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MATURITY EFFECTS ON AVOCADO POSTHARVEST PHYSIOLOGY IN FRUITS PRODUCED UNDER COOL ENVIRONMENTAL CONDITIONS

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ABSTRACT

The influence of cold storage and increasing fruit maturity on ripening physiology was investigated. Fruits that were cold-stored for 28 days at 5,5°C before ripening, always ripened faster than non-stored fruits of a similar maturity. Non-stored fruit showed a decrease in ripening time with increasing maturity. In cold-stored fruit the relationship between ripening time and maturity was less clear. Cold-stored fruit lost less water during ripening than non-stored fruit of similar maturity, but lost water at a faster rate than non-stored fruit. Increasing maturity reduced the total amount of water lost during ripening. Vascular browning appears to be maturity (time of harvest) related with similar results in both cold-stored and non-stored fruit. Cold storage increased the incidence of mesocarp discolouration which became more acute with increasing fruit maturity

INTRODUCTION

Little is known about the effect of increasing maturity on avocado fruit ripening physiology (Bower & Cutting, 1988). However, it is known that the fruits of commercial avocados will not ripen while attached to the tree (Schroeder, 1953), even when exposed to ethylene (Gazit & Blumenfeld, 1970). The respiratory climacteric in avocado fruits, presumably mediated by increased sensitivity to ethylene (Yang, 1985), is initiated only after harvesting (Leopold & Kriedemann, 1975). Oil content is known to increase and water content to decrease with increasing maturity (Pearson, 1975). Time to ripening is a function of fruit maturity, less time being required with increasing maturity (Zauberman & Schiffman-Nadel, 1972; Adato & Gazit, 1974). The potential and often the incidence of the physiological disorders, vascular browning and mesocarp discolouration, increase with increasing maturity (Cutting *et al.,* 1988). The activity of the enzyme polyphenol oxidase (PPO) associated with browning disorders in avocado (Kahn 1975) and the concentrations of the growth regulator abscisic acid (ABA), both increase with increasing maturity (Cutting *et al.,* 1986; Cutting *et al.,* 1988).

The South African avocado export industry is characterised by long transport and storage times of up to 30 or more days at temperatures of about 5,5°C. This extended storage period often results in poor fruit quality, particularly the physiological disorders, grey pulp and vascular browning (Leclereq, 1990). An additional problem is early softening. There appears to be a seasonal trend, with worse quality both early in and toward the end of the marketing season. In addition some seasons are worse than others (Eksteen, 1990). This problem is magnified by the extended harvesting period of any one cultivar (up to six months) from different production areas and the overlap of cultivars.

This paper reports on the effect of increasing fruit maturity on some aspects of postharvest ripening physiology and quality on fruits produced under cool environmental conditions, which were either stored or not stored at low temperature for four weeks.

MATERIALS AND METHODS

Fruit used in this study was of the cv Fuerte from a commercial orchard in the Natal Mistbelt region near Pietermaritzburg, Natal. Trees were not subjected to any cultural stress. Fruits were randomly selected for each harvest date from four and five-year-old trees on Duke 7 rootstocks. There were 30 fruits per harvest date, split into three groups of ten. Two of the groups were used in this study and were treated as follows: the one group was ripened at 21 °C, the other group was stored at 5,5°C for 28 days, after which it was ripened at 21 °C. All fruits were individually weighed at harvest and again at full softness. The time of ripeness for each fruit was recorded. When ripe, the fruits were sectioned and assessed for the physiological disorders grey pulp/mesocarp discolouration and vascular browning. Harvesting began on 25 May 1990 (early winter) and continued at two weekly intervals until 26 October 1990 (spring), when the following season's fruit-set was underway. This gave an effective five month harvesting period, reflecting the extremes used by commercial growers in similar areas.

