# The effect of coatings and packaging on fruit quality in avocado cv Hass stored at low temperature for phytosanitary purposes

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**ABSTRACT**

*Avocado fruit are usually considered to be chilling sensitive. However, for export to certain markets, a low temperature shipping protocol will be necessary to satisfy phytosanitary regulations. Previous work has shown that shipping at 2ºC results in good internal quality, but that external damage may be problematical unless some form of acclimation or modification to the fruit environment is imposed. Packaging to decrease water loss, appeared to help. However, most of the work has been done on green skins, and little is known about the reaction of 'Hass' fruit, particularly from different areas. Fruit were sourced from Limpopo Province (warm with early maturing fruit) and KwaZulu-Natal (KZN) (cool with late maturing fruit). Limpopo fruit were transported to Pietermaritzburg, with a variable temperature regime, while KZN fruit were immediately subjected to low temperature storage at 2ºC, as well as an acclimation regime of 10ºC for 2 days before storage. Fruit mass loss was noted in relation to fruit left unwaxed, waxed and packed in polypropylene bags. Final chilling injury after 30 days at 2ºC was noted. Results indicated that controlling water loss could substantially reduce risk of external chilling injury. Further, critical mass loss (assumed to be mainly water) appears to be between 5% and 6% of fresh mass, after which chilling injury rapidly increases with further mass loss. Considerable mass loss occurs early in the fruit cooling cycle. The acclimation process used did not appear to enhance quality significantly. It is concluded that provided that fruit mass loss postharvest can be controlled, preferably to less than 6% of fresh mass, 'Hass' fruit can successfully be shipped under phytosanitary protocols. Nevertheless, it is suggested that further work is necessary in relation to fruit maturity and precooling systems.*

## INTRODUCTION

The South African avocado industry is presently investigating the possibility of expanding export markets (Boyum, 2004). Included in this is the potentially large North American market. Of this, the USA is clearly the largest and most important. However, phytosanitary restrictions will require mitigating treatments, of which low temperature will need to be a part.

The avocado is considered to be chilling sensitive (Yahia, 1998), and thus shipping at low temperature may be questionable. Chilling damage may be manifested as internal with a collapse of cell membranes and thus browning (possibly characterized by grey pulp) and, or external damage, which can be manifested by variable symptoms of cell collapse, ranging from small black pitted areas to widespread sunken black lesions.

Previous work has shown that low temperature shipment, including that of 2ºC, is possible from an internal quality perspective (Van Rooyen & Bower, 2003), and in fact may even be advantageous where there is a high risk of internal disorders.

However, external damage in the form of traditionally accepted chilling injury was at times present. Work at minimizing water loss as a component of postharvest stress appeared to decrease this (Bower, Dennison & Fowler, 2003), but most experience was gained on greenskins such as 'Fuerte' and 'Pinkerton' (Bower & Magwaza, 2004).

As 'Hass' is to be targeted for export to North America in particular, it is necessary to gain experience of the effect of cold injury mitigating treatments (particularly water loss reduction) on this cultivar. It was with this in mind, that the effects of water loss reduction treatments and low temperature storage in relation to apparent chilling injury, was studied.

## MATERIALS AND METHODS

Fruit of cv Hass was obtained from Limpopo Province (one consignment) and KwaZulu-Natal (KZN).

### Limpopo fruit

Fruit were packed as counts 14, 16, 18 and 20 so as to determine the effect if any, of fruit size in relation to chilling damage. Postharvest treatments consisted of:

- Control (no treatment other than brushing on the packline);
- Waxed (standard packhouse treatment including waxing);
- Packaging in polypropylene bags with 9 μm perforations and anti-mist coating, and packed after arrival at the laboratory in Pietermaritzburg.

Fruit were transported by road from Limpopo to Pietermaritzburg and the temperature within the cartons monitored by data logger during this period. On arrival in Pietermaritzburg, fruit were divided such that there were 5 single fruit replications, with the main treatments as listed, but fruit were also divided into a further 2 groups, one for storage at 2ºC and another at 5.5ºC. Within each if these, sufficient fruit were packed to allow for evaluation and destructive sampling at time 0, 10 days, 20 days and 30 days. Total storage time was 30 days, after which the fruit were allowed to ripen at room temperature. Polypropylene bags were removed for the ripening phase.

Data collected included fruit mass (for determination of mass loss), external appearance to determine rind damage, and internal quality.

### KZN fruit (Experiment 1)

The same treatments that pertained to Limpopo fruit were used, with the exception that fruit were collected from the packhouse and immediately treated and placed in storage. Further, only 2 counts, 16 and 18, were used, as initial data from Limpopo fruit indicated that no differences due to count were evident.

