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QUALITY OF AVOCADO (*PERSEA AMERICANA* MILL.) FRUIT AFTER STORAGE IN MODIFIED ATMOSPHERE FRESHAWAY™ BAGS

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ABSTRACT

The use of polyethylene bags to investigate humidity effects on storage and ripening may introduce a confounding effect due to the possible development of a modified atmosphere that inhibits ripening. Potential modified atmosphere effects were separated from the influence of humidity using Freshaway™ modified atmosphere bags. These bags were perforated with small holes to allow free gas exchange but still maintain a high humidity. There were three treatments: control (no bags in storage and ripening), high humidity modified atmosphere (intact Freshaway™ bags), high humidity (Freshaway™ bags perforated with 6mm diameter holes). Storing fruit in intact Freshaway™ bags reduced weight loss during storage and ripening compared to control fruit and increased the average ripening time by 3 days. Adding holes to the bags only slightly increased total weight loss during storage and ripening compared to intact bags and did not increase the ripening time relative to the control. These results suggest that perforating plastic bags used to generate high humidity storage environments removes a likely modified atmosphere effect of storage in plastic bags.

Keywords: *weight loss, stem-end rots, body rots, ripening, relative humidity*

INTRODUCTION

Understanding the relationship between postharvest losses of avocados and water loss on ripening is an important goal of the New Zealand avocado industry research programme. Previous research has indicated that ripening time after storage was increased where fruit weight loss was lowest or exogenous ethylene was removed (Dixon *et al.,* 2003). Longer ripening times led to greater incidence and severity of rots. An increase in ripening time was correlated to a delay in the onset of ripening that was related to greater levels of rots. Reducing water loss during storage alone did not reduce the rate of ripening whereas exogenous ethylene removal using ethylene adsorbent sachets increased the ripening time of the fruit.

A confounding factor in investigating the effect of humidity around the fruit during storage and ripening in polyethylene bags is the possible development of a modified atmosphere within the plastic bag. As avocado fruit are alive and respiring (Kays and

Paul, 2004) during storage and ripening considerable amounts of oxygen are consumed and carbon dioxide produced by the fruit. As a consequence of respiration a modified atmosphere can be generated within plastic bags where the oxygen concentration is less and the carbon dioxide concentration is much greater than found in normal air. Polyethylene bags can inhibit oxygen movement into the bag and carbon dioxide movement out of the bag as well as inhibiting water vapour movement into the surrounding atmosphere. Reduced oxygen and/or increased carbon dioxide concentrations within the atmosphere of a polyethylene bag are likely to inhibit the ripening of avocado fruit (Kays and Paull, 2004).

To assess if a modified atmosphere within a polyethylene bag has affected ripening and to isolate the influence of water loss from the effect of a modified atmosphere a trial was conducted examining ripening rates and rot development using modified atmosphere bags. To remove the modified atmosphere and allow only high humidity to be maintained the bags were perforated with small holes that would allow free gas exchange. The effects of high humidity and/or modified atmosphere during coolstorage and ripening on 'Hass[1] avocado fruit ripening and rot development were investigated in the 2003/2004 avocado harvest season.

MATERIALS AND METHODS

Avocado fruit cultivar 'Hass' were harvested from one commercial orchard in the Bay of Plenty (37°S, 176°E). Three hundred fruit were harvested on the 19 December 2003. Within 4 hours of harvest the ungraded fruit, average weight 246.56g, were weighed and packed into trays of 20 fruit.

There were three treatments each consisting of 100 fruit (5 trays of 20 fruit) per orchard:

Treatment 1: control. Fruit were stored in standard single layer trays with cardboard plixes.

Treatment 2: high humidity modified atmosphere. Fruit were stored on their cardboard plix trays within a standard single layer tray. The tray was placed into a 25-30 µm Freshaway™ modified interactive packaging (modified atmosphere bags, Bantec International Pty Ltd, Australia) 570mm wide by 800mm long. Bags were loosely sealed by folding over the open end of the bags before the trays were placed into storage.

Treatments: high humidity. Fruit were stored on their cardboard plix trays within a standard single layer tray. The tray was placed into a 25-30 pm Freshaway™ modified interactive packaging (modified atmosphere bags, Bantec International Pty Ltd, Australia) 570mm wide by 800mm long. The bags were modified by cutting 18 6mm diameter holes (9 per side of bag) using a no. 2 cork borer. Holes were positioned at the top and bottom of trays to ensure that a high humidity was maintained but that any modified atmosphere should be minimal. Bags were loosely sealed by folding over the open end of the bags before the trays were placed into storage.

