruit. We rated the fruit external color on a 1 to 6 scale (originally developed by A. Woolf and co-workers in New Zealand) before and after ripening. Figure 3 shows the ripe fruit color for the different varieties. All these varieties have been described as "black" when ripe but one can note that in most cases the color of the ripe fruit ranges from "just turning" black to "mostly black". The use of ethylene in general enhances color development. We also noted a trend to more fully colored fruit following storage.

Sensory Evaluation of the different cultivars. Difference Tests were conducted on the fruit. The results are summarized below. Table 2 indicates that differences between the visual appearance of the unripe fruit could be detected when 'Harvest', 'Marvel' and 'GEM' were compared to 'Hass'. The judges could not determine differences between the 'Nobel' and the 'Hass' nor the 'Hass' pair. When the fruit were ripe, the results were different. In the ripe fruit the judges could still determine that the 'Marvel' and the 'GEM' were different from the 'Hass'. They also were able to detect visual differences between the 'Hass' and the 'Nobel'. This is most likely due to the lack of "black" color development in the ripe 'Nobel' (see Figure 3). Following

ripening, the difference between the 'Harvest' and the 'Hass' that was detected in unripe fruit was not detectable.

Figure 3. The influence of storage duration on the skin color of ripe fruit.



All fruit clipped. 24 hour ethylene treatment.

Table 2. Fruit visual evaluation.

UNRIPE		
Hass vs. Hass	17/23* and 22/23***	A highly significant number of judges could determine that this pair was the same variety
Hass vs. Nobel	12/23	No significant differences could be detected
Hass vs. Harvest	18/23**	Significant differences at the 1% confidence level
Hass vs. Marvel	20/23***	Significant differences at the 0.1% confidence level
Hass vs. GEM	18/23**	Significant differences at the 1% confidence level
RIPE		
Hass vs. Hass	8/26 and 26/26***	The first pair did not ripen at the same rate and did not look similar at the time of evaluation; a highly significant number of judges could determine that the second pair was the same variety
Hass vs. Nobel	20/26***	Significant differences at the 0.1% confidence level
Hass vs. Harvest	6/26	No significant differences could be detected
Hass vs. Marvel	18/26**	Significant differences at the 1% confidence level
Hass vs. GEM	26/26***	Significant differences at the 1% confidence level

Protocol:

1. Unripened (green) fruit of similar size and weight.
2. Stored at 41F for approximately 1 week.
3. Presented fruit in pairs. Judges asked to decide if fruit in each pair were of the same or different variety.
4. Used rolling cart to take samples to judges at various places at KAC.

Table 3 presents the results of two tests, again using pairs of fruit, on the flavor of the fruit. We conducted these tests either after 0 or 3 weeks of storage. Without any storage, the panelists were not able to detect any flavor differences between the pairs of fruit. Following ripening after 3 weeks of storage, however, the judges were able to detect the difference ($P \leq 0.01$) between the 'Harvest' and the 'Hass'.

Table 3. Paired Difference Test of Flavor of Avocado Cubes

Results of 0 week storage test:		
Hass vs. Nobel	14/30	Out of 26+ responses for each variety, none were determined to taste significantly different than 'Hass'.
Hass vs. Harvest	15/26	
Hass vs. Marvel	13/26	
Hass vs. GEM	15/30	
Results of 3 week storage test:		
Hass vs. Nobel	8/16	The panelists could detect differences between the 'Hass' and the 'Harvest'. The other varieties were not easily distinguished from the 'Hass'.
Hass vs. Harvest	14/16**	
Hass vs. Marvel	10/16	
Hass vs. GEM	10/16	

Protocol:

1. Ripened fruit was cut into cubes and presented to panelists in 1-oz. soufflé cups.
2. Two sets of each variety were presented.
3. Pairs were presented in randomized order and coded with 3-digit random numbers.
4. Panelists were asked to taste the samples and indicate if the two samples in each pair were the same variety avocado or different varieties.
5. Panelists were asked to rinse their mouth with the distilled water provided to cleanse the taste of the previous sample tasted.

B. To develop a research program aimed at quantifying ripening of the 'Hass' avocado and development of a non-destructive ripening measure at point of sale.

The research for this project objective is being conducted by researchers (Anne White, Katy Cox, Allan Woolf, Anne Gunson and Shane Walker) at HortResearch in Aukland, New Zealand. What follows is their report of progress to date.

Ripening characteristics of 'Hass' avocados
Preliminary Report September 2000

Flesh softening is the most important physical change observed during ripening and is used by consumers as an indication of when a fruit is ready to eat. A range of methods is available to measure firmness. In this study whole fruit firmness was assessed by Hand squeezing (0=very firm to 6=very soft), the Firmometer (skin intact) and puncture with the Effegi probe (skin removed). Spatial firmness was measured by driving a 2 mm diameter probe into the flesh of a

fruit which had been cut in half longitudinally. Each fruit was probed in the proximal (4 measurements), equatorial (3 measurements) and distal (3 measurements) zone.

Flavor is determined once a fruit is "ripe" or "soft" and is largely dependent on fruit maturity. Although there has been considerable research into the effect of maturity on flavor acceptability, the sensory attributes of avocado have not been described in detail.

The purpose of this investigation was to quantify the changes during ripening/softening as measured for the whole fruit or spatially within the 'Hass' avocado. The influence of postharvest handling (cold storage, ethylene treatment and ripening temperature) fruit size and fruit temperature at the time of measurement on ripening/softening was determined. The importance of skin thickness and strength was also examined. Sensory descriptors were developed to describe odor, flavor and texture and will form the groundwork for subsequent research.

Whole fruit firmness. This work has confirmed that a significant linear relationship (R^2 of 0.89) exists between hand firmness and the Firmometer value in avocados ripened under a variety of conditions. A curvilinear relationship was found between hand firmness and Effegi puncture values. As fruit approach eating ripeness the Effegi puncture values change very little.

Effegi puncture measurements were affected by fruit size. During ripening, smaller fruit (184 - 207 g) were measured as being firmer than larger fruit (325+ g) at the same hand firmness. This trend also occurred when puncture measurements were categorizing by Firmometer values instead of hand ratings which suggests that the difference was not simply due to misclassification by hand. This effect may be due to the Effegi probe building up greater resistance pressure in smaller fruit.

There was a trend for fruit to be firmer at lower temperatures (5°C) than higher temperatures (25°C) when measured using the Effegi puncture or Firmometer, but this was not statistically significant.

Spatial firmness. In general, fruit ripened first at the equator, then at the distal end and lastly at the proximal end. Once fruit had softened to a hand firmness rating of about 3 there was no difference in firmness between the three zones. Ethylene treatment and cold storage did not significantly influence the way in which fruit ripened spatially. Fruit of the same hand firmness (rating = 2.5) were firmer at the proximal end when ripened at 15°C than when ripened at 25°C. There was no significant difference in spatial softening between fruit ripened at 15 and 20°C.

Under normal ripening conditions, skin thickness and strength did not influence firmness measurements. Skin thickness ranged from 1 - 2.2 mm, with skin at the front (button side) being thicker than skin at the back of the fruit. Although skin thickness varied significantly around a fruit, skin thickness did not influence the Firmometer measurement. Skin strength did not change during ripening, implying that the Firmometer primarily measures changes in the flesh.

The main sensory attributes of 'Hass' avocados identified using descriptive analysis were Hay/Dried Grass, Green and Nutty odor, Woody/Pine, Savory and Canned Pea flavors and Bitter

taste. The main texture terms were Oil Release, Water Release and Fibrousness. Reference standards were developed for these descriptors.

Future research will expand on this work by quantifying changes in physical and sensory parameters as fruit ripen to define ripeness stages and how they vary over a commercial season.