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A storage temperature regime for South African export avocados

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SYNOPSIS
Optimum storage temperature of avocado fruit varies with cultivar and time of season. Therefore, adaptation of the temperature throughout the season is necessary. A decrease in physiological disorders was observed in treatments using a higher temperature during the early stages of storage (7,5°C) and a lower temperature during the later stages of storage (3,5°C), compared to a temperature of 5,5°C for the full storage period, as previously used for export by sea of South African avocados.

INTRODUCTION

The South African avocado industry relies on export by sea for a large part of its sales and this takes approximately 28 days. The condition of sea-freighted avocados varies on arrival. Soft fruit and/or cold damage on arrival are major problems. Physiological disorders, which are also problematical, have often been associated with low temperature storage (Chaplin, Wills & Graham, 1982; Eaks, 1976).

Optimum temperature and storage periods of avocados varies with cultivars (Vakis, 1982), environmental influences (Smith, 1985) and stage of development (Bezuidenhout, 1983; Kosiyachinda & Young, 1976; Toerien, 1986). Bower (1986) found that the potential of fruit for physiological disorders and cold damage varies throughout the season. This means that there are periods when exporters run an increased risk of physiological problems which are enhanced by low temperature storage (Bower, 1986). For marketing reasons it is not possible to cease exporting during these periods of increased risk. The avocado industry must therefore find ways of coping with fruit with a higher potential for physiological disorders.

According to Kosiyachinda & Young (1976), chilling sensitivity of Fuerte and Hass avocados is a function of the stage of climacteric. The least sensitive stage is the post-climacteric stage. Avocados on the climacteric rise and the climacteric peak were found to be most sensitive. Early season fruit is more sensitive to low temperatures than late season fruit (Toerien, 1986), this probably being a function of a higher oil content and/or orchard temperatures (Smith, 1985).

Experiments based on the above factors were conducted. An attempt was made to place less stress on the fruit by using a temperature regime which included a moderate temperature during the early stages of storage. A lower temperature during the later stages of storage was implemented to prevent fruit from becoming soft in transit.

MATERIALS AND METHODS

Fuerte, Hass and Ryan avocados of count 14 (mass range 266 g to 305 g) were obtained from the commercial packing line of the packhouse at Westfalia Estate. Fruit was stored for 28 days at various temperature combinations. Ten treatments consisting of 10 cartons per treatment were used in every experiment over the total harvesting season. The different treatments were adapted as the season proceeded and more results became available. After this period, the fruit was left to ripen at 16°C ± 2°C, after which it was cut open longitudinally and inspected externally and internally for cold damage, Colletotrichum and Dothiorella complex, anthracnose, pulp spot, vascular browning and grey pulp, using a scale of 0 (none) to 10 (severe). For the purpose of this paper, only two treatments are highlighted. The control refers to a treatment which included a storage temperature of 5,5°C for the total storage period. Treatment (I) refers to a temperature regime of 7,5°C for one week, 5,5°C for two weeks and 3,5°C for the last week of storage. These treatments illustrated certain important principles. Percentage oil content was used as an indication of maturity of the fruit and was determined according to the method described by Swarts (1976).

STATISTICAL ANALYSIS

Experiments were based on a completely random design and were analysed by the Kruskal Wallis test (Steel & Torrie, 1960).

RESULTS

Fuerte

Physiological disorders - Early-season Fuerte (oil less than 14 per cent) appears to be very sensitive to cold. Higher temperatures during the early stages of storage led to less cold damage. More mature fruit (oil content 14-20 per cent) tends to have less external cold damge in treatment (I) compared with the control (Figure 1).

Mature fruit (oil content 20 per cent plus) appears to be least sensitive to cold and a temperature regime of 5,5°C for up to 21 days, followed by 3,5°C for the rest of the storage period, appears to have advantages. Higher temperatures (7,5°C) during the early stages of storage and lower temperatures (3,5°C) during the later stages of storage, gave a decrease in pulp spot (Figure 3) and grey pulp (Figure 4).

Pathological disorders - No significant differences or any definite tendencies were observed within treatment (I) when compared with 5,5°C for 28 days.

Days to ripen - No significant differences (P=0,05) were observed between a temperature regime as used in treatment (I) and the control.