The fruit were placed into a commercial cool store at 4°C ± 0.5°C, 85% ± 5% RH for 28 days. After removal from storage the fruit was removed from the bags, weighed and assessed for disorders according to the Avocado Industry Council Fruit Assessment Manual (Dixon, 2003) then placed back into trays which were then placed back into the

bags and ripened at 19.5°C ± 1 °C, 60% ± 5% RH.

Each day the bags were opened and fruit were assessed for firmness by hand squeeze. Once the fruit had reached eating ripeness as assessed by hand squeeze, equivalent to a firmness reading of at least 85 using a firmometer with a 300 gram weight the fruit were cut and assessed for disorders according to the Avocado Industry Council Fruit Assessment Manual (Dixon, 2003). Weight loss was calculated as the percentage difference of fruit mass when removed from storage or when cut as ripe from fruit mass when harvested. 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.

The results were analyzed as a complete randomised block design using tray average values for each treatment by MINITAB version 13.31.

RESULTS AND DISCUSSION

The fruit used in this experiment had an average dry matter content of 29.11% ± 2.5% (mean ± standard deviation). Storage in intact bags reduced weight loss by about half while storage in perforated bags reduced weight loss by about one quarter (Table 1). Weight loss during ripening was the same for intact or perforated bags and was about half the weight loss of control fruit. Total weight loss was greatest for the fruit stored and ripened in trays while the lowest weight loss occurred in fruit stored and ripened in intact bags (Table 1). The rate of weight loss was greater in perforated bags than intact bags suggesting that the holes made in the bags altered the gas exchange characteristics of the bags.

Table 1. Average weight loss and rate of weight loss of avocado fruit stored for 28 days at 4°C, 85% RH or in high humidity (Freshaway™ micro-perforated modified atmosphere bags), with and without 6mm holes, then ripened at 19.5°C, 60% RH.

Treatment	% Weight loss			Rate of weight loss (percent per day)	
	Storage[1]	Ripening[2]	Total	Storage	Ripening
Control	3.3a[3]	4.3a	7.5a	0.12a	0.88a
Modified atmosphere bags	1.7b	2.5b	4.1b	0.06b	0.31b
Perforated modified atmosphere bags	2.4c	2.3b	4.7b	0.09c	0.44c

[1]Weight loss of fruit on removal from storage, [2]Weight loss of fruit over the ripening period, fruit were retained in bags for ripening, [3]Means followed by the same letter are not different according to a One-way analysis of variance using a Tukeys family error rate of 5%.

Avocado fruit stored and ripened in intact bags had a very high incidence and severity of rots (Table 2). These fruit were ripened in the bags and it was noted that there was considerable condensation within the bags. The condensation is likely to have

contributed to the very high severity of rots. The perforated bags had a greater incidence and severity of rots than the control fruit (Table 2). Ripening time was the same for both treatments even though fruit stored in perforated bags had less weight loss than the control fruit (Table 2). The greater numbers of rots may have also been due to a longer ripening time of 3 days for fruit stored in intact bags. Ripening was slower for fruit stored in modified atmosphere bags (Figure 1). The development of stem-end rots in intact modified atmosphere bags was slower than in perforated bags. Such results suggest that the modified atmosphere bags had an additional effect apart from reducing weight loss.

Table 2. Average number of days to ripen, incidence and severity of stem-end and body rot and incidence of unsound fruit for avocado fruit stored for 28 days at 4°C, 85% RH or in high humidity (Freshaway™ micro-perforated modified atmosphere bags), with and without 6mm holes, then ripened at 19.5°C, 60% RH.

Treatment	Days to ripen[1]	Stem-end rot		Brown patches		Unsound fruit
		Inc[2]	Sev[3]	Inc	Sev	Inc[4]
Control	4.9a[5]	11.0a	0.2a	53.0	1.6a	12.0a
Modified atmosphere bags	8.2b	78.0b	8.7b	89.0	19.2b	73.0b
Perforated modified atmosphere bags	5.0a	44.0a	2.5c	56.0	6.5ab	32.0a

[1]The average number of days at 19.5°C after removal from coolstorage until ripe; [2]Incidence; [3]Severity; [4]Incidence of fruit with at least one disorder at greater than 5% severity; [5]Means followed by the same letter are not different according to a One-way analysis of variance using a Tukeys family error rate of 5%.

