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SENSITIVITY OF AVOCADO FRUIT TO ETHYLENE

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Abstract

The respiration of individual 'Hass' and 'Fuerte' fruit was monitored during storage at 8ºC and 10ºC respectively for 14 days, under a continuous flow of humidified air containing ethylene (C_2H_4) at 0, 0.01, 0.05, 0.25, 1.0 and 5.0 $\mu L.L^{-1}$. Respiration rates of 'Fuerte' fruit under 0.01 $\mu L.L^{-1}$ C_2H_4 were significantly higher than the controls after 3.3 days of storage, but for 'Hass' fruit respiration rates did not become significantly higher until under 1.0 $\mu L.L^{-1}$ for 5.7 days.

In another experiment, 'Hass' fruit were held in the presence of 0, 35, 70, 140, 280 or 1000 g of Purafil® (C_2H_4 absorbent) at 20ºC. Increasing amounts of Purafil® consistently reduced the maximum concentration of C_2H_4 detected in the storage containers. Days from harvest to maximum detected C_2H_4 production rate (MDEPR) in bulk samples was increased from 8.1 to an average of 11.1 days by the presence of Purafil®, but increasing amounts of Purafil® had no further effect. Fruit stored individually in ventilated containers in the absence of Purafil® reached MDEPR on average at 13.8 days.

These results indicate that stimulation of ripening by C_2H_4 evolution from earlier- ripening fruit may be important in hastening ripening of fruit stored in bulk. Ethylene removal in storage may offer some advantage, but concentrations may need to be reduced to 0.05 $\mu L.L^{-1}$ or lower to obtain significant benefit, especially for 'Fuerte'. However, storage of only those fruit with similar storage capacity is likely to be of greater benefit. A knowledge of production factors contributing to poor storage life is required.

1. Introduction

Avocado marketing within Australia generally requires transport by road under cold storage temperatures (ideally 7-10ºC) for 3-7 days, and sea freight to export markets will require 3-5 weeks storage life. Control of ripening is essential to successful marketing under these conditions.

Ethylene plays an important role in fruit ripening. Fruit sensitivity to C_2H_4 and the presence of C_2H_4 during storage is generally undesirable, and reduction of C_2H_4 in commercial storage of several fruits is practiced. Since avocado fruit are sensitive to C_2H_4 (Zauberman and Fuchs, 1973; Adato and Gazit, 1974), their storage should benefit by control of C_2H_4 concentrations. This paper describes some of the responses of avocado fruit to storage under various conditions in relation to C_2H_4.

2. Materials and Methods

2.1 Experiment 1

'Hass' avocado fruit were obtained by road freight from south east Queensland, and in another experiment 'Fuerte' fruit from north Queensland by airfreight. Fruit were placed in individual, sealed containers and ventilated with air (93-95% RH) containing 0, 0.01, 0.05, 0.25, 1.0 and 5.0 $\mu L.L^{-1}$ C_2H_4, at a flow rate of 25-40 $mL.min^{-1}$. Effluent gas streams from each container were connected via a rotary gas sampling unit to an infra-red gas analyser (Horiba PIR-2000) for carbon dioxide (CO_2) analysis. Seven fruit were used for each C_2H_4 concentration. 'Hass' fruit were stored at 8ºC and 'Fuerte' fruit at 10ºC, to represent typical temperatures observed during commercial refrigerated road transport. Fruit were removed at 14 days, and held for a further 6 days at 20ºC to ripen.

Skin colour was measured using a Hunter Labscan 6000 0/45º spectrocolorimeter fitted with a 25 mm orifice, D65 illuminant, and 10º observer. Fruit firmness was quantified using an Instron Universal Testing Machine model 1122, fitted with a 12 mm hemispherical probe (probe penetration 2 mm at 20 $mm.min^{-1}$).