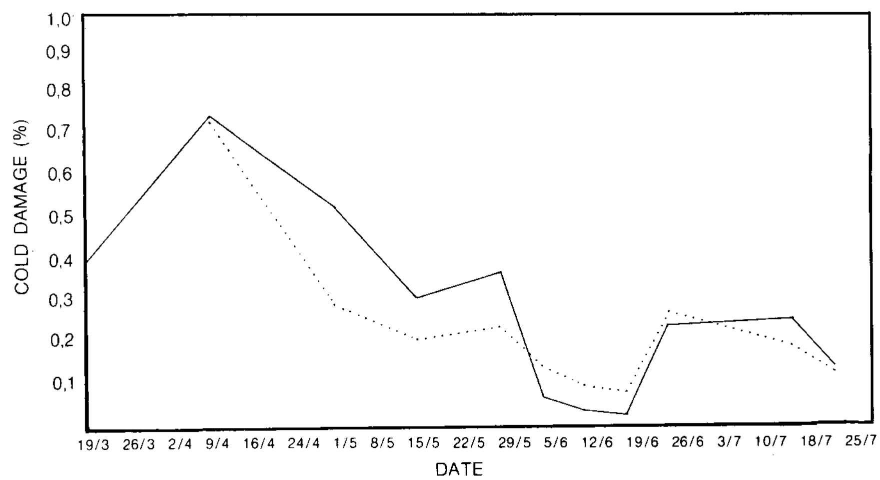

Fig 1 External cold damage in Fuerte which occurred at two different storage temperature regimes during 1986.
(a) Temperature regime of 5,5°C for 28 days. (—).
(b) Temperature regime of 7,5°C for seven days followed by 5,5°C for 14 days and 3,5°C for seven days. (....).

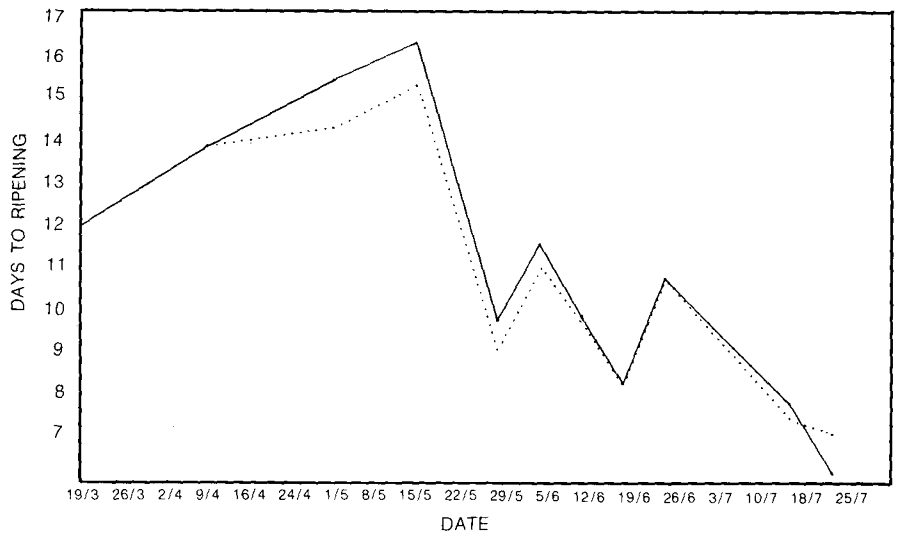

Fig 2 Days to ripening of Fuerte after a storage period of 28 days at two different temperature regimes during 1986.

(a) Temperature regime of 5,5°C for 28 days (—).

(b) Temperature regime of 7,5°C for seven days followed by 5,5°C for 14 days and 3,5°C for seven days (....).

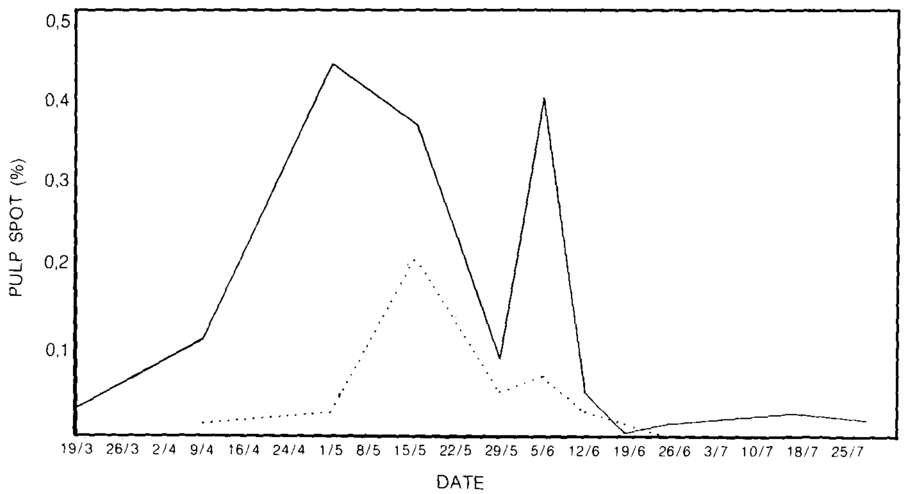

Fig 3 The incidence of pulp spot in Fuerte at two different temperature regimes during 1986.
(a) Temperature regime of 5,5°C for 28 days (—).
(b) Temperature regime of 7,5°C for seven days followed by 5,5°C for 14 days and 3,5°C for seven days (....).

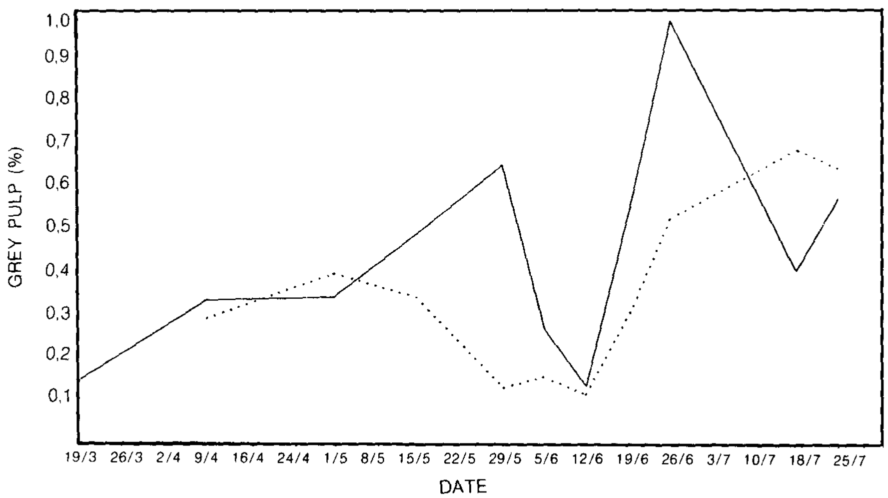

Fig 4 The incidence of grey pulp in Fuerte at two different temperature regimes during 1986.
(a) Temperature regime of 5,5°C for 28 days (—).
(b) Temperature regime of 7,5°C for seven days followed by 5,5°C for 14 days and 3,5°C for seven days (....).

RESULTS

Hass and Ryan

Physiological disorders - From the experiments conducted, it is clear that these cultivars are not sensitive to a temperature of 3,5°C for up to 21 days. This temperature was not tested over a period longer than 21 days. Fruits used in these experiments were, according to the percentage oil content, quite mature (oil content 20 per cent and higher). According to Vakis (1982), temperatures as low as 2,2°C are acceptable in Cyprus for Hass storage. Pulp spot and grey pulp were observed in very isolated cases. It appears that physiological disorders in the temperature regime of 5,5°C and 3,5°C will not be a problem in these cultivars.

Pathological disorders - These were observed only in isolated cases.

DISCUSSION

Considerable differences in sensitivity to low temperatures were observed during different stages throughout the season and between different cultivars. Because of this, adaptation of the temperature regime throughout the season is necessary. The results agree with prior publications (Bezuidenhout, 1983; Toerien, 1986) that a higher temperature during the early stages of storage has definite advantages from a physiological point of view.

Chilling injury (CI) in all its forms, is the consequence of low temperatures disrupting the fluidity and order of the membrane lipids, affecting their function as semi-permeable barriers and their interaction with associated enzymes (Lyons & Raison, 1970). A membrane is composed of a variety of lipids, all having different freezing temperatures depending on their degree of saturation. As a plant is exposed to progressively lower temperatures, the composition of its membrane lipids may change in such a way that lipids with a lower freezing point become more dominant (Lyons, Raison & Graham, 1980). This may explain the acclimatisation of fruit at lower temperatures and possibly explains the value of declining temperature regimes.

Kahn (1975) found that the rate of browning of three avocado cultivars was directly related to the polyphenoloxidase (PPO) activities in the crude enzyme fraction. According to Van Lelyveld & Bower (1984), peroxidase may also play a role in the browning of avocados. There is evidence that low temperature storage causes an increase in both solube and total PPO activity. This could result in enhanced browning after cutting and an increased presence of pulp spot and mesocarp discolouration (Bower, 1986). A decrease in pulp spot and grey pulp was found at a temperature of 3,5°C later during the storage period. It seems possible that a temperature as low as 3,5°C later in the storage period, may depress the activity of enzymes involved in the browning of avocado fruit.

There is no doubt that the principle of a higher temperature during the early stages of storage and a lower temperature during the later stages of storage, has advantages.

In the implementation of a variable temperature regime during transit, Figure 5 may be used as a broad guideline for Fuerte.

From the experiments conducted and literature cited (Vakis, 1982), it is clear that Hass and Ryan are least sensitive to temperatures in the range of 3,5°C to 5,5°C. However, fruit used in the experiments were (according to the percentage oil content) quite mature. Based on these results a temperature of 5,5°C can be considered for the first consignment of these cultivars. Figure 5 can be used as a guideline for more mature fruit (oil content 20 per cent and higher). Reliable feedback from overseas markets will have to be used in future to optimise the temperature model. Percentage oil content as an indication of maturity of the fruit, played a major role in the drawing up of this proposed guideline. Fruit may differ from area to area, which should also be taken into consideration.

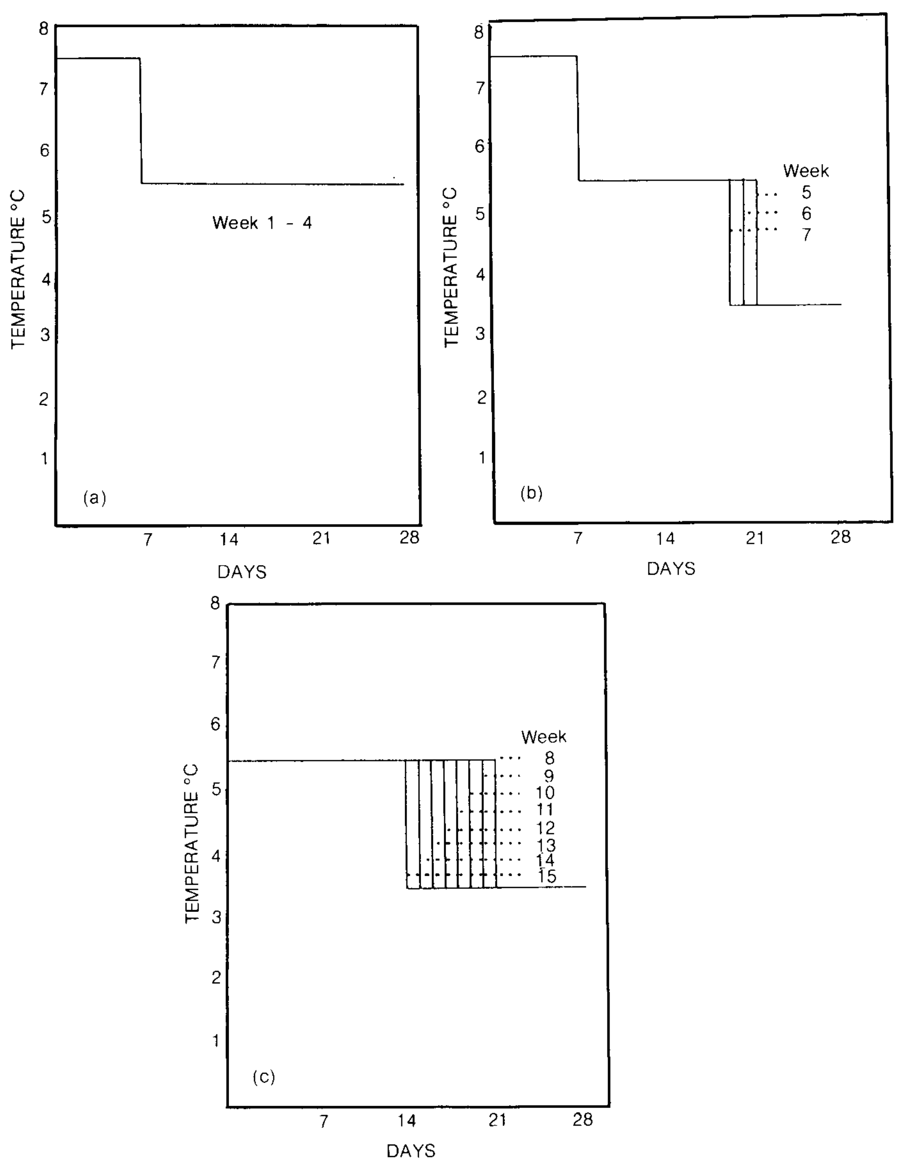

Fig 5 A proposed guideline of storage temperatures for South African Fuerte.
(a) Fuerte harvested from week 1-4 (expected oil content between 10 and 14 per cent).
(b) Fuerte harvested from week 5-7 (expected oil content between 14 and 19 per cent).
(c) Fuerte harvested from week 8 onwards (expected oil content 20 per cent and more).
This guideline was based on seasonal changes in oil content of Westfalia avocados.

These recommended temperatures are air temperatures and it can be expected that fruit temperatures in a commercial system will naturally be 1°-2°C higher than air temperatures.

However, it is not feasible to make recommendations for the avocado industry on only one season's experimental results. For this reason the proposed temperature regime will be evaluated again on an experimental basis during the coming season.

It can be expected that the proposed temperature regime will change when controlled atmosphere storage (Truter & Eksteen, 1986) is used, or when storage at a high relative humidity (Bower, unpublished) is introduced. These are concepts with potential for the future.

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