RESULTS

Time to ripening (Figure 1)

Increasing maturity decreased the time to ripen. When fruits were not cold-stored the time decreased from about ten days at the beginning of the season to about seven at the end of the season. Cold storage markedly decreased the time to ripening for any given harvest date over non-stored fruit. Ripening times for cold-stored fruit only decreased for the first three months, after which they remained constant at about three days.

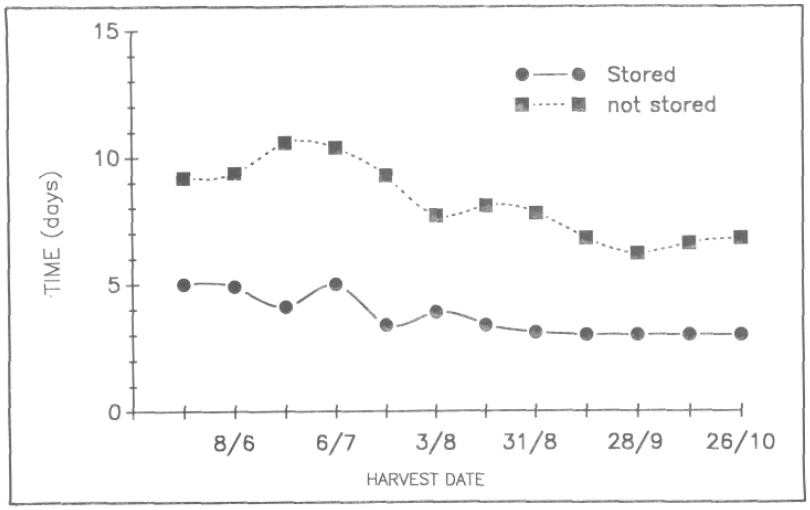

Fig 1 Effect of increasing maturity (harvest time) on the ripening/softening time of Fuerte avocado fruits, either stored for 28 days at 5,5°C or not cold-stored.

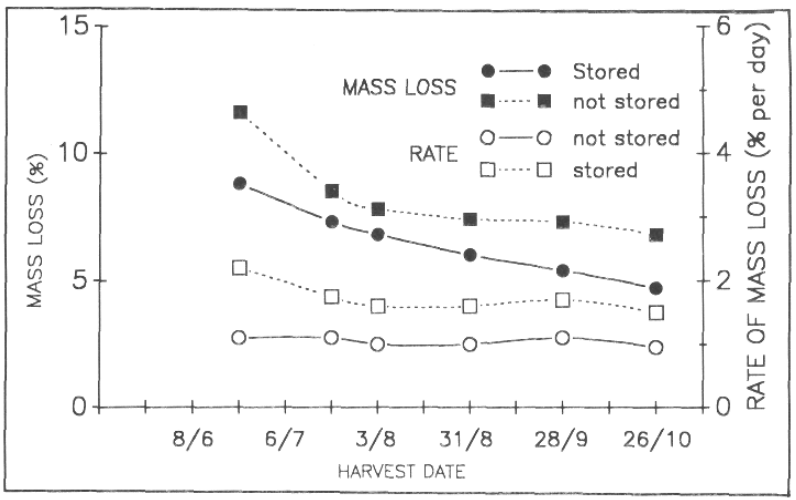

Fig 2 Effect of increasing maturity on mass loss (mostly water) and rate of mass loss during ripening of Fuerte avocado fruits, either stored for 28 days at 5,5°C or not cold-stored.

