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EFFECT OF MODIFIED ATMOSPHERES ON INTERNAL PHYSIOLOGICAL BROWNING OF FUERTE AVOCADOS

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ABSTRACT

Fuerte avocados were stored under controlled atmosphere (CA), modified atmosphere (CO_2 "shock") and regular atmosphere (RA) conditions for four weeks. Prior to, during and after storage samples were analysed for PPO activity and ABA content. Both PPO activity and ABA content were lowest in ripe CO_2 "shock" treated fruit, which indicated that these fruit may have been subjected to lower post-harvest stress than fruit from the other treatments. PPO acitivity was highest in ripe CA treated fruit, but these fruit had the lowest incidence of physiological browning. The highest incidence of physiological browning was found in control fruit. CO_2 "shock" can extend the storage life and maintain the quality of avocados, because it decreases the potential of postharvest disorder development and is relatively easy to apply.

INTRODUCTION

The distance between South Africa and its overseas markets is more than 9 000 km. Avocados exported can take up to 30 days to reach their destination. Under these conditions, avocados sometimes arrive overseas in an advanced stage of maturity. Lowering of the shipping temperature to prevent this is not feasible due to the danger of chilling injury (Couey, 1982). In South Africa, it was shown that controlled atmosphere (CA) storage decreased the risk of chilling injury considerably (Truter & Eksteen, 1987). The optimum CA conditions for avocados are 2% O_2/10% CO_2 at 5,5°C (Hatten & Reeder, 1972; Truter & Eksteen, 1987).

Internal physiological disorders can also develop as a result of low temperature storage. Engelbrecht & Koster (1986) found that the incidence of internal disorders is affected by a temperature/time interaction. To enable South African exporters to land avocados in Europe in an unripe state, they are forced to use temperatures around 5,5°C during the shipping phase. Eaks (1976) found that a period of longer than 14 days at this temperature increases the risk of developing physiological disorders.

Previous work by Spalding & Reeder (1974), Eksteen & Truter (1982,1985) and Truter

& Eksteen (1987) indicated that it may be possible to decrease the incidence of physiological disorders if a controlled or modified atmosphere is used during storage. However, the effect of these treatments on the biochemistry of the fruit has not been evaluated. The most important physiological disorders of avocados are vascular abnormalities and mesocarp discolouration (Swarts, 1984). The potential for flesh browning of avocados is primarily a function of the browning enzyme polyphenol oxidase (PPO) (Kahn 1975). A further contributing substance is abscisic acid (ABA) which increases with maturity and ripening (Cutting *et al,* 1990).

Bower, Cutting & Truter (1990) studied the effect of CA, CO_2 "shock" and regular atmosphere (RA) storage in PPO activity in Fuerte avocados. Both CA and CO_2 "shock" treated fruit showed a lower incidence of physiological disorders than the control fruit after four weeks' storage. PPO activity was lowest in the $C0_2$ "shock" and highest in the CA stored fruit. The results indicated that the fruit in CA storage for four weeks, were in a state similar to that at harvest.

In an attempt to further elucidate the effect of controlled, modified and regular atmospheres on the internal quality of avocados and the role of PPO and ABA, Fuerte avocados were subjected to these treatments and PPO activity and ABA levels were determined at weekly intervals over a four week storage period.

MATERIALS AND METHODS

Fruit used in these tests were picked during May from irrigated Fuerte trees at Westfalia Estate, Duivelskloof in Northern Transvaal. After normal packhouse treatment, the fruit were transported at approximately 6°C to Stellenbosch, about 2 000 km away. On arrival, about four days after harvest, the following treatments were applied: CA storage at 2% O_2/10% CO_2 and CO_2 "shock" using 25% CO_2 with decreasing O_2, reaching 1% after three days. After treatment, fruit of the latter treatment were stored in regular atmosphere. Fruit stored in RA from harvest served as controls. Fruit were stored at 5,5°C for a total period of 32 days from harvest.