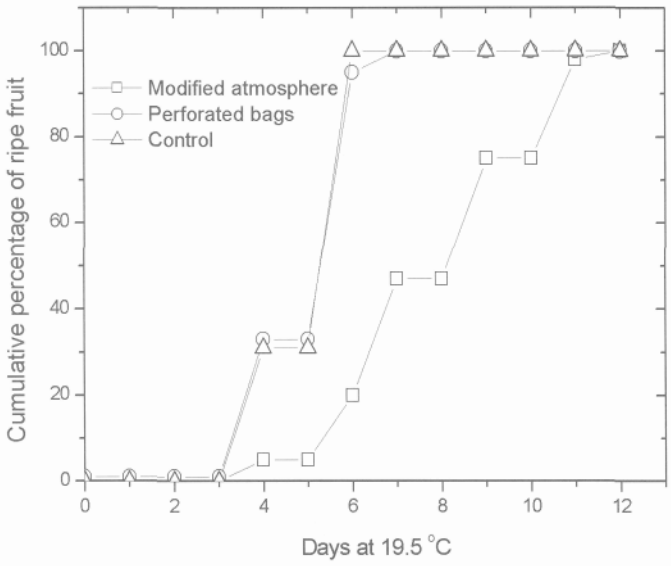

Figure 1. Cumulative percentage of fruit at the ripe stage during ripening at 19.5°C, 65% RH after storage for 28 days at 4°C, 85% RH.

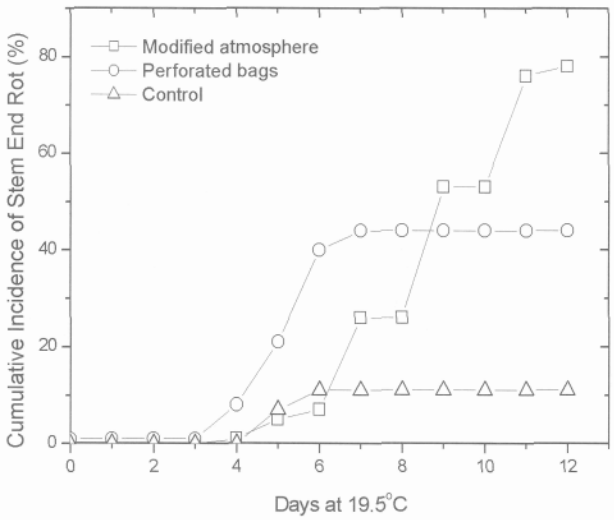

Figure 2. Cumulative incidence of stem-end rot in fruit at the ripe stage during ripening at 19.5°C, 65% RH after storage for 28 days at 4°C, 85% RH.

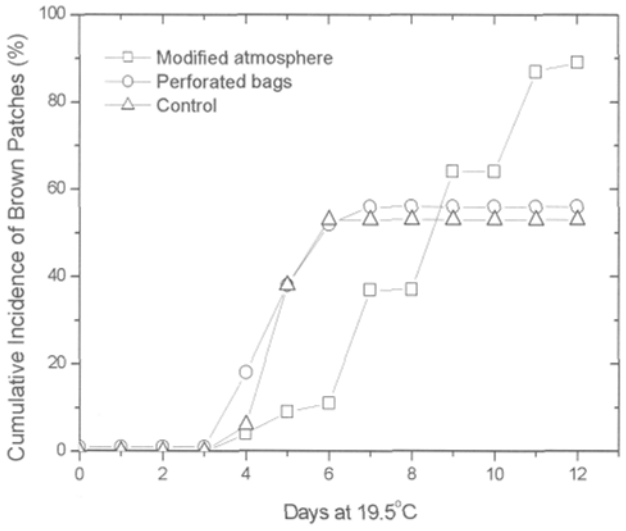

Figure 3. Cumulative incidence of brown patches (body rots) in fruit at the ripe stage during ripening at 19.5°C, 65% RH after storage for 28 days at 4°C, 85% RH.

The expression of stem-end rots and brown patches followed the same pattern as the cumulative incidence of ripening in the fruit stored and ripened in intact modified atmosphere bags (Figures 1, 2 and 3). Control fruit and fruit stored and ripened in perforated bags had different patterns of stem-end rot and brown patches expression to the cumulative incidence of ripe fruit. Stem-end rot development was increased in perforated bags compared to control fruit (Figure 2). There was no difference in the brown patches development between fruit in perforated bags and control fruit.

CONCLUSIONS

Storage of fruit in intact Freshaway™ bags reduced weight loss during storage and ripening compared to control fruit and increased the average ripening time by 3 days. Adding holes to the bags only slightly increased total weight loss during storage and ripening compared to intact bags and did not increase the ripening time relative to the control. These results suggest that perforating plastic bags used to generate high humidity storage environments removes a likely modified atmosphere effect of storage in plastic bags. Holding fruit in polyethylene bags during ripening was detrimental to fruit quality.

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