**KZN fruit (Experiment 2)**

This fruit was treated in a similar manner to the previous, with two exceptions. Firstly, an additional treatment of 2 days at 10ºC before fruit were subjected to shipping temperatures, was included, so as to attempt to induce an acclimation to later postharvest stress. Secondly, a treatment of a temporary polypropylene bag, removed after 2 days from the start of the experiment (at the end of acclimation period, that being after 2 days in storage).

**Table 1. Air temperature during transport of fruit from Limpopo to Pietermaritzburg.**

| DAY | Min temp (˚C) | Max temp (˚C) |
|---|---|---|
| 1 | 14.5 | 16.0 |
| 2 | 12.0 | 23.5 |
| 3 | 8.5 | 16.0 |
| 4 | Decrease to 2˚C | Decrease to 2˚C |

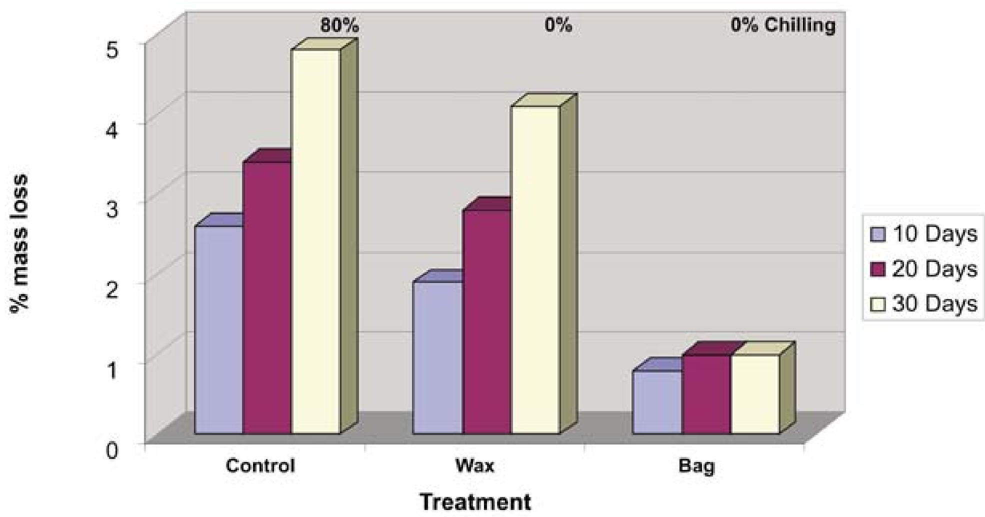


**Figure 1. Effect of treatment on fruit mass loss and chilling injury after storage at 2ºC for 10, 20 and 30 days (Limpopo fruit).**

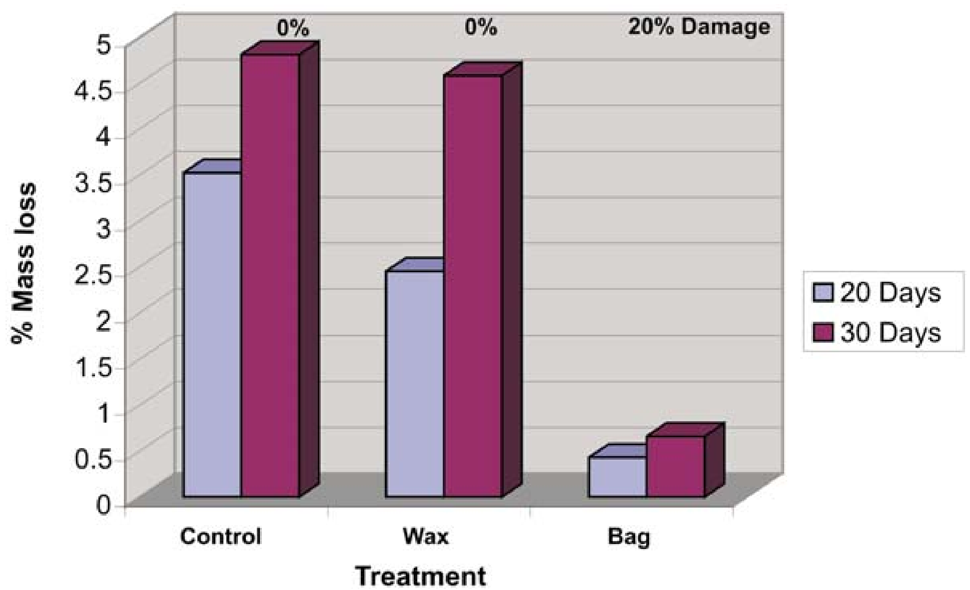


**Figure 2. Effect of treatment on fruit mass loss and chilling injury after storage at 2ºC for 20 and 30 days (KZN fruit).**

**RESULTS**

As no external chilling damage was found on fruits stored at 5.5ºC, these results will not be presented, and only those for fruits stored at 2ºC will be discussed.

