THE EFFECT OF ETHYLENE TREATMENT ON FRUIT QUALITY AND RIPENING FOR LATE SEASON 'HASS' AVOCADOS STORED UP TO SIX WEEKS.

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ABSTRACT

New Zealand avocados exported long distances are usually ethylene ripened before sale. These fruit naturally ripen quickly without ethylene treatment. Treating these fruit with ethylene unnecessarily could potentially have an adverse affect on their quality. Late season fruit (March harvest) were treated with ethylene after various storage periods up to 42 days at 4°C. Fruit treated with ethylene immediately after harvest had better quality and ripened faster than control fruit. The improvement in quality was small and unlikely to be important commercially. Coolstored fruit had poorer quality and faster ripening times with increased storage periods. Fruit treated with ethylene after 14 days storage had slightly greater severity of brown patches and greater incidence of unsound fruit than the untreated control. For fruit stored longer than 14 days there was no effect of ethylene treatment on either ripening time or unsound fruit. Ripening late season avocados stored longer than 14 days with ethylene did not alter ripening times or affect fruit quality. Treating exported avocados with ethylene is unlikely to affect fruit quality.

keywords: ethylene treatment, fruit age, quality, weight loss, days to ripen

INTRODUCTION

Avocado fruit are harvested unripe and require a period after harvest to soften and attain eating ripeness. When left to ripen naturally a batch of avocado fruit can, depending on the time year, dry matter content and ripening temperature, vary considerably in the time taken to ripen (Dixon *et al.*, 2003a). Consumers of avocados are increasingly being presented with avocado fruit that are ready to eat. Exposing avocado fruit to ethylene forces them to ripen more quickly and evenly than when ripened naturally (Woolf and White, 1999). An increased rate of ripening may also have the additional benefit of improving fruit quality through reduced incidence and severity of post harvest rots (Dixon *et al.*, 2003a).

Rates of avocado ripening change as the harvest season progresses with early season fruit taking longer to ripen than late season fruit (Dixon *et al.*, 2003b). In addition, coolstored avocados ripen faster the longer they are kept in storage (Dixon *et al.*, 2003a). Fruit that is exported typically has been in

storage for a sufficiently long period to have ripening times similar to those of ethylene treated, non-stored fruit. In other words these fruit do not require ethylene treatment to trigger the ripening process. New Zealand avocado fruit exported to the USA and Australia are often ethylene ripened prior to sale but neither the fruit age nor maturity of the fruit is taken into account in determining the necessity for ethylene treatment. There remains the possibility that ethylene treatment of fruit already primed to ripen rapidly could compromise fruit quality. Late season fruit were treated with ethylene to determine if the ripening treatment has any adverse consequences on fruit quality in late season avocados. To simulate the time taken to reach export markets fruit were stored for different lengths of time before ethylene treatment to determine if fruit age was a factor affecting the response of fruit quality to ethylene.

MATERIALS AND METHODS

Avocado fruit were harvested from three commercial orchards in the Bay of Plenty (37°S, 176°E). Eight hundred fruit were harvested from each orchard on 6 March 2003. Within 4 hours of harvest fruit were weighed and packed into trays. The fruit were then placed into a commercial coolstore at 4°C ± 0.5°C, 85% RH. A sample of 100 fruit per grower was removed from storage every 14 days for up to 42 days and treated with ethylene at 100 ppm for 12 hours at 17°C ± 1°C in a commercial ripening facility before venting for 12 hours then removed to 20°C, 60% RH for ripening. Untreated control fruit were maintained at 17°C ± 1°C for 24 hours before ripening. A non-stored control sample of 100 fruit per orchard was ripened at 20°C, 60% RH, immediately after ethylene treatment. An additional 20 fruit sample from each orchard was assessed for percentage dry matter by drying flesh peelings from the inside face of one quarter of each fruit after the seed, seed coat and skin were removed. After removal from storage unripe green fruit and eating ripe fruit were assessed for disorders according to the Avocado Industry Council Fruit Assessment Manual (Dixon, 2001a).