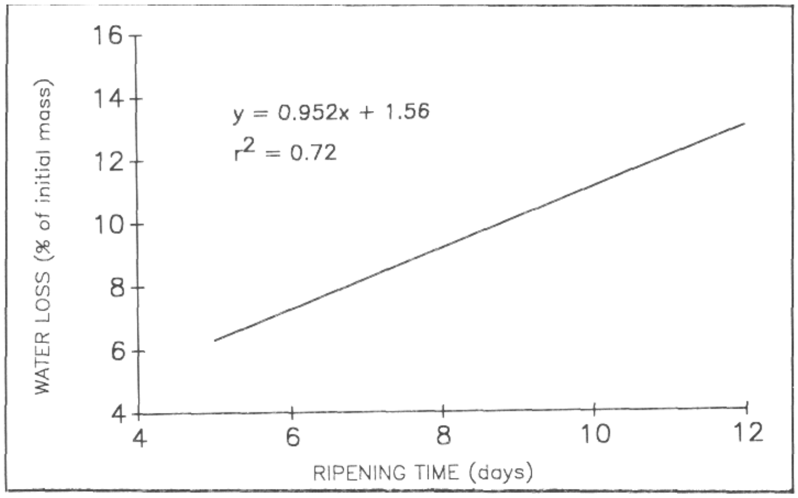

Fig 3 Regression of relationship between ripening time (in days) and percentage water loss during ripening of Fuerte avocado fruits, either stored for 28 days at 5,5°C or not cold-stored.

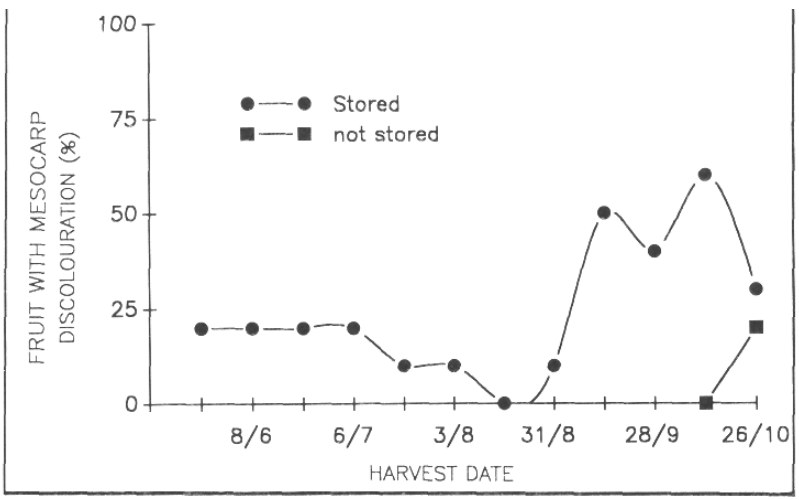

Fig 4 Effect of increasing maturity on the incidence of pulp spot and mesocarp discolouration of Fuerte avocado fruits, either stored for 28 days at 5,5°C or not cold-stored.

Mass (mainly water) loss (Figure 2)

Fruits that were not cold-stored after harvest, lost more water during ripening for any given harvest date when compared to fruit that were stored. Increasing maturity resulted in a decrease in the total amount of water lost by the fruits during ripening. The rate of water loss was higher in cold-stored fruit and declined from an initial 100% increase over the control to about 50% as the fruit maturity increased. Increasing fruit maturity had no effect on the rate of water loss in fruits which were not stored. These fruits lost about 1% of their mass per day, irrespective of time of harvest. The regression relationship between water loss and time to ripening is presented in Figure 3.

Pulp spot/mesocarp discolouration

(Figure 4)

Fruits that were not cold-stored did not show mesocarp discolouration. A percentage of all fruit that were cold-stored for 28 days showed mesocarp discolouration. The incidence of mesocarp discolouration was about 20% initially and declined marginally during midseason. However, the incidence of this disorder rose rapidly towards the end of season, showing the marked effect of advanced maturity on mesocarp discolouration in cold-stored fruit.

Vascular browning (Figure 5)

Fruits that were either cold-stored or not stored, showed a similar pattern of vascular browning. Maturity (time of harvest) had a dramatic and obvious effect on the incidence of vascular browning and was very high in fruits harvested early in the season. Thereafter, the incidence of the disorder declined, but rose rapidly as the fruit reached an advanced stage of maturity.

