Proc. of Second World Avocado Congress 1992 pp. 387-393

Maturity Effects on Avocado Postharvest Physiology in Fruit Produced under Cool Environmental Conditions

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Abstract. **The influence of cold storage and increasing fruit maturity on ripening physiology was investigated. Fruit that were cold stored for 28 days at 5.5C before ripening always ripened faster than non-stored fruits of a similar maturity. Non-stored fruit snowed 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, however the rate of water loss was greater in 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 discoloration which became more acute with increasing fruit maturity.**

Little is known about the effect of increasing maturity on avocado fruit ripening physiology (Bower and Cutting, 1988). However we do know that the fruits of commercial avocados will not ripen while attached to the tree (Schroeder, 1953) even when exposed to ethylene (Gazit and Blumenfeld, 1970). The respiratory climacteric in avocado fruits, presumably mediated by increased sensitivity to ethylene (Yang, 1985), is initiated only after harvesting (Leopold and 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 and Schiffman-Nadel, 1972; Adato and Gazit, 1974). The potential and often the incidence of the physiological disorders, vascular browning and mesocarp discoloration, 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 characterized by long transport and storage times of up to 30 or more days at temperatures of about 5.5C. 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 poorest fruit quality both early in and toward the end of the marketing season, with some seasons 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 of fruit 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 were of the cv. Fuerte from a commercial orchard in the Natal Mistbelt region near Pietermaritzburg, Natal. Trees were not subjected to any cultural stress. The fruit were randomly selected for each harvest date from four- and five-year-old trees on Duke 7 rootstocks. There were 20 fruit per harvest date, split into two groups of 10. The control group of 10 was ripened at 21 C, the other group was stored at 5.5C for 28 days after which they were ripened at 21 C. All fruit were individually weighed at harvest and again at full softness. The time to ripeness for each fruit was recorded. When ripe, the fruit were sectioned and assessed for the physiological disorders grey pulp, mesocarp discoloration and vascular browning. Harvesting began on 25 May 1990 (early winter) and continued at biweekly 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

<u>Time to ripening</u> (Fig. 1). Increasing maturity decreased the time necessary for fruit to ripen. When fruit were not cold-stored the time decreased from about 10 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.

<u>Mass (mainly water) loss</u> (Fig. 2). Fruit that were not cold-stored postharvest 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 fruit during ripening. The rate of water loss was higher in cold stored fruit and declined from an initial 100% increase over the non-stored 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 Fig. 3.

<u>Pulp spot/mesocarp discoloration</u> (Fig. 4). Fruit that were not cold stored did not show mesocarp discoloration. A percentage of all fruit that were cold stored for 28 days showed mesocarp discoloration. The incidence of mesocarp discoloration was about 20% initially and declined marginally during midseason. However, the incidence of this

disorder rose rapidly toward the end of the season showing the marked effect of advanced maturity on mesocarp discoloration in cold-stored fruit.

Vascular browning (Fig. 5). Fruit 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.

Discussion

This study highlighted the problems of trying to market avocado fruit, especially of the problematic 'Fuerte' cultivar, free of physiological disorders over a long period. In contrast to other fruits such as stone and pome 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 with maturation (Pearson, 1975). The reduction in ripening times in response to increased maturity could be related to water loss. The possibility of water loss playing a key role in fruit ripening has been suggested 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 ($r^2 = 0.69$). This could be explained in terms of a 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. This would result in 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. Thus, it appears that cold storage increases the subsequent rate of transpiration in fruit when compared to fruit of similar maturity which were not stored.

Controlling postharvest water loss from fruit is apparently more important late in the season when fruit are more mature. Once fruit have been cold-stored, they appear to become more sensitive to water loss and every effort should be made in preventing 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 discoloration. The fruit in this study were not waxed or treated in other ways to reduce water loss.

While fruit are attached to the tree and increasing in maturity, the tree continues with its normal phenological cycle (Whiley ef *al.,* 1988b). This implies periods of strong competition for limited resources of minerals during new vegetative and flowering growth flushes, intensifying during late maturity when flowering and fruit set occurs for the subsequent season. Both vegetative and flowering flushes exhibit powerful sink strength for water (Whiley *et al.,* 1988a) and minerals (Cutting and Bower, 1989; Witney *et al.,* 1990). Young fruit and shoot development are also strongly competitive (Whiley *et al.,* 1988a) for water, minerals and carbohydrates. Any older, more mature fruit from the previous season may have considerably reduced relative sink strength once the following season's flowering and fruit set events have 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 and Wolstenholme, 1982). Therefore it can 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 discoloration late in the season. Detailed physiological studies of these fruits are currently underway.

