Effect of carton wrapping on fruit cooling

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ABSTRACT

Previous work has shown that, if fruit was sealed in micro-perforated polypropylene bags before shipping at low temperatures for extended periods, as may be necessary for phytosanitary purposes, external damage such as chilling injury was reduced. However, it was not known if pallets of wrapped fruit could be adequately cooled. The objective of the work was therefore to check whether adequate cooling of cartons of wrapped fruit under pack house cold room conditions is possible. Work was conducted twice, on a cold day when fruit was partially cooled on arrival and a hot day when fruit arrived warm from the field. Pallets of fruit were built in the pack house before being placed in the cold room. Temperatures were monitored at 15 minute intervals at the top, centre and bottom of the pallets. A standard pallet acted as control, while wrapped fruit were sealed in micro-perforated polypropylene bags placed inside the cartons. Both pallets cooled to acceptable levels. However, wrapped fruit did take longer. On the hot day, cooling took over 35 hrs for wrapped as opposed to 9 hrs for non-wrapped fruit, and on the cold day, 20 hrs as opposed to 7 hrs. It is suggested that cooling fruit before packing and / or forced air cooling will need to be investigated.

INTRODUCTION

The effects of post-harvest avocado fruit wrapping has previously been evaluated for cv Hass (Bower, 2005) and positive quality attributes were found. In particular it was found that due to a probable interaction between water loss and low temperature storage, the potential for chilling injury after long periods of low temperature storage could be decreased (Bower & Magwaza, 2004). This is due to efficient post-harvest water loss control, most likely during the initial pre-cooling stage of temperature management. As water loss and low temperature storage both constitute stress, any decrease will have a positive effect on final post-shipping fruit quality. This is particularly important if shipping to new markets requires phytosanitary treatments that include cold sterilization. A further advantage of wrapping relates to the ability to manipulate fruit ripening after arrival on the market. Increasing volumes of fruit are destined for the ready-ripe programmes of major supermarket groups.

Most packers outside South Africa do not appear to wax fruit (Lemmer *et al*., 2005) while the process is a standard practice in South Africa. Waxing changes the gas diffusion characteristics of fruit: not only is oxygen and carbon dioxide transfer restricted (Amerante & Banks, 2001), but ethylene movements into the fruit is also decreased. The internal gas modification and restriction of ethylene diffusion into fruit if applied externally, most probably result in slower and possibly less uniform ripening of South African avocados as compared with those from other countries. Further, in order to take account of water loss during cooling and transport and still meet minimum net mass per carton requirements in the EU, cartons need to be slightly over-packed (up to 10%), which is in effect a net loss of potential income.

There are therefore a number of reasons, both quality and market driven, which indicate that fruit wrapping may be advantageous. However, it is unlikely that individual fruits will be wrapped in a commercial situation, and the minimum unit size is likely to be a carton. Packing and wrapping of the cartons will presumably have to take place in the pack house, with cooling after completion of the pallet stack. Previous work has shown that individually wrapped fruit can be cooled acceptably, but there appears to be no data indicating whether a full pallet of wrapped cartons of avocado fruit can be cooled to target temperature, and if so, how long it may take. This is essential knowledge if such a system is to be used commercially.

The objective of the work was to test effectiveness of cooling and time taken to reach set temperature of fruit within wrapped cartons stacked in a commercial pallet.

MATERIALS AND METHODS

The work was conducted in a commercial pack house in the KwaZulu-Natal midlands. All fruit was taken from the packline and had been treated for export. No wax was applied, but all other treatments were as normally used.

The fruit were placed in polypropylene bags containing micro-perforations of 9 µm and an anti-mist coating on the interior (Bower & Magwaza, 2004). The bags were sealed using a heat sealer, and placed in standard export cartons, which were then stacked in a standard stacking pattern in the pack house before being transferred to the cold room. For the control a similar pallet without packaging was constructed before placement in the cold room.

In order to check the temperature and relative humidity profile within a pallet, as well as rate of cooling, Hobo® H8 data loggers were used. These included a probe to check fruit flesh temperature as well as air temperature. The data loggers were placed at the centre of each pallet in a carton on the bottom layer, the centre and top layer. In the case of wrapped cartons, the data logger was placed inside the bag before it was sealed. The data loggers were also able to determine relative humidity. Data was logged at 15 minute intervals.