2.2 Experiment 2

'Hass' avocado fruit were harvested from south east Queensland and dipped in 0.55 $mL.L^{-1}$ prochloraz for 30 sec. The following day, 42 fruit were individually weighed and sealed in separate 1.4 L respiration chambers at 20ºC, each ventilated with 90-160 $mL.min^{-1}$ C_2H_4-free, humidified (93% RH) air. In addition, samples of 20 fruit were sealed in each of 6 ventilated 30 L plastic containers, each receiving about 300 $mL.min^{-1}$ C_2H_4-free, humidified air. Purafil® (0, 35, 70, 140, 280 and 1 000 g) was placed in each of the containers to absorb fruit-produced C_2H_4. The effluent gas from each container was connected via the 50 channel rotary gas sampling unit to a Shimadzu gas chromatograph for C_2H_4 analysis. The days to C_2H_4 peak, the maximum detected concentration in each container, and the % dry matter (DM) of fruit at eating soft were determined.

3. Results

3.1 Experiment 1

'Fuerte' fruit showed enhanced ripening at 10ºC (significantly higher respiration rate, and softer fruit) under all C_2H_4 treatments compared to the control (figure 1; tables 1 and 2), while 'Hass' fruit showed similar responses only under 1 and 5 $\mu L.L^{-1}$ C_2H_4 at 8ºC. Ripening was enhanced with higher C_2H_4 concentrations, and a similar pattern was also evident after a further 6 days at 22ºC (data not presented).

3.2 Experiment 2

The presence of Purafil® in the storage container increased the time to first detected C_2H_4 ($\geq$ 0.1 $\mu L.kg^{-1}.hr^{-1}$) and the time to maximum detectable C_2H_4 production rate (MDEPR), and decreased the MDEPR compared to the control (table 3). Increasing amounts of Purafil® logarithmically reduced the MDEPR but had no further effect on the time to first detectable C_2H_4, nor on the time to MDEPR.

Fruit from the same harvest, when stored individually, on average reached MDEPR after 13.8 days (table 4), compared to 8.1 days for the 20 fruit stored together in the 30 L container (table 3, 0 Purafil®). There was also considerable variation in MDEPR, days to MDEPR, and % DM between individual fruit (table 4). No significant correlation was observed between days to MDEPR and % DM. Similar results, indicating more rapid ripening of fruit stored together compared to fruit stored in isolation, were obtained with later harvests (data not presented).

4. Discussion

These results confirm avocado sensitivity to C_2H_4, even at relatively low storage temperatures. The significance of these results depends on storage time, but the enhancement of ripening noted under exposure to 1.0 and 0.01 $\mu L.L^{-1}$ C_2H_4 for 'Hass' and 'Fuerte'' respectively is likely to be significant in long-term commercial storage. The apparently greater sensitivity of 'Fuerte' in this experiment would have been slightly influenced by the higher storage temperature used for 'Fuerte'. Possible differences in maturity between the two cultivars may also have had an effect. However the magnitude of the difference suggests a cultivar difference in sensitivity. The thicker skin of 'Hass' may contribute to a reduced sensitivity to C_2H_4, mediated through increased diffusive resistance to C_2H_4 (Banks et al., 1993).

The variation in % DM and days to MDEPR in avocado fruit harvested on the same day and from the same trees has also been noted by Smith et al. (1992), and in % DM and days to eating soft in mango by Hofman et al. (1995). This has significant commercial implications, and an attempt to reduce this variation to give uniform ripening is one of the main reasons for the development of C_2H_4 ripening procedures for avocado in Australia (Ledger and Barker, 1994). The present results also indicate that this variability can reduce shelf life (and potentially storage life) of bulk-stored fruit, presumably because C_2H_4 produced by early-ripening fruit triggers the ripening of adjacent fruit. The ineffectiveness of increasing amounts of Purafil® to further increase shelf life indicates that, under the current experimental conditions, Purafil® has only limited capacity to remove C_2H_4 evolved by earlier ripening fruit, even at 1 kg Purafil® to 7 kg fruit. The results of experiment 1 indicate that C_2H_4 concentrations may need to be reduced below 1 $\mu L.L^{-1}$ (and possibly below 0.05 $\mu L.L^{-1}$) to have reliable benefit.

Therefore, a more effective means of increasing storage life than C_2H_4 removal may be to exclude from storage those fruit which will ripen prematurely. An understanding of factors causing variability in postharvest ripening behaviour is essential to this, and studies to identify these pre-harvest factors are part of an ongoing program in our laboratories.