Five fruit from each treatment were randomly selected for biochemical analysis on the day of arrival in Stellenbosch and subsequently at weekly intervals for four weeks. The flesh (meso- and endocarp) of each fruit was cut into approximately 100 mm cubes which were immediately frozen in liquid nitrogen and freeze-dried for later analysis. The specific activity of soluble PPO was analysed using the method of Bower & Van Lelyveld (1985), while abscisic acid (ABA) was determined according to the method of Cutting *et al* (1986).

After 32 days the remainder of the fruit were ripened at 20°C until eating ripe and sampled again for biochemical analysis. All the other fruit were evaluated for the incidence of the physiological disorders mesocarp discolouration and vascular abnormalities by cutting each fruit longitudinally (Swarts, 1984).

RESULTS PPO activity

Changes in PPO activity as influenced by treatment, storage time and maturity are

shown in Figure 1. In the control fruit the PPO activity increased steadily from four days after harvest (week 0) until the fruit reached the eating ripe stage. In the CO_2 "shock" treated fruit it remained almost unchanged during storage at 5,5°C and increased more rapidly during softening. In the CA stored fruit, the PPO activity followed almost the same pattern as the other two treatments, except after four weeks when the difference between treatments were bigger, with the lowest activity in the CA stored fruit. However, during softening it increased very sharply to reach the highest level of all treatments.

ABA content

The ABA levels in fruit of all treatments were high (approximately 636 ng g^{-1}) before the treatments were applied (week 0). It then decreased sharply during the first week of storage and stabilised for the remainder of the storage period (Figure 2). During storage the control fruit had the highest ABA content, followed by CA and CO_2 "shock" treated fruit respectively. After four weeks the ABA levels in all treatments were almost the same at approximately 150 ng g^{3-1}. During softening the ABA content of the fruit of the $C0_2$ "shock" treatment remained at the same level as in weeks 3 and 4, while those of the control and CA treatments increased to 296 and 241 ng g^{-1} respectively.

Internal fruit quality

The incidence of mesocarp discolouration was significantly higher in the ripe control fruit than in fruit of the other two treatments, but there were no significant differences between CO_2 "shock" and CA treated fruit (Table 1). Vascular abnormalities were also significantly higher in the ripe control fruit, compared with that of the other treatments and CA-treated fruit had a significantly lower incidence than CO_2 "shock" treated fruit.

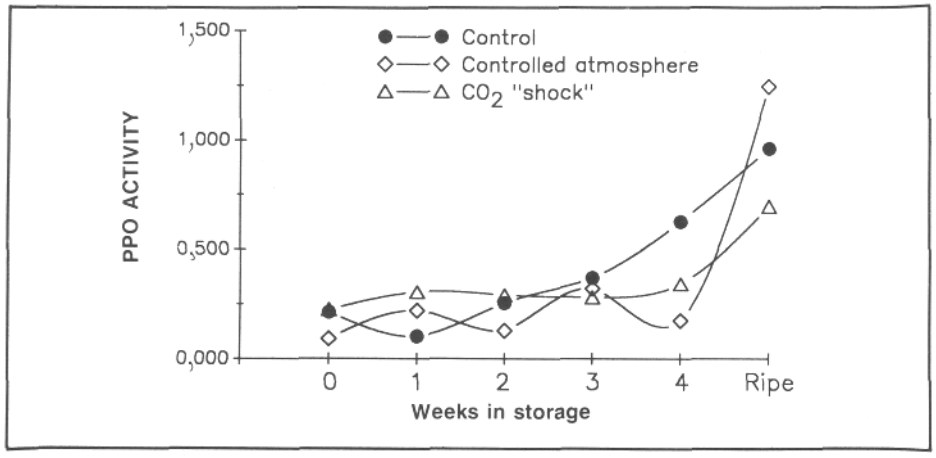

Fig 1 Polyphenol oxidase (PPO) activity in Fuerte avocados during different storage regimes.