RESULTS AND DISCUSSION

Non-stored fruit

Treatment with ethylene significantly ($p<0.001$) reduced the time to ripen by about 17 hours (0.7 days) and reduced the spread of ripening times by one day (Table 1). Ethylene treated fruit had significantly ($p<0.05$) less weight loss during ripening than control fruit. Fruit treated with ethylene had a significantly ($p<0.05$) greater incidence of stem-end rot but there was no significant difference in the severity of stem-end rots (Table 3). The incidence and severity of brown patches was the same in control and ethylene treated fruit (Table 4). There was no significant difference in diffuse flesh discolouration between control and ethylene treated fruit (Table 5). The incidence of unsound fruit, using a 5% disorder severity threshold (Dixon, 2001b), was significantly ($p<0.05$) greater in control fruit than in ethylene treated fruit (Table 6).

Coolstored fruit

Ripening time was faster for coolstored fruit than non-stored fruit (Table 1). Fruit stored longer than 14 days had faster ripening times taking 2-3 days to ripen compared with 3-4 days with fruit stored for 14 days or the control. With more than 14 days coolstorage ethylene treated fruit had a similar ripening time compared to the control fruit. Coolstored fruit ripened more evenly than non-stored fruit with ethylene treated fruit ripening within one day of each other when treated after 14 days storage (Table 1). The spread of ripening times was the same for fruit stored longer than 14 days regardless of treatment.

In general, ethylene treatment decreased ripening times and the unevenness of ripening in non-stored fruit but had little effect on coolstored fruit. Based on these findings it would appear that treating late season avocados with ethylene after coolstorage will make little practical difference to the ripening time and the evenness of ripening.

Table 1. Effect of ethylene treatment on ripening time and evenness of ripening time for 'Hass' avocados harvested 6 March 2003.

	Days at 4°C, 85% RH							
	0	14	28	42	0	14	28	42
	Days to ripen				Range of days to ripen			
Control	5.5	4.3	2.4	3.2	3.9	1.1	1.1	1.1
Ethylene[1]	4.8	3.9	2.5	3.3	2.8	0.2	0.9	0.9
Significance[2]	***	*	NS	*	*	**	NS	NS

[1]Fruit were exposed to 100 ppm ethylene for 12 hours at 17°C before venting after storage at 4°C

[2]NS = not significant, * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$

Weight loss generally was greater for control fruit than ethylene treated fruit. The longer the fruit were stored the more weight was lost (Table 2). Weight loss during ripening was significantly ($p<0.001$) less in fruit treated with ethylene after 42 days storage but was similar for fruit stored for either 14 or 28 days.

Table 2. Effect of ethylene treatment on weight loss in storage and during ripening for 'Hass' avocados harvested 6 March 2003.

	Days at 4°C, 85% RH							
	0	14	28	42	0	14	28	42
	Weight loss storage (%)				Weight loss ripening (%)			
Control	-	4.3	4.7	6.2	5.3	2.7	2.2	2.4
Ethylene[1]	-	4.5	5.8	5.1	4.4	2.7	2.3	1.9
Significance[2]	-	NS	*	**	**	NS	NS	***

[1]Fruit were exposed to 100 ppm ethylene for 12 hours at 17°C before venting after storage at 4°C

[2]NS = not significant, * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$

The incidence and severity of stem-end rot and brown patches increased with longer storage times (Tables 3 and 4). While stem-end rot in coolstored fruit was not affected by ethylene treatment the severity of brown patches was significantly ($p<0.05$) increased in fruit treated with ethylene after coolstorage for either 14 or 28 days. Although the incidence of brown patches was greater in control fruit after 42 days storage the quality of fruit in both treatments was poor.

Table 3. Effect of ethylene treatment on incidence and severity of stem-end rots for 'Hass' avocados harvested 6 March 2003.