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Table 1 - Days to first significant increase in respiration from higher compared to lower C_2H_4 concentrations ($\mu L.L^{-1}$). # = no significant difference ($P \leq 0.05$) between the C_2H_4 concentrations.

C_2H_4	'Hass', 14 days at 8°C					'Fuerte', 14 days at 10°C				
($\mu L.L^{-1}$)	5.0	1.0	0.25	0.05	0.01	5.0	1.0	0.25	0.05	0.01
1.0	2.7					1.6				
0.25	2.2	5.5				1.5	1.9			
0.05	2.7	7.5	#			0.9	1.0	1.1		
0.01	2.2	3.0	#	#		1.1	1.1	1.3	#	
0.0	2.2	5.7	#	#	#	0.9	0.9	0.9	3.3	3.3

Table 2 - Firmness (Newtons) and external colour (Hue angle; H°) after storage of avocados for 14 days at 8°C ('Hass') or 10°C ('Fuerte') under 0 to 5 $\mu L.L^{-1}$ C_2H_4. Other components of skin colour (Hunter L, a, b and Chroma) were not significantly affected. Means in columns with different letters are significantly different ($P \leq 0.05$).

C_2H_4	'Hass', 14 days at 8°C		'Fuerte', 14 days at 10°C
($\mu L.L^{-1}$)	Firmness (N)	H (°)	Firmness (N)
0	58.9a	120.4a	53.0a
0.01	61.1a	119.3a	46.0b
0.05	55.9a	120.2a	45.1b
0.25	59.8a	118.2a	34.6c
1.0	34.6b	115.3b	20.5d
5.0	31.6b	114.4b	14.1d

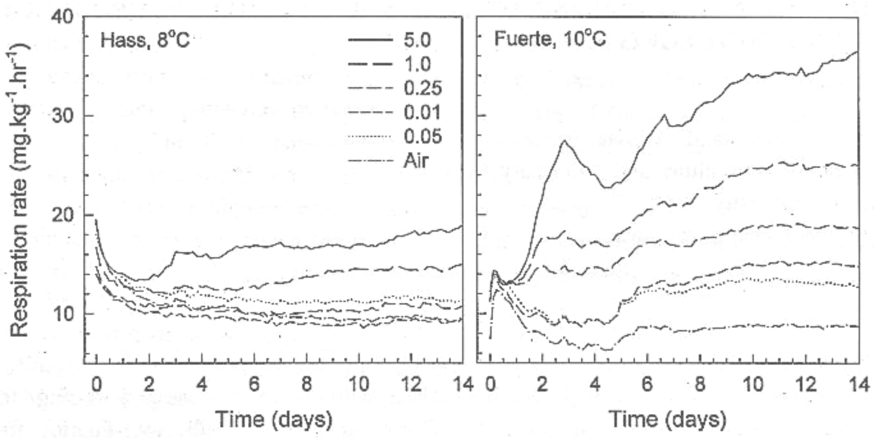

Figure 1 - Effect of continual exposure to ethylene (0 to 5 μL.L^{-1}) during storage at 8°C or 10°C on the respiration rate of 'Hass' and 'Fuerte' avocado fruit.

Table 3 - Effect of Purafil® in the storage container on days from harvest to first detectable ethylene and to maximum detected ethylene production rate (MDEPR), and the MDEPR, of 'Hass' avocado fruit ripened at 20°C.

Purafil® (g per container)	Days to first detectable ethylene	Days to MDEPR	MDEPR (μL.kg^{-1}.hr^{-1})
0	5.0	8.1	331
35	7.0	11.0	91
70	7.7	11.5	64
140	7.0	10.8	45
280	7.0	10.8	37
1 000	7.7	11.5	12

Table 4 - The maximum detected ethylene production rate (MDEPR), the days from harvest to MDEPR (μL.kg^{-1}.hr^{-1}), and % dry matter of 42 'Hass' avocado fruit harvested from the same tree on the same date, and ripened at 20°C in individual, ventilated containers.

Characteristic	Mean	Range	Standard deviation
MDEPR (μL.kg^{-1}.hr^{-1})	144.6	63.1-301.9	45.2
Days to MDEPR	13.8	10.8-15.8	1.3
% dry matter	22.9	19.8-26.8	1.7