**Limpopo fruit**

The temperatures to which the fruit were subjected between Limpopo and Pietermaritzburg, are shown in Table 1. During the majority of the transport period, air temperature was between 12ºC and 16ºC, with one day on which temperature rose to 23.5ºC, followed by a night temperature of 8.5ºC.

The fruit mass loss during the storage period (all counts combined) is shown in Fig. 1. It was found that count played no significant role in mass loss, and thus data was combined. Overall, mass loss (assumed to be primarily water) was highest in unwaxed fruit and lowest in those packed in bags. In the case of control and waxed fruit, a substantial mass loss occurred during the first 10 days of storage. In the case of the control, little further loss occurred until day 20, followed by a significant change in the last 10 days, where it is assumed that the cell damage had occurred, resulting in a decreased control of water loss. Very similar mass loss occurred in waxed fruit until day 20, but lower loss thereafter, resulting in an overall lesser mass loss during storage than that of the unwaxed control fruit. The fruit packed in bags lost significantly less mass (assumed to be primarily water) than the other treatments, and there was no change over time from 10 to 30 days. This resulted in a mass loss of approximately 1%, as opposed to slightly more than 4% and 5% for the waxed and control fruit respectively.

Fruit in the bags showed no external damage, as opposed to the unwaxed, 80% of which showed collapsed cells attributed to chilling. The waxed fruit, although not showing characteristic chilling injury, did have some cell damage, the cause of which is not known.

There were no internal physiological disorders in any of the treatments.

**KZN fruit (Experiment 1)**

A somewhat similar pattern to that of Limpopo fruit was evident (Fig. 2) for the first experiment using fruit from KZN. The final mass loss of fruit for the control and waxed fruit was similar (although slightly less) than that of the fruit from Limpopo, at approximately 4.9%, 4.2% and 1% for the unwaxed, waxed and bag packaged fruit respectively. No external damage attributable to cold injury was visible, although 20% of fruit in bags showed some form of tissue damage. It is believed this may have been of fungal origin. No internal disorders were recorded.

**KZN fruit (Experiment 2)**

In the case of fruit subjected to an acclimation period of 2 days at 10ºC, a technical problem precluded evaluation of results at 10 days after the start of storage. Nevertheless, evaluations were conducted at 20 and 30 days of storage. Again, the final pattern of mass loss (Fig. 3) was similar to that found in the previously discussed work. Of possible note was the relatively low mass loss during the first 20 days, but followed by rapid loss thereafter, such that the control and waxed fruit were similar to those of the fruit not subjected to acclimation (4.9% with acclimation and 4.8% without for the control, and 4.3% and 4.5% respectively for the waxed fruit. Very low mass loss occurred for the fruit in temporary bags as well as those in bags for the duration of the shipping period. In the unwaxed control fruit, 20% of the sample showed some evidence of cold damage, but this was relatively minor. No other fruit showed any clear cold damage, and there were no differences between the acclimated and non-acclimated fruits.

## DISCUSSION AND CONCLUSIONS

There appeared to be little difference between fruits from the two origins, implying that the principle applying to the preharvest susceptibility to later cold injury was similar. Previous work indicated that a significant interaction between temperature and water loss in relation to chilling injury exists (Bower & Jackson, 2003). In fact, Bower & Magwaza (2004) indicated that a threshold mass loss during postharvest storage may exist, beyond which apparent chilling injury would become progressively worse. This threshold loss (essentially water loss) appeared to decrease with decreasing storage temperature. Further, the intensity of damage visible as chilling injury was higher with lower temperature. The previous work implied that at a storage temperature of 2ºC, the threshold postharvest mass loss was approximately 6%. When relating this to the work reported in this paper, very similar results seemed to be evident. The only substantial chilling injury appeared to be in the unwaxed control fruit sourced from Limpopo (80% of fruits showing damage). The fruit mass loss was calculated as 5%.