The set temperature of the cold room was 6°C. Fruit was left in the cold room until spot checks of fruit pulp temperature indicated that temperature was stable and further decrease was unlikely. Pallets were then removed, dismantled and data loggers retrieved for downloading.

The experiment was conducted twice, once when packing occurred on a cold day (initial fruit temperature at packing 12-14°C) and a hot day with fruit temperature at packing of 29.5°C.

Data collected included the temperature change profiles for each data logger, such that the time taken to reach a stable temperature at each site within the pallets could be determined, as well as the relative humidity of the surrounding air.

RESULTS

The recorded temperatures at the start and after stabilization for each set of starting conditions (cold and hot packaging day) are shown in **Figures 1** and **2**. In the case of the cold starting day it was unfortunate that, as a result of two data loggers which either failed to record or appeared faulty, a full data set could not be retrieved. Nevertheless, sufficient data was obtained to indicate that there was little to no temperature difference between positions within the pallets. The mean temperature of the unwrapped pallet reached the set temperature of 6°C, while the wrapped pallet appeared slightly higher at 7.0°C.

In the case of the hot day packing (**Figure 2**), the pattern was very similar. Unwrapped fruit ranged from 6.6°C at the bottom of the pallet to 5.4°C at the top. Wrapped fruit was 6.6°C at top and bottom, and slightly higher (7.0°C) in the centre. It would thus appear that wrapping resulted in a temperature slightly higher than set temperature, and a tendency for fruit packed when hot, to be slightly warmer in the centre (wrapped and unwrapped), although this was small.

The time that was taken for temperatures to decrease to a stable value differed considerably, depending upon starting temperature and packaging format. This is shown in **Figure 3**.

On a cold packing day unwrapped fruit took a mean time (all positions within the pallet considered) of 7 hours to reach set temperature (starting temperature 13°C), while wrapped fruit packed at the same time, took 20.8 hours.

On a hot packing day, fruit cooling (from a starting temperature of 29.5°C) took slightly longer for unwrapped fruit for the same treatment on a cold day, being 9.1 hours. Wrapped fruit, however, took proportionally considerably longer, at 35.8 hours.

The relative humidity surrounding unwrapped fruit was 87% to 91% at the set temperature of 6°C (cold room conditions). Wrapped fruit rapidly reached a relative humidity of 100% within the carton bags, but did not show any visible accumulation of water because of the anti-mist coating.

Overall condition of fruit from wrapped and unwrapped cartons appeared good at the termination of the trial, with no indication of premature softening, fungal or chilling damage.

DISCUSSION AND CONCLUSIONS

The work has demonstrated that it is possible to cool fruit which has been wrapped and stacked in a standard pallet. However, it is probably necessary to decrease the air delivery temperature slightly (approximately 1°C) to reach

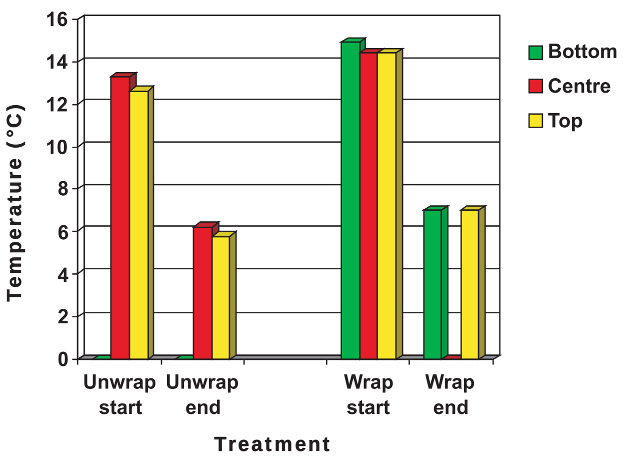

Figure 1. Initial and final temperature within wrapped and unwrapped pallets packed on a cold day.

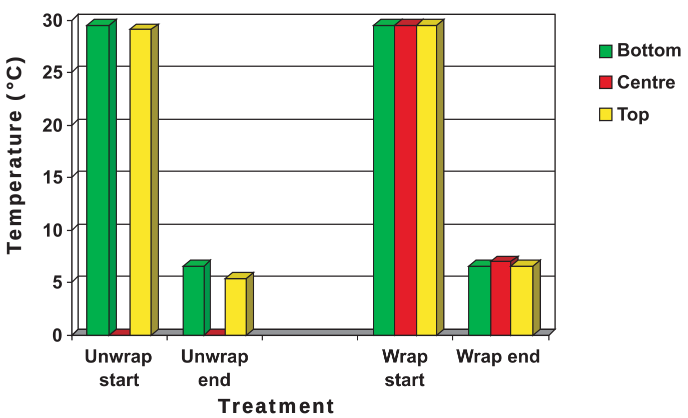

Figure 2. Initial and final temperature within wrapped and unwrapped pallets packed on a hot day.