The South African Avocado Growers Association is thanked for providing research funds for this project. Everdon Estate is thanked for the avocado fruit used in this study.

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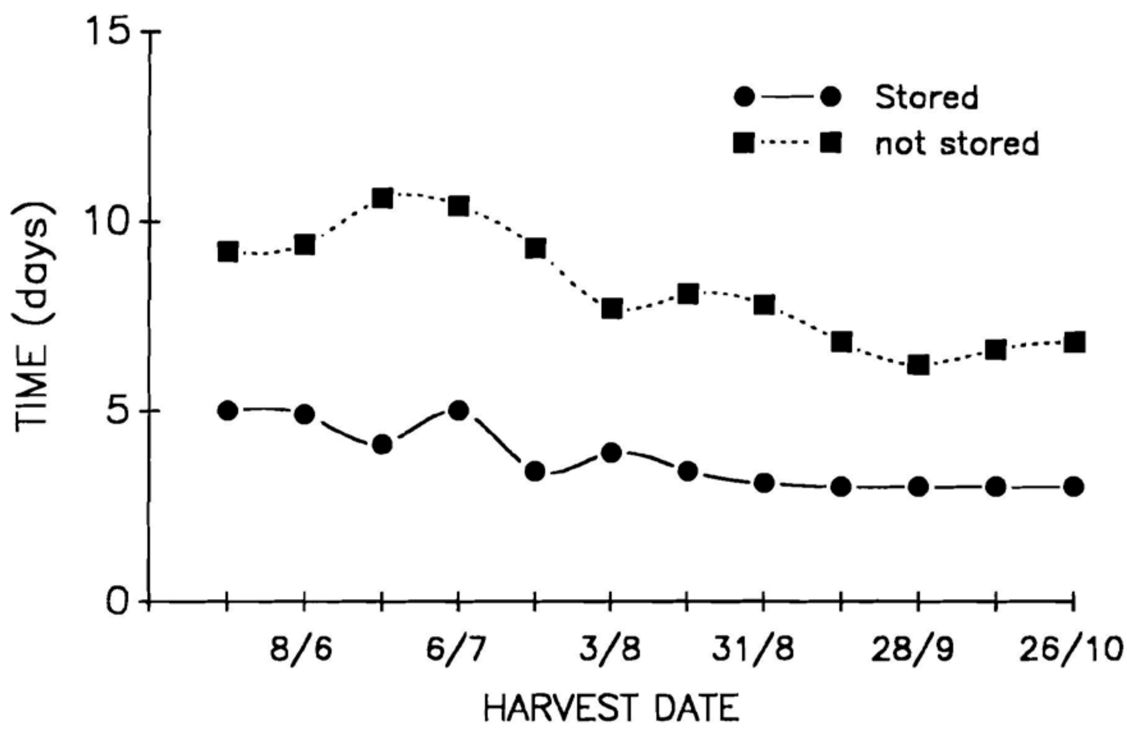

Fig. 1. Effect of increasing maturity (harvest time) on the ripening/softening time of 'Fuerte' avocado fruit stored for 28 days at 5.5C or not cold-stored (control) prior to ripening at 21 C.

