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1991 Temperature survey of export avocados

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INTRODUCTION

Extensive temperature surveys and investigations into handling and transport procedures done over four consecutive seasons have confirmed the following:

* Very accurate air delivery temperature control, with a maximum deviation of ±0,5°C from the optimum, is required.

* Optimum carrying temperature varies according to the physiological maturity of the avocado fruit.

* A temperature management system, whereby the carrying temperature is decreased as the season progresses (maturation) and during the voyage (ripening), reduces both chilling injury and soft fruit.

* The postharvest "age" of the fruit should not exceed 28 days between picking and marketing.

Studies resulting in the formulation of the above basic rules were done on an industry basis with the co-operation of all involved in avocado exports. This has resulted in the application of a temperature management system for avocados during sea shipment.

PROCEDURE

Temperature sensors were installed in the fruit in the warmest and coldest positions, as well as in the delivery and return air. All temperature sensors were connected to a Grang Squirrel electronic data logger. The temperatures were monitored on a four-hourly basis, from the packhouse to the market. In this way fruit in 20 containers (15 vessels) were monitored and more than 2 000 000 temperature readings taken.

RESULTS AND DISCUSSION

Discussion of the results can be subdivided into the three different phases of transport, ie refrigerated motor transport (RMT) from the packhouse to Cape Town, voyage conditions and transport after discharge to the market.

Road transport

Pulp temperatures during the commercial road transport conditions to Cape Town can best be described by the data represented in Figure 1. If all the industry data is considered, the following comments can be made:

Pulp temperatures can be reduced by ± 2°C during transport, as indicated in Figure 1. In this case the avocados were precooled to ± 10°C prior to loading into a precooled RMT with a temperature setting of 7°C.This confirms similar findings for the 1989 and 1990 season.

- Pulp temperatures can be maintained accurately within the defined parameters, provided the fruit is precooled to the carrying temperature before loading into a precooled RMT.

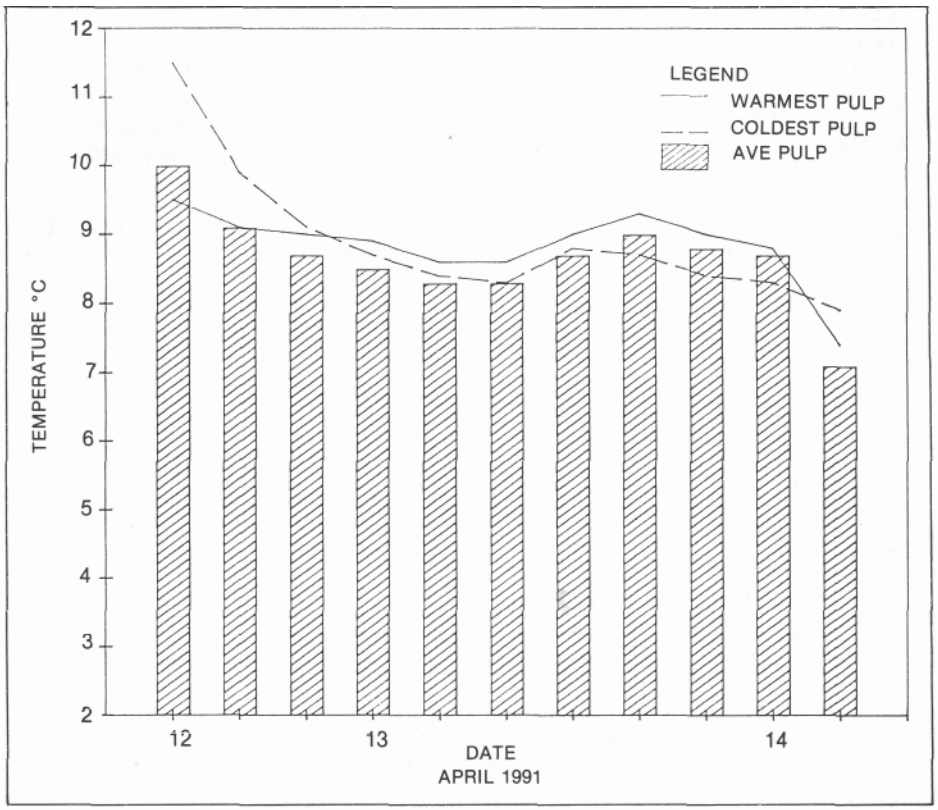

Fig 1 Pulp temperatures of avocado fruit in the warmest and coldest positions in a refrigerated truck during road transport to Cape Town.

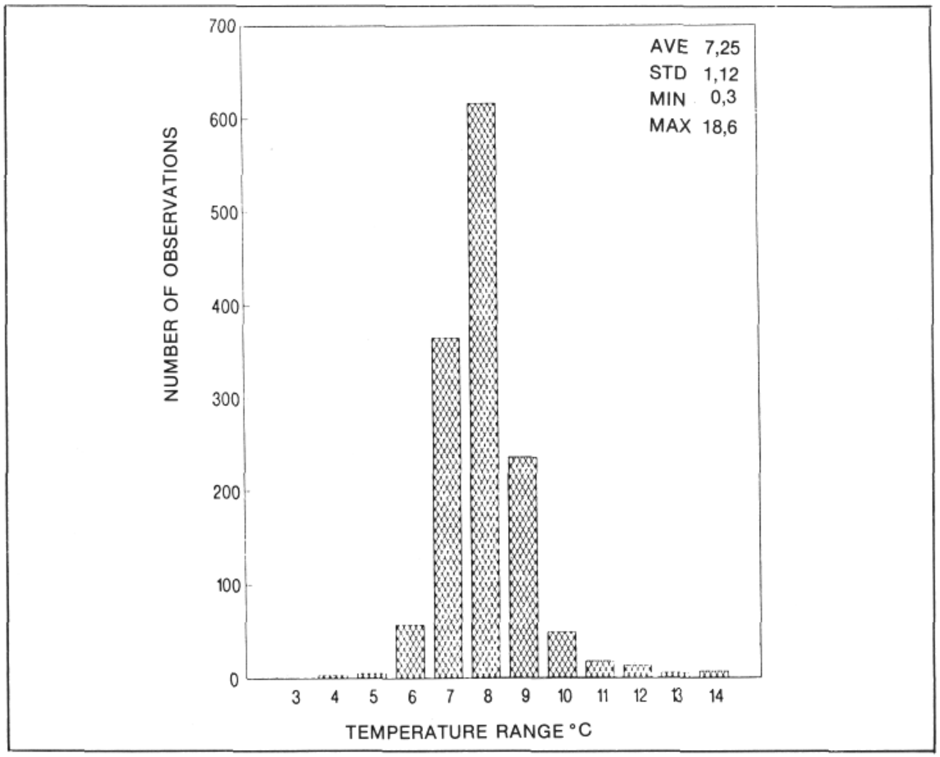

Fig 2 Frequency distribution of avocado fruit temperatures following refrigerated road transport to Cape Town.

- Pulp temperatures can even increase during refrigerated road transport. This can be due to a number of factors, such as malfunctioning of cooling equipment, poor or deteriorated insulation or inadequate air circulation to remove product heat. Incorrect calibration or temperature setting, or even intermittent cooling to save fuel can also result in a temperature increase.
- Inadequate precooling, especially in the centre of pallets, can result in slow cooling of the warmest fruit, whilst the temperature of the coldest fruit tends to increase.

Pulp temperatures of fruit in the centre of the pallet were taken on arrival in Cape Town. More than 600 consignments were monitored in this way and the data is summarised in Figure 2.

Figure 2 indicates that the average pulp temperature on arrival in Cape Town for the 1991 season was 7,31 ± 1,17°C. This is a vast improvement over previous seasons and may be one of the major reasons for less variation in ripeness on the overseas market.

Incorrect positioning of the temperature control sensor (in the return air) resulted in one consignment of avocados arriving at 3°C. Malfunctioning of a cooling unit resulted in one consignment arriving at 18°C. If these extreme deviations (both related to mechanical problems) are discarded, it becomes clear why no "dead line" fruit (freshly picked but not yet adequately cooled) was shipped during 1992.

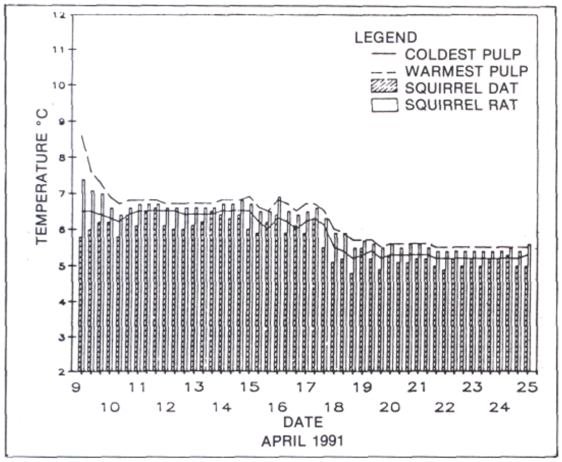

Fig 3 Delivery and return air as well as pulp temperatures of avocado fruit in the warmest and coldest positions in a container shipped at 6,5°C/5,5°C.

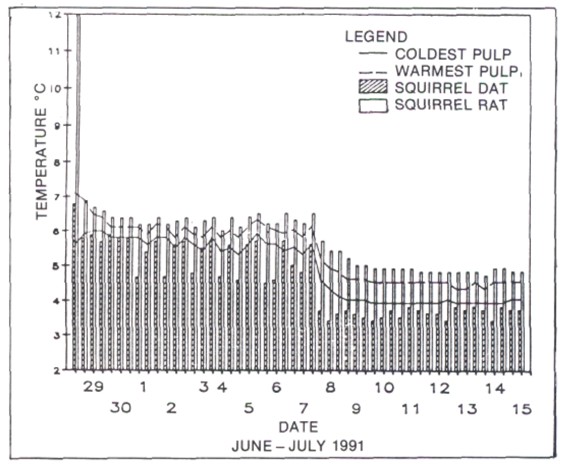

Fig 4 Delivery and return air as well as pulp temperatures of avocado fruit in the warmest and coldest positions in a container shipped at 5,5°C/3,5°C.

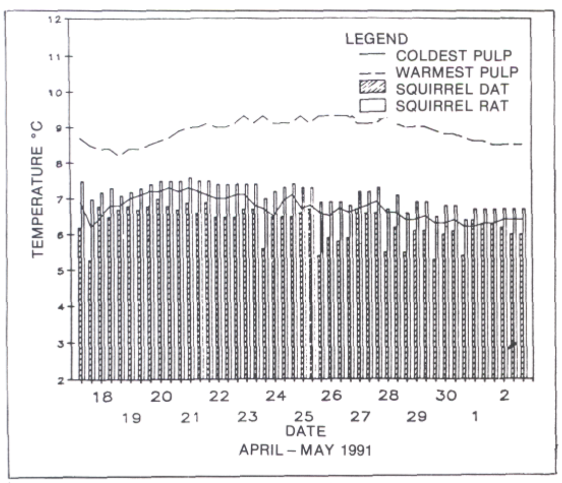

Fig 5 Delivery and return air as well as pulp temperatures of avocado fruit in the warmest and coldest positions in a container shipped at 6,5°C/5,5°C.

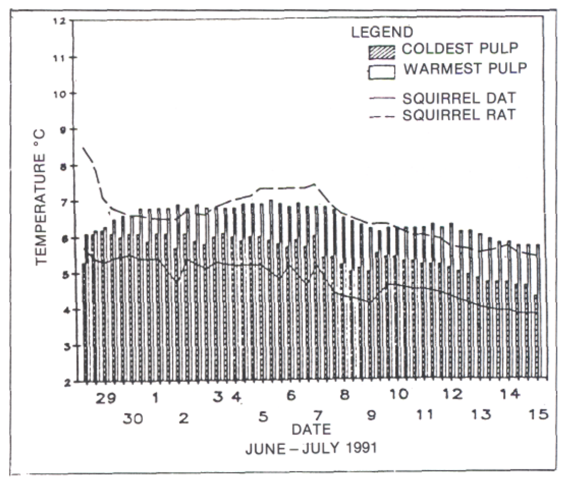

Fig 6 Delivery and air return temperatures in a container with avocados shipped at 5,5°C/3,5°C.

Voyage conditions

Previous seasons

The container vessels, containers and equipment used for avocados are designed to carry chilled produce at a specified air delivery temperature with a maximum deviation of +0,5°C from set point (carrying temperature). The vessels are well designed to allow some cooling of produce not shipped at the prescribed carrying temperature (dead line fruit).

During the past three avocado export seasons, the following problems were experienced:

- 1988 maintenance of air and pulp temperatures within the optimum range was not practised. Variation in pulp temperatures prior to shipping and inconsistent delivery and return air temperature control during the voyage, resulted in a high incidence of chilling injury and soft fruit.

- 1989 temperature control during the voyage was identified as a serious problem. The main reason for this was a big variation in air volumes and temperature of the supply air. Temperature control was based on return air, resulting in too low delivery air temperatures.
- 1990 carrying conditions improved to such an extent that chilling injury was controlled satisfactorily on a commercial scale. Soft fruit now became the major problem despite improved temperature maintenance.

It was established that the time between packing and retail marketing greatly determines firmness. Avocados, correctly handled and stored, should be sold within 28 days. Procedures were introduced to reduce the commercial average fruit age from 28 days to 24 days. This has resulted in far less problems with softening.

1991 season

The concept of lowering the delivery air temperature (DAT) during the sea voyage was again practised with very good results. Temperature curves for a 6,5/5,5°C and a 5,5/3,5°C temperature regime are described in Figures 3 and 4 respectively. The following comments can be made from this data:

- The DAT was controlled within 0,5°C from the prescribed temperature. This was fairly easy during the first part of the season (Figure 3), but several cold blasts (1°C lower than specified temperature for three hours out of every six hours) had to be applied during the 5,5 °C period, as can be seen in Figure 4.

This is the result of more respiration heat given off by later picked fruit.

- The return air temperatures (RAT) were less than 1°C above the DAT during the early part of the season (Figure 3). The RAT of fruit shipped later in the season (Figure 4) increased to more than 2°C above the DAT. This was especially noticeable during the latter part of the voyage, again confirming increased respiration rates as the season progresses and towards the latter part of the voyage.
- Minimum and maximum pulp temperatures were at the DAT and RAT respectively during the early part of the season. During the latter part of the season however, the minimum pulp temperatures were between 0,5°C to 1°C above the DAT. This resulted in the increased RAT observed, but it is interesting to note that the fruit in the warmest position were still slightly colder (±0,5°C) than the RAT. This indicates good circulation, as the circulating air could remove the total heat load (respiration heat and heat leakage into the system).

It can therefore be concluded, after evaluating 15 shipments, that the prescribed optimum shipping temperatures were very well maintained in almost all the containers monitored. This again confirms that a temperature management system for avocados can be successfully applied to maintain quality.

Deviations from optimum conditions, however, did occur, as can be see from Figure 5. Avocados were loaded into a container between 7°C and 9°C and shipped at 6°C DAT. The following comments can be made:

- The DAT off the cooler was kept at 6,0 + 0,5°C, but increased to between 6,5°C and 7°C at the container. Various cold blasts (DAT of 5°C for three hours) had to be applied to maintain an average DAT of 6,0 ± 0,5°C. It can, therefore, be concluded that the Refrigeratin Engineer applied the prescribed procedures.
- Avocados loaded at 7°C were carried between 6,5°C and 7°C. This was at, or slightly above, the average DAT.
- Avocados loaded at ± 9°C into the same container, stayed at 9,0 ± 0,5°C throughout the voyage. This fact again confirms the importance of proper precooling prior to transport.

The reason for the avocados loaded at 9°C and staying at 9°C was found to be inadequate ventilation through the pallet. This was caused by incorrect configuration and spacing of the pallet planks, which resulted in the blocking of the bottom ventilation slots.

Unacceptable increases or variation in temperatures can also be caused by other factors unrelated to the product. An example can be found in the data described in Figure 6. From this Figure it is clear that the vessel delivered air to the container at 5,5°C/3,5°C as specified. The RAT, however, showed an increase of between 1,5°C and more than 2,5°C above the DAT. The RAT also steadily increased from ± 6,5°C to almost 8°C during the first part of the voyage. Thereafter upon discharge, it decreased slowly to ±6°C.

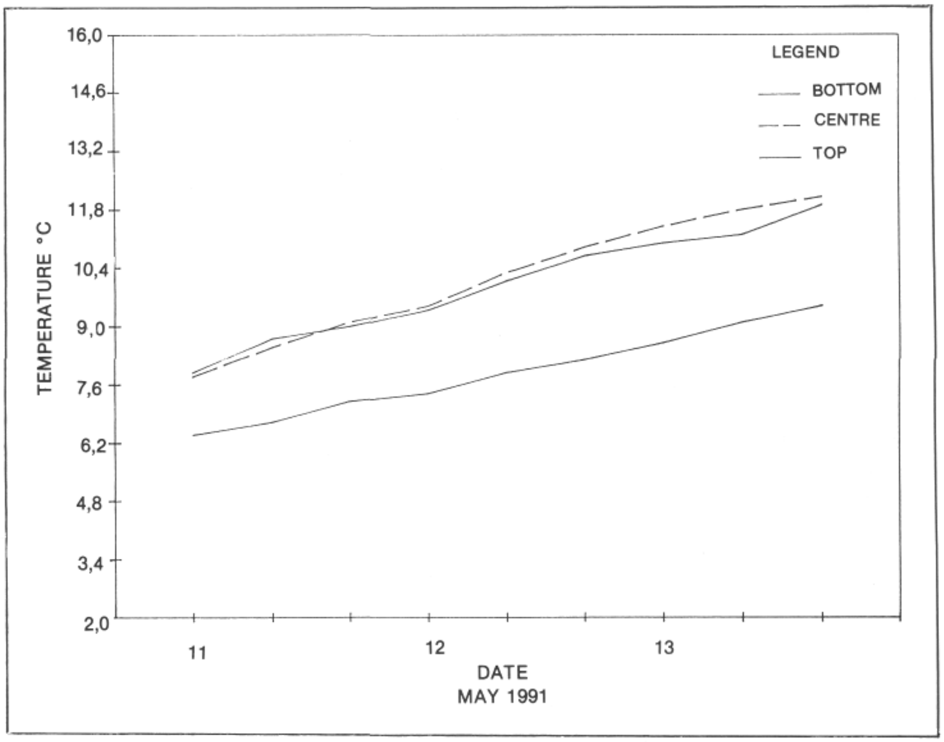

Fig 7 Changes in pulp temperatures of avocado fruit in a non-refrigerated, insulated container kept at 20°C following shipment at 5,5°C.

The data clearly proves that the refrigeration and air circulation system could not cope with the total heat load. Part of the heat load is generated by the product. The facts that the RAT increased as the equator is approached and decreased again when moving into the cooler conditions, indicates excessive heat leakage into the container.

Increased heat leakage into the container can be attributed to deteriorated insulation and/or significant temperature differences across the container insulation. Only containers with intact insulation should therefore be used. Under-deck temperatures must be controlled.

The data accumulated during the 1991 season clearly confirms the following important aspects:

- The prescribed average DAT can only be maintained by several cold air blasts during the voyage.
- Optimum air and pulp temperature conditions can be better maintained during the first part of the season and also during the first part of the voyage. Older fruit respires at a faster rate resulting in increased pulp and return air temperatures.
- Lowest pulp temperatures, in commercial consignments, are at least 0,5°C to 1°C above the DAT. Warmest fruit temperatures can bel°Ctol,5°C above the DAT. This aspect causes considerable confusion amongst exporters, who often maintain that fruit were carried at too high temperatures. The Refrigeration Engineer on board can only control the DAT. Any excessive heat build-up (in-

creased RAT) cannot be rectified during the voyage.

- The temperature management concept was successfully applied. Lowering of the DAT during the voyage can control increased respiration and therefore reduce the rate of softening.

Temperature changes after discharge

The temperatures in all containers were monitored after discharge. Most containers were moved to the market within 24 hours after discharge. One container however, was delayed for three days. Changes in bottom, centre and top fruit are given in Figure 6. It can be seen from this Figure that:

- Temperatures of all fruit increased by 3°C over three days.
- Fruit in cartons in the bottom layers increased from + 6,2°C to 9,2°C and remained the coldest during this period.
- Fruit in the centre and top layers were at the same temperature (+ 7,6°C) when discharged. The temperature in both positions increased at exactly the same rate and reached + 12,1°C after three days without cooling.

The data confirms the importance of maintaining the cold chain after discharge. If no cooling is applied, temperatures increase by at least 1°C per day. A big temperature gradient of between 1,5°C to 2,6°C existed between coldest and warmest fruit respectively.

Any temperature increase after shipment will result in fruit softening. If oxygen levels decrease with an increase in carbon dioxide concentration, physiological disorders may occur. Differences in pulp temperatures will also result in over-ripe and hard fruit in the same pallet.

It is also expected that the RH around the fruit will increase to 100%, resulting in condensation and causing the collapse of cartons and increased decay.

SUMMARY

Improved precooling as well as RMT operation and calibration resulted in much better loading temperatures than in previous seasons. All commercial fruit were shipped within 2°C from the carrying temperature.

The temperature management system resulted in improved quality. It can only be effective if the fruit temperature is within 2°C from the optimum specified carrying temperature, at the time of loading the container.

The Refrigeration Engineer can only manipulate the temperature of the delivery air. Any increase in pulp temperatures during the voyage cannot be controlled.

Cartons and pallets must be well-ventilated to avoid heat build-up or respiration.

Containers must be put onto cooling after discharge, if it is not immediately taken to the market.

ACKNOWLEDGEMENTS

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