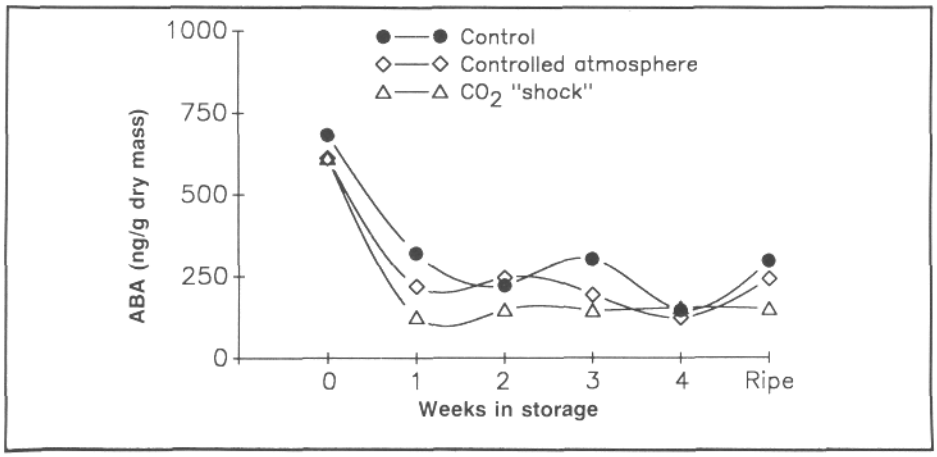

Fig 2 Absisic acid (ABA) levels in Fuerte avocados during different storage regimes.

TABLE 1 Incidence of mesocarop discolouration and vascular abnormalities in Fuerte avocados at the eating ripe stage after four weeks' storage under three regimes

Treatment	Mesocarp discolouration (%)	Vascular abnormalities (%)
Controlled atmosphere (2% O_2 10% CO_2)	8,9a	11,2a
CO_2 "shock" (25% CO_2 for three days)	11,9a	17,9a
Control	21,2b	64,9b

DISCUSSION

According to Kahn (1975) and Golan, Kahn & Sadovski (1977) there is a positive correlation between the tendency of avocado fruit to turn brown internally and PPO activity. Therefore, the following potential of CA stored fruit should have been the highest of all the treatments. However, when the avocados were evaluated internally the opposite was found (Table 1).

According to Bower *et al* (1990), CA storage decreases the post-harvest physiological processes in avocados to the extent that after 28 days' storage, avocados under CA had remained in a state similar to that at harvest. A freshly harvested Fuerte avocado in a non-stressed state has a specific soluble PPO activity of approximately 5, but it decreases rapidly during the early stages of softening (Bower *et al,* 1990). According to the results of this study, CA storage has stopped this sudden decrease in PRO activity.

The CO_2 "shock" treatment showed the lowest PPO activity in eating ripe fruit, but the internal quality was also better than those of the control fruit. This confirms results of Truter & Eksteen (1987) and Bower *et al* (1990). It therefore appears as if the potential for physiological disorders was decreased by the CO_2 "shock" treatment.

ABA levels in avocado fruit flesh increase with maturity and ripening and is a major factor in avocado fruit quality (Cutting *et al,* 1990). Four days after harvest, ABA levels in Fuerte avocados were high. This was also found by Adato, Gazit & Blumenfeld (1976) in freshly harvested avocados. High initial ABA levels can also be caused by stress conditions such as chilling (Ludford & Hillman, 1990; Van Gorsei & Kader, 1990). No apparent stress factors were present during the four-day-period before the fruit were treated, unless transport over a 2 000 km journey for more than 30 hours can be regarded as a stress condition. The reason why the ABA level in the CO_2 "shock" treated fruit remained low and did not increase during softening, is not clear and will have to be investigated further.

CA "shock" treatment holds promise as a storage technique, especially where CA facilities on ships are not yet readily available, or when available, the costs are still very high. A further advantage of this technique is that the fruit can be treated prior to export under RA conditions.

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