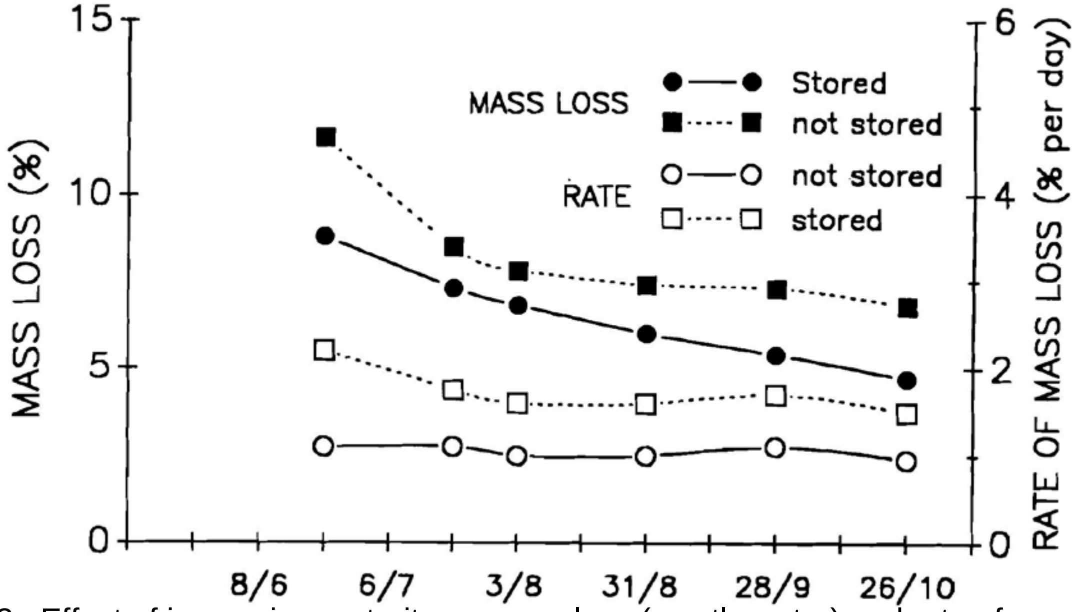

Fig. 2.. Effect of increasing maturity on mass loss (mostly water) and rate of mass loss during ripening of 'Fuerte' avocado fruit stored for 28 days at 5.5C or not cold-stored (control) prior to ripening at 21 C.

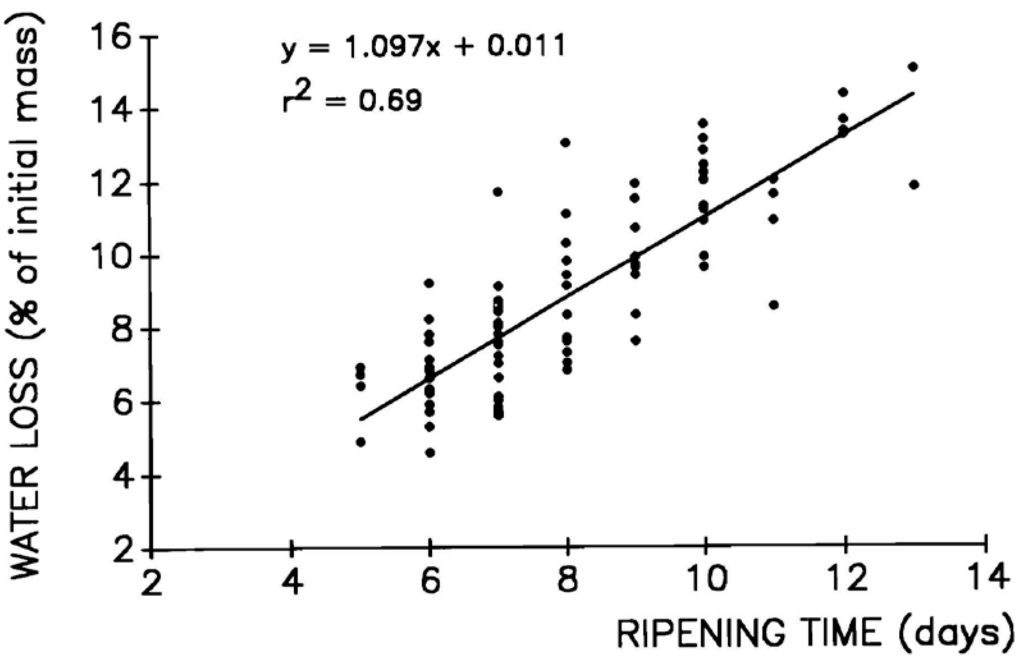

Fig. 3. Regression relationship between ripening time (in days) and percentage water loss during ripening of 'Fuerte' avocado fruit stored for 28 days at 5.5C or not cold-stored (control) prior to ripening at 21C.