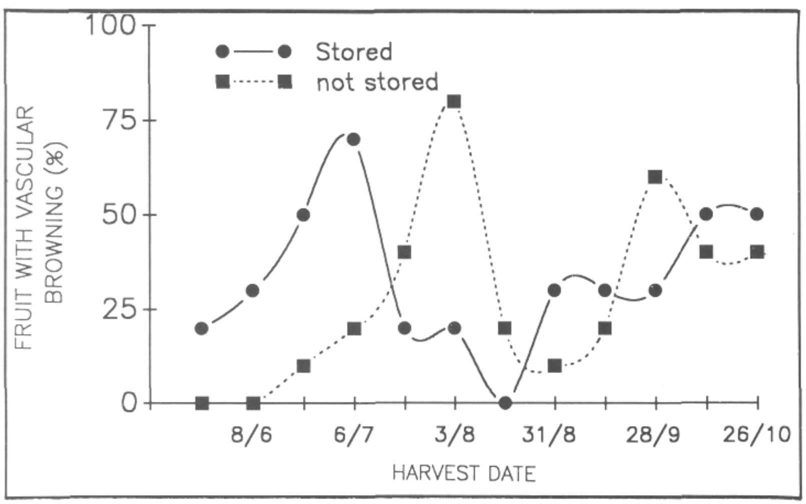

Fig 5 Effect of increasing maturity on the incidence of vascular browning of Fuerte avocado fruits, either stored for 28 days at 5,5°C or not cold-stored.

DISCUSSION

This study highlighted the problems of trying over a long period to market avocado fruit free of physiological disorders, especially the problematic Fuerte cultivar. In contrast to other fruits such as stone and some fruits with relatively short harvest periods, which seldom exceed two to three weeks, the avocado is harvested over long periods of time. During this long harvest period fruit composition alters as maturity increases (Pearson, 1975). The reduction in ripening times in response to increased maturity could be related to water loss. The possibility that water loss plays a key role in fruit ripening has been mooted previously (Cutting *et al.*, 1988). The findings in this study lend further support to this. This study found a positive relationship between postharvest water loss and rate of ripening (r = 0,85). This could be explained in terms of decreasing percentage of water with increasing maturity at harvest. A similar amount of water lost (because of transpiration losses) would result in increased internal water stress in more mature fruit. The result is fruit ripening under stressed conditions. Cold storage reduced the total amount of water lost during ripening, but increased the rate at which water was lost. It appears therefore that cold storage has the ability to increase the subsequent rate of metabolism in fruits when compared to fruits of similar maturity which were not stored.

Controlling postharvest water loss from fruit is apparently more important late in the season when fruits are more mature. Once fruits have been cold-stored, they appear to become more sensitive to water loss and every effort should be made to prevent water loss, both during storage and ripening. This should result in increased shelf-life and a reduction in the incidence of physiological disorders, such as mesocarp discolouration. The fruits in this study were not waxed or treated in other ways to reduce water loss.

While fruits are attached to the tree and increasing in maturity the tree continued with its normal phenological cycle (Whiley *et al.,* 1988). This implies periods of strong competition for limited resources of minerals during new vegetative and flowering growth flushes, intensifying during late maturity, when overlapping occurs with flowering and fruit-set in the subsequent season. Both vegetative and flowering flushes exhibit powerful sink strength for water (Whiley *et al.,* 1988) and minerals (Cutting & Bower, 1989; Whitney *et al.,* 1990). Young fruit and shoot development are strongly competitive (Whiley *et al.,* 1988) and exert powerful attraction on water, minerals and carbohydrates. Any older, more mature fruit from the previous season would have considerably reduced relative sink strength, once the following season's flowering and fruit-set events had been set in motion, bearing in mind correlative phenomena and auxin export induced sink dominance (Bangerth, 1989). However, as long as fruit are attached to the tree they continue to grow (McOnie & Wolstenholme, 1982). Therefore, it must be assumed that mineral concentration will decrease as fruit reach advanced stages of maturity. This would have a major effect on membrane stability and integrity and may explain why fruits tend to develop membrane related physiological disorders such as mesocarp discolouration late in the season. Detailed physiological studies in these fruits are currently underway.

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