	Days at 4°C, 85% RH							
	0	14	28	42	0	14	28	42
	Incidence Stem-end Rot				Severity Stem-end Rot			
Control	2.0	2.3	8.3	42.3	0.03	0.03	0.20	1.40
Ethylene[1]	7.7	2.3	10.3	38.3	0.14	0.04	0.25	1.40
Significance[2]	*	NS	NS	NS	NS	NS	NS	NS

[1]Fruit were exposed to 100 ppm ethylene for 12 hours at 17°C before venting after storage at 4°C
[2]NS = not significant, * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$

Table 4. Effect of ethylene treatment on incidence and severity of brown patches for 'Hass' avocados harvested 6 March 2003.

	Days at 4°C, 85% RH							
	0	14	28	42	0	14	28	42
	Incidence Brown Patches				Severity Brown Patches			
Control	35.7	32.3	51.3	90.3	0.8	0.7	2.4	9.2
Ethylene[1]	39.3	40.7	60.7	82.7	0.8	1.4	4.5	9.2
Significance[2]	NS	NS	NS	*	NS	*	*	NS

[1]Fruit were exposed to 100 ppm ethylene for 12 hours at 17°C before venting after storage at 4°C
[2]NS = not significant, * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$

Incidence and severity of diffuse flesh discolouration (typically seen as a flesh greying) was low in fruit coolstored up to 28 days but increased significantly after 42 days storage (Table 5). Ethylene treatment did not affect either the incidence or severity of diffuse flesh discolouration.

Fruit stored for longer than 14 days had an appreciable increase in unsound fruit (Table 6). Ethylene treatment increased the incidence of unsound fruit in fruit treated after 14 days coolstorage but had no effect on the incidence of unsound fruit when coolstored for longer than 14 days (Table 6).

Table 5. Effect of ethylene treatment on incidence and severity of diffuse flesh discolouration for 'Hass' avocados harvested 6 March 2003.

	Days at 4°C, 85% RH							
	0	14	28	42	0	14	28	42
	Incidence Diffuse Flesh Discolouration				Severity Diffuse Flesh Discolouration			
Control	0.0	0.3	0.7	27.7	0.0	0.0	0.4	7.3
Ethylene[1]	0.3	0.3	1.0	30.0	0.0	0.2	0.5	6.6
Significance[2]	NS	NS	NS	NS	NS	NS	NS	NS

[1]Fruit were exposed to 100 ppm ethylene for 12 hours at 17°C before venting after storage at 4°C
[2]NS = not significant, * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$

Table 6. Effect of ethylene treatment on the incidence of unsound fruit for 'Hass' avocados harvested 6 March 2003.

	Days at 4°C, 85% RH			
	0	14	28	42
	Incidence Unsound fruit (5% threshold)			
Control	4.3	3.0	16.7	64.3
Ethylene[1]	1.0	7.7	23.3	58.3
Significance[2]	*	*	NS	NS

[1]Fruit were exposed to 100 ppm ethylene for 12 hours at 17°C before venting after storage at 4°C
[2]NS = not significant, * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$

CONCLUSIONS

Late season avocados, treated with ethylene immediately after harvest in March, ripened faster and more evenly and had better quality than untreated control fruit. The differences in the time taken to ripen and the improvement in quality was small, however, and unlikely to be important commercially. Fruit stored for increasing durations had poorer quality and faster ripening times with increasing storage periods. Fruit ripened after 14 days storage had slightly faster ripening and more even ripening when treated with ethylene. There was a slightly greater severity of brown patches and a greater incidence of unsound fruit. Fruit stored longer than 14 days tended to be similar in their response to ethylene ripening where there was no effect on ripening time and had similar incidences of unsound fruit. Treating late season avocados coolstored for longer than 14 days with ethylene, in this trial, did not alter ripening times or affect fruit quality. Treating late season avocados with fruit ages greater than 14 days from harvest with ethylene does not appear to have any adverse impact on fruit quality.

ACKNOWLEDGEMENTS

Thanks to Simon Owen of NZ Kiwifruit Ltd packhouse for ethylene treating the fruit and Hugh Moore for the coolstore facilities. Thanks also to Rob Bayly, Brian Robinson and Hugh Moore for fruit.

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