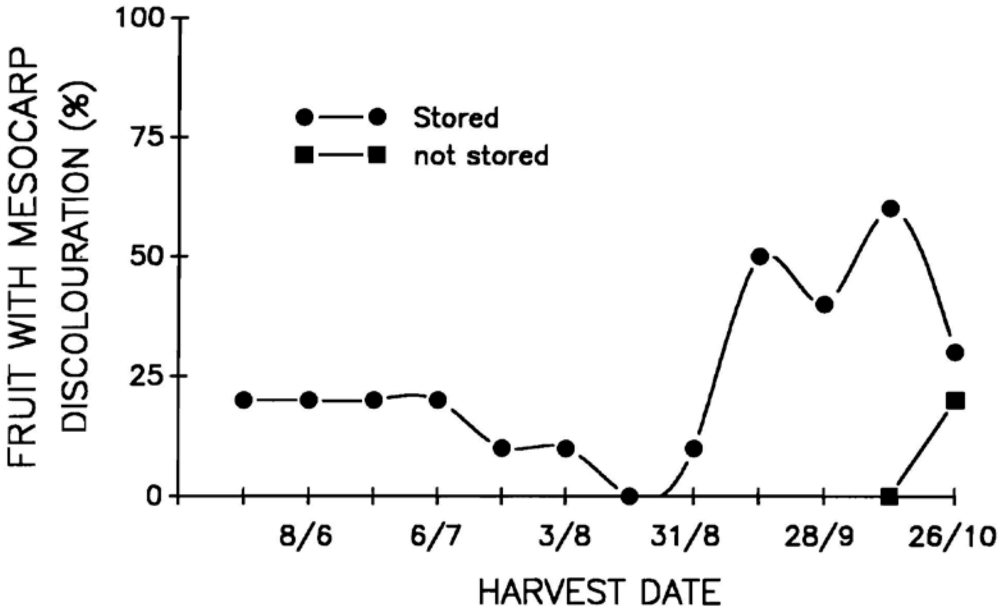

Fig. 4. Effect of increasing maturity on the incidence of pulp spot and mesocarp discoloration of 'Fuerte' avocado fruit stored for 28 days at 5.5C or not cold-stored (control) prior to ripening at 21 C.

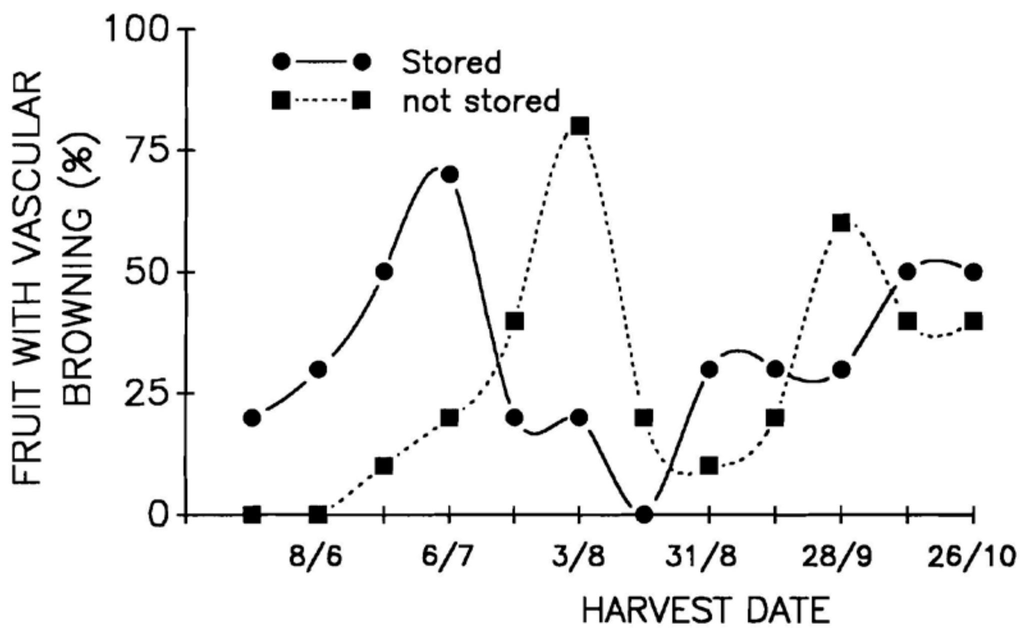

Fig. 5. Effect of increasing maturity on the incidence of vascular browning of 'Fuerte' avocado fruit stored for 28 days at 5.5C or not cold-stored (control) prior to ripening at 21C.