However, in reality, this was probably higher, as some water loss will have occurred during transport to Pietermaritzburg. Although the actual amount is unknown, fruit sourced in KZN and subjected to conditioning at 10ºC for 2 days, lost approximately 0.6% of their mass during this period. Added to the 5% mass loss, 5.6% mass loss may explain the 80% of fruit showing damage in this treatment as opposed to none or very little in any of the other treatments. The closest to this was the 4.9% mass loss in the control fruit held at 10ºC for 2 days before storage, where some chilling injury was evident.

The waxed fruit showed only small, and in some cases insignificant differences to the non-waxed controls as far as mass loss was concerned. The slightly lower mass (assumed to be water) loss appeared to mitigate against chilling, but some of the fruit did show a form of rind collapse of unknown origin. It is suggested that this may be due to inadequate oxygen or carbon dioxide transfer, as there are numerous references to this effect (Banks, 1984; Amerante, Banks & Siva, 1997; Amerante & Banks, 2001) and overall, questions of the usefulness of wax beyond that of cosmetic appearance, may be asked.

The polypropylene packaging was very effective in preventing fruit mass loss, and no rind damage, which could be clearly ascribed to chilling injury, occurred. However, some fruit, especially those from KZN, did show some damage. It is suggested that the damage was caused by a fungal infection, with growth enhanced by the very high humidity conditions in the bags. This would be consistent with previous work using polyethylene bags (Eksteen & Truter, 1985). If a bag type environment was to be used commercially, attention will need to be paid to this issue.

A rapid water loss is likely to occur during initial cooling of the product (Wills *et al*., 1998). Mass loss of fruit from Limpopo and the first group of fruit from KZN seemed to confirm this. Later rapid water loss may be due to damage incurred early in the cooling or storage period. It is therefore suggested that there is a need to conserve water loss during initial cooling. The use of hydrocooling should therefore be investigated.

As little chilling injury was recorded in the work conducted, and where this did occur fruit mass loss was above 5% of fresh mass, it is concluded that it is possible to ship 'Hass' fruit at 2ºC air inlet temperature for at least 30 days. This is provided overall fruit stress (King & O'Donoghue, 1995) can be minimized by decreasing water loss from the fruit to below the threshold level for tissue damage, when the interaction with this temperature is taken into account.

However, the effects of preharvest water stress and the effects of decreasing fruit water content with increasing fruit maturity, have not been studied, and should be considered. Circumstantial evidence indicates that this may be of importance.

It did not appear that the conditioning procedure played a significant role, but physiological evaluation of the effects has not been completed, and as such, the value of the procedure can not be commented upon.

Overall, the work reported on has provided a strong indication that 'Hass' fruit can be shipped at temperatures acceptable for phytosanitary mitigation, with commercially acceptable internal and external quality, provided that water loss postharvest, can be adequately controlled.

Further work to identify risk based on pre- and postharvest water status and other quality factors will, however, be advisable before commercial implementation.

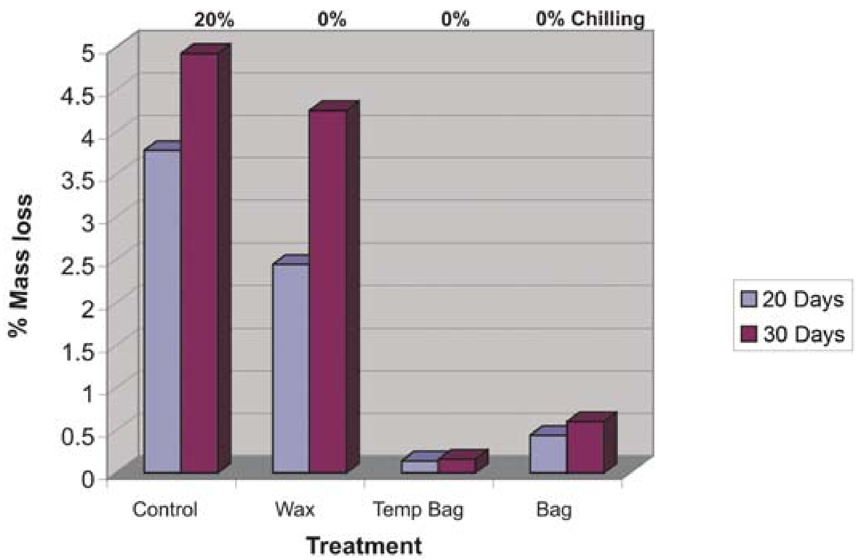


**Figure 3. Effect of treatment on fruit mass loss and chilling injury after acclimation for 2 days at 10ºC followed by storage at 2ºC for 20 and 30 days (KZN fruit).**

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