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Effects of Clip vs. Snap Harvest of Avocados on Ripening and Weight Loss[1]

Irving L. Eaks[2]
University of California, Riverside

ABSTRACT. Avocado fruits of cvs. Bacon, Fuerte, Hass, and Zutano were harvested by clipping (stem in) or snapping stem removed and placed directly at 20°C. The 2 harvest methods showed no significant differences within each cultivar in the percentage wt loss or ripening rate. Clipped and snapped 'Fuerte' avocados stored at 5°C for 2, 3, or 4 weeks and transferred to 20°C showed similar rates of wt loss, ripening and respiration for the respective storage periods. Storage at 5°C tended to reduce the rate of ripening at 20°C. The respiratory patterns at 20°C for snapped and clipped 'Fuerte' placed directly at 20°C and held at 5°C for 2, 3, or 4 weeks were similar within each storage treatment. 'Fuerte' stored at 5°C displayed peak respiration rates 18 to 24 hr after transfer to 20°C and then a decreasing rate without a subsequent rise associated with ripening.

Harvesting avocado fruits is an expensive and, with larger trees, a difficult and hazardous operation (2). In California harvesting is done with hand clippers or a long pole equipped with a clipper and cloth catching bag (9). Emphasis is placed on clipping close to the fruit and leaving the stem in place to insure uniform ripening (9). Preliminary tree-shake harvest trials indicated that part of the fruit was removed without stems. Adopting this method would necessitate handling fruit with and without stems (10). In addition hand snapping avocados instead of clipping would increase picking rates and reduce costs. The ripening rate of avocados is influenced by maturity (4, 15), temp (8, 12), and relative humidity (7). The industry practice is based on the belief that there is a difference in storage life and ripening rate between fruit with and without stems. There is nothing in the literature to substantiate this idea. Herein, I report results comparing the ripening response and rate of wt loss of avocado fruits with and without stems.

Materials and Methods

Avocado, *Persea americana* Miller, fruits were harvested by clipping (stems in fruit) and snapping (stem removed), brought to the laboratory, weighed, and placed under experimental conditions within 3 hr for all experiments, except those with 'Bacon' for which the delay was 24 hr. Also, with 'Bacon' 2 types of shaker removal systems were used, i.e., a tree and a limb shaker (10). Although fruits with and without stems were recovered from the shaker removal, only fruit without stems were used. The stem scar

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[2] Department of Biochemistry

of some fruit was waxed by covering the stem car with a water emulsion fruit wax. Twelve fruits for each treatment from each of 2 harvests, 10 days apart, were used for the 'Zutano' and 'Hass' avocados, and only 1 harvest of 'Bacon' was used. The fruits were placed in open trays at 20°C with the relative humidity ranging from 55 to 70%. Two experiments were conducted with 'Fuerte' avocados. The clipped and snapped fruit for each experiment were randomly divided into 4 samples of 12 fruits each. One set of samples was placed at 20° C and the others were stored in open trays at 5°C for 2, 3, and 4 weeks before transferring to 20°C. At 20°C, 6 fruits of each sample were placed in open trays and the other 6 were placed in respiratory chambers.

Table 1. Effect of harvesting practices and waxing the stem scar of snapped fruit on wt loss of 'Bacon', Zutano', and 'Hass' fruit at 20°C.

Treatment	% wt loss, Days at 20°C, 4	% wt loss, Days at 20°C, 10
	Bacon	
Hand picked clip	4.2±.2	11.4±.4
Hand picked snap	4.1±.2	11.0±.5
Hand picked snap[z]	3.6±.2	9.7±.4
Limb shaker	4.2±.2	11.5±.4
Trunk shaker	4.3±.3	11.8±.5
	Zutano	
Hand picked clip	4.9±.3	12.0±.4
Hand picked snap	4.5±.2	11.6±.5
Hand picked snap[z]	3.9±.2	9.8±.4
	Hass	
Hand picked clip	3.9±.2	10.7±.4
Hand picked snap	3.7±.2	10.3±.4
Hand picked snap[z]	3.2±.2	8.8±.4

[z]Stem scar waxed.

Percentage wt loss was determined by weighing each fruit to the nearest g initially and periodically during the experimental period. Ripening was evaluated subjectively by applying gentle pressure with the fruit held in the palm of the hand. Four categories were used as follows; hard, firm, softening, and soft (ripe) and were given numerical values of 0, 1, 2, and 3, respectively. The ripening index was calculated by multiplying the number of fruit in each category by the respective value, summing the products and dividing by the total number of fruits.

The rate of CO_2 production was determined by a model 215 Beckman infrared nondispersion CO_2 analyzer connected to a Leeds and Northrup recorder. The air stream, metered by calibrated capillaries through the chambers, was freed of CO_2 by bubbling it through a fritted gas-dispersion tube into 2 N NaOH and then through water to humidify it. Anhydrous $CaCl_2$ was used to dry the gas stream before it entered the analyzer. A 13-channel switching device directed the air stream from each of the 12 fruit chambers and the air background in sequence once each hr to the analyzer. Readings were taken every 3 hr from the chart, converted to μl CO_2/l from standard curves and the respiratory rate calculated as ml CO_2/kg/hr.

Results and Discussion

The percentage wt loss after 4 and 10 days at 20°C for 'Bacon', 'Zutano' and 'Hass' was not significantly different between fruit harvested by clipping or snapping (Table 1). The snapped fruit tended to have slightly lower percentages of wt loss than the clipped fruit, which may reflect the influence of the stem in facilitating water movement in addition to the more rapid rate of water loss of the succulent stem itself. Waxing the stem scar of snapped fruit reduced the percentage of wt loss, indicating that the stem scar plays an important role in wt loss. Although the cut stems of the clipped fruit were not waxed, indications are that this also would reduce wt loss, at least prior to ripening, because the stem abscises as the fruit ripens. When abscission occurred, the abscised stem was weighed with the respective fruit. 'Bacon' fruit removed by the limb or trunk shaker had

slightly higher percentages of wt loss, but not significantly different from hand-picked fruit. Although the fruit used were selected at random (without stems), few surface injuries were present. Scratched hand-harvested fruit (3 scratches - 1 mm deep and 2.5 cm long) had percentages of wt loss 25 to 35% higher than the non-scratched fruit reported in Table 1. Shaker-harvested fruit with prominent mechanical injuries should be graded out to eliminate the wt loss problem, decay, and also the scars that would be objectionable in the market.

Table 2. Effect of harvesting practices and waxing the stem scar of snapped fruit on ripening of 'Bacon', 'Zutano', and 'Hass' fruit at 20°C.

	Ripening index[z]							
	Days at 20°C							
	5	6	7	8	9	10	11	12
				Bacon				
Hand pick clip	0.0	1.2	1.6	1.8	2.1	2.4	2.8	3.0
Hand pick snap	0.0	1.5	1.9	2.1	2.3	2.6	2.9	3.0
Hand pick snap[y]	0.0	1.4	1.7	1.9	2.2	2.4	2.7	3.0
Limb shaker	0.4	1.8	2.2	2.5	2.7	2.8	2.9	3.0
Trunk shaker	0.3	1.8	2.1	2.3	2.5	2.8	2.9	3.0
				Zutano				
Hand pick clip	0.3	0.8	1.3	2.0	2.6	3.0		
Hand pick snap	0.5	1.1	1.7	2.3	2.7	3.0		
Hand pick snap[y]	0.4	1.0	1.5	2.2	2.6	3.0		
				Hass				
Hand pick clip	0.5	0.9	1.2	1.9	2.5	2.8	3.0	
Hand pick snap	0.4	0.8	1.0	1.7	2.4	2.7	3.0	
Hand pick snap[y]	0.5	0.8	1.1	1.8	2.4	2.8	3.0	

[z]Hard-0; Firm-1; Softening-2; Soft-3.
[y]Stem scar waxed.

The ripening rate for 'Bacon', 'Zutano' and 'Hass' at 20°C was not influenced by harvesting practice or waxing the stem scar (Table 2). Considerable variation occurred in the rate of ripening of individual fruits. The number of days for individual fruit to reach the soft stage (ripe) ranged from 8 to 12 for 'Bacon', 7 to 10 days for 'Zutano', and 8 to 11 days for 'Hass', but the ripening indices on any one day for each cultivar showed only minor variation between harvesting practices.

Clipping vs. snapping 'Fuerte' had no significant effect on the percentage wt loss during storage at 5°C or during ripening at 20°C (Table 3). For fruit placed directly at 20°C and those held 2 weeks at 5°C and transferred to 20°C, there was a tendency for the snapped fruit to show less wt loss than the clipped fruit, similar to the other 3 cultivars (Table 1).

Table 3. Effect of harvesting practices and 0, 2, 3, and 4 weeks storage at 5°C on wt loss of 'Fuerte' fruit at 20°C.

Weeks at 5°C	Treatment	% wt loss	
		When transferred to 20°C	After 5 days at 20°C
0	clip	0.0	7.8±.3
	snap	0.0	7.5±.4
2	clip	2.4±.2	8.4±.4
	snap	2.0±.2	8.0±.4
3	clip	3.0±.2	8.8±.4
	snap	3.4±.2	9.2±.4
4	clip	3.7±.2	9.9±.5
	snap	4.0±.3	10.2±.6

However, for those fruit held for 3 or 4 weeks at 5°C and transferred to 20°C the tendency was reversed. The differences in wt loss between the harvesting techniques would be of minor commercial importance. The effect of the vapor pressure deficit as pointed out previously (13, 14) is strikingly illustrated by the differences in the rate of wt loss at 5° and 20°C. The average vapor pressure deficit was 1.0 and 6.1 mm Hg for 5° and 20°C, respectively. Converting the percentage wt loss given in Table 3 to percentage wt loss per day at 5° and 20°C, the range at 5°C is 0.13 to 0.17% and at 20°C from 1.16 to 1.24%, about a 10 fold difference.

Clipping vs. snapping 'Fuerte' fruit had little effect on the rate of ripening within each storage treatment (Table 4). Storage at 5°C, however, decreased the rate of ripening at 20°C compared with fruit placed directly at 20°C. This phenomenon has been observed in other storage studies with avocados (unpublished data), which is contrary to a

previous report (3). The delay in ripening is attributed to chilling injury as well as the surface discoloration observed on fruit ripened at 20°C subsequent to storage for 3 and 4 weeks at 5°C. Although 5°C is below the recommended storage temp for avocados (12, 13), it was used because this is the storage temp employed by the California avocado industry for a majority of the fruit.

Table 4. Effect of harvesting practice and 0, 2, 3, and 4 weeks storage at 5°C on ripening of 'Fuerte' fruit at 20°C.

Weeks at 5°C	Treatment	Ripening index[z] Days at 20°C 2	3	4	5	6	7
0	clip	0.2	1.0	2.0	3.0		
	snap	0.1	1.0	2.1	3.0		
2	clip	0.1	0.8	1.7	2.5	3.0	
	snap	0.4	0.9	1.4	2.7	3.0	
3	clip	0.6	1.0	2.0	2.8	3.0[y]	
	snap	0.3	1.4	2.2	2.7	3.0[y]	
4	clip	0.2	0.7	1.8	2.5	2.8	3.0[x]
	snap	0.1	0.4	1.3	2.0	2.6	3.0[x]

[z]Hard-0; firm-1; softening-2; soft-3.
[y]Slight surface discoloration.
[x]Moderate to severe surface discoloration.

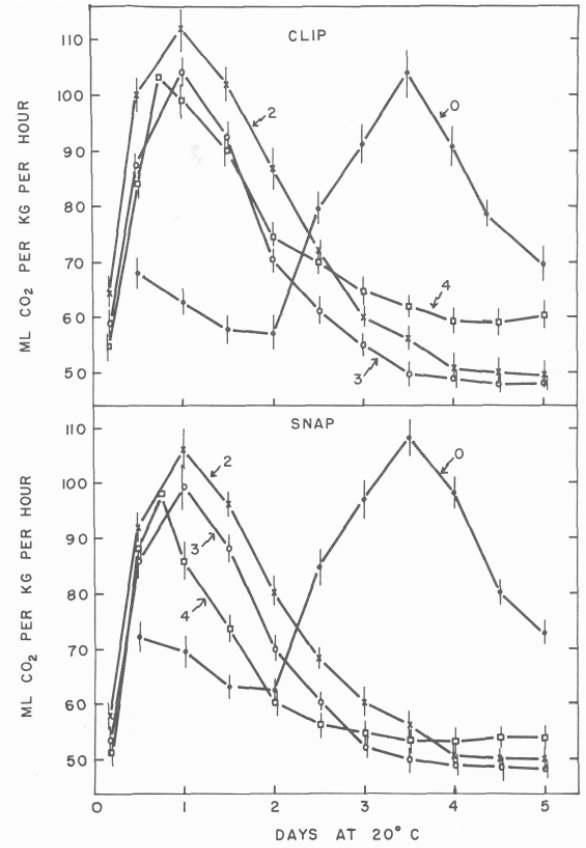

Fig. 1. Average respiratory rate of clipped and snapped 'Fuerte' fruit at 20°C after 0, 2, 3, and 4 weeks at 5°C. Weeks at 5°C are indicated by number and symbol (● = 0 weeks, X = 2 weeks, ○ = 3 weeks and □ = 4 weeks). Standard error of the mean is given by the vertical lines.

The respiratory rates of clipped and snapped 'Fuerte' fruit at 20°C after 0, 2, 3, and 4 weeks at 5°C are shown in Fig. 1. The fruit placed directly at 20°C displayed a broad climacteric pattern typical for the average of several fruit. The individual fruit, however, reach the peak at different times with insignificant differences between the clipped and snapped fruit. The pattern for individual fruits displayed a rather sharp climacteric peak as reported previously (6). The respiratory rates following transfer to 20°C from 5°C show a rising respiratory rate initially which is attributed to 2 factors, the first is the increase in temp. The fruit reached temp equilibrium at 20°C 4 to 5 hr after transfer as indicated by thermocouples placed in fruits not used for respiratory rate determinations. The remainder of the burst of CO_2 production was attributed to the response to chilling injury as has been observed at non-chilling temp following exposure to chilling temp (1, 5, 11). The response of clipped and snapped fruits at 20°C following chilling were similar. The initial rise of chilled avocados reached the peak rate within 18 to 24 hr after transfer to 20°C, and the subsequent softening (Table 4) was not accompanied by another rise in the respiratory rate. Snapped fruit held for 3 and 4 weeks at 5°C

developed small areas of decay (Dothiorella) at the stem end in the high relative humidity conditions in the respirator chambers, but no decay was observed on fruit held in open trays.

These results indicate that snapping (stems removed) avocado, fruits does not significantly influence the rate of wt loss, storage ability, ripening rate, or respiratory response compared with. clipped fruit (stems in). Therefore, it appears commercially feasible to market snapped or shaker harvested avocados.

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