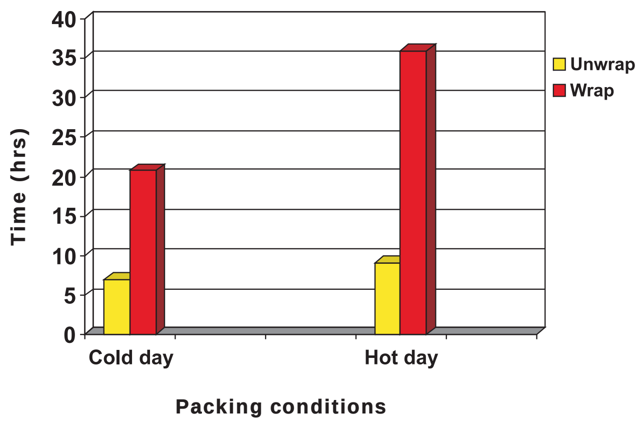

Figure 3. Time taken to reach stable temperature for wrapped and unwrapped fruit packed on a cold or hot day.

desired temperature.

A significant finding, however, was that the time to reach the desired temperature was considerably longer for wrapped fruit. This is clearly related to the rate of heat removal from the fruit, as there was no direct contact between cold air and the fruit, which may have resulted in at least some evaporate cooling. (Wills *et al*., 2004). The hotter the fruit at the time of packing, the more important this issue seems to become, as demonstrated by the difference in time taken for the cold day and hot day fruit cooling rates. The cold room used for the work was a static cooling unit, and it is suggested that a forced air cooling unit would be more efficient in removing heat from the system (Wills *et al*., 2004). Normally, a forced air system could increase the chance of wind chill damage due to rapid air movement across the fruit surface, and resulting evaporative cooling decreasing the temperature to that which could cause chilling injury, or water loss from the rind, increasing stress to the point of cell damage (Shewfelt, 1993). However, this would not be the case for wrapped fruit. Total heat removal required is clearly also important, shown by the difference between the hot and cold packing day. It is therefore suggested that the more the heat is removed from the fruit before packing, the easier it will be to achieve cooling of wrapped fruit within an acceptable time in the cold room. This is also important, because longer cooling times may result in increased risk of post-harvest disease development (Lallu *et al*., 2003). However, the slightly longer time that the wrapped fruit take to cool, could be an acclimation treatment to the ultra-low temperature storage. If there is no increase in fungal disease, this delay may even be advantageous. It would nevertheless also be more difficult to ensure all cartons are sufficiently cooled before shipping. An interrupted or inadequate cold chain has been cited as cause of soft fruit on arrival (Nelson, 2006). Hydro-cooling is an efficient pre-cooling system. It is relatively simple to incorporate in a packing line and has an advantage over air cooling of cooling fruit without water loss (Wills *et al*., 2004).

The results showing that relative humidity within the wrapped cartons reached 100% within a short time, while that of the cold room remained at 87% to 91%, implies that more water would be lost from fruit in unwrapped cartons as opposed to wrapped, with hotter fruit at start loosing more water (Wills *et al*., 2004). Lallu *et al*. (2003) also showed that such fruit would possibly increase post-harvest disease incidence. This further demonstrates the usefulness of carton wrapping within the overall post-harvest chain.

The technical possibility of cooling wrapped cartons within a pallet stack has been demonstrated. However, the additional time taken to achieve this is problematical and it is recommended that the cooler the fruit at packing the better, with hydro cooling suggested as the preferred method of heat removal, as water loss during the cooling process will be prevented. Once in the cold room, efficiency of heat removal is also important, and it is suggested that forced air cooling would be desirable.

As the sealing of fruit in each carton may be logistically somewhat difficult, it is suggested that the principle of carton wrapping be extended to full pallet wrapping. This will require additional work, to check the cooling parameters of such pallets. It is suggested, however, that initial fruit temperature and cold room cooling efficiency will be more critical. Nevertheless, the principle of commercial fruit wrapping to decrease water loss and enable shipping at cold sterilization temperatures without significant cold